Analysis of growth data for breastfed infants and its relevance to breastfeeding

A Thesis submitted in partial fulfilment of the requirements for the award of the degree

Master of Midwifery - Research

From

The University of Wollongong

By

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2003

Acknowledgements

I wish to express my thanks to the following people. First I would like to thank my supervisors Dr. John Sibbald and Professor Patrick Crookes without whose encouragement this project would not have commenced. They have continued to offer their guidance and support throughout the last three years. I wish to express my sincere gratitude to my statistical supervisor Professor Ken Russell who has taught me so patiently and who has shown me such depth of integrity, in his recognition of my clinical expertise. I would like to thank the following Illawarra Health (I.H.) Service managers for supporting my requests for study leave - Professor Sue Kirby, General Manager, and Peter Armour, Regional Operations Manager in the Shoalhaven. I would like to thank Liz Green the I.H. Librarian for all her assistance and support. I would like to thank my work colleagues, especially those who acted as mentors - Julie Parkinson, Janet Langridge, Sue Vella and Yvonne White for all their encouragement and support over the last three years. I would like to thank all of the Child and Family Health nurses in the I.H. and Central Sydney Area Health Service for their patience while I collected my data and for the support they provided. I would also like to thank the Nurse Unit Managers - especially Robyn White who made a special effort to accommodate my requests. I wish to thank the following friends -

Frank Gonzalez in simplifying mathematical formulae for ease in my comprehension; Judy Svedberg; Nora Collis; Pat Doohan; Sheila Cheary; Georgina Morvai.

Last but by no means least, a huge thank you to my long-suffering husband Ron Cooper who described this project as a "3-year pregnancy", the culmination of which was a gigantic push to Birth!

Thank you all for your love and support. I would never have survived the gestation period without you!

Declaration

I, *Emer Cooper* declare this work to be my own unless otherwise referenced or acknowledged. This Thesis has not been submitted to any other university or academic institution.

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Contents

Abstract

Monitoring infants' growth in the first year of life is a complex issue. It has been almost twenty years since the last Australian research was published on the topic of infant feeding methods and growth and no studies have compared Australian breastfed infants with the U.S. National Center for Health Statistics (NCHS) 1977 reference longer than three months. The NCHS Hamill et al. (1977) standard is the World Health Organisation (W.H.O.) recommended guideline currently accepted in Australia. It was decided to explore a sample of breastfeeding women of European descent and their infants from metropolitan Sydney and semi-rural NSW. The research hypothesis is, that the mean weight and length of breastfed infants, is significantly less at 1 year than the NCHS reference (Hamill et al. 1977) currently in use and with the revised Center for Disease Control (CDC) 2000 reference chart. Therefore the null hypothesis is that the mean weight and length of breastfed infants at 1 year are equal to the "true" mean weight and length of the Hamill et al. (1977) NCHS reference currently used at the time. The study is not representative of all breastfeeding mothers as subjects were attendees of Child Health Clinics who were following advice of Child and Family Health nurses.

Methods: In order to test this hypothesis the weight and length of 300 breastfed infants was collated for each month between 1 month and 12 months of age and put into the format of a mathematical slope. Sections of the slope in a time series were compared e.g. 1 month to 3 months, 3 months to 6 months and 6 months to 12 months respectively. The reasons for this comparison in a time series are -

1. The literature review provided evidence that between 1 month and 3 months, breastfed infants grow faster than the current NCHS (1979) reference.
2. Between 3 months and 6 months breastfed infants' growth rate begins to slow down when compared to the current NCHS (1979) reference.

3. Between 6 months and 12 months, breastfed infants continue to grow at a slower rate that the current NCHS (1979) reference.

Following the collection of data, a series of slopes on a graph for weight and length was prepared for the comparison between male and female breastfed infants and the NCHS (Hamill et al.1977) data and the CDC (2000) revised data. The slopes of the graphs were compared mathematically using a statistical format and a p value of <0.05 was considered significantly different. The gradient was measured using a 95% confidence interval statistic on the slopes of the graphs for weight and length between 1 and 3 months, between 3 and 6 months, and, 6 and 12 months and compared with the NCHS (1977) data and the revised version CDC (2000).

Results: When the breastfed group was compared to the NCHS (1977) reference between 1 month and 3 months, male and female infants grew at a faster rate than the NCHS reference. The breastfed group continued to be above the average weight gain of the slope suggested by the revised CDC 2000 reference also during this time period. Between 3 and 6 months only the weight of both sexes is significantly different and it begins to slow down at this time, growing slower than both the NCHS and CDC average. The CDC 2000 guide also remains faster than the breastfed group between 3 and 6 months. Between 6 and 12 months, only the female breastfed infants' weight gain was slower at the end of the first year and was significantly different to the NCHS reference. Male weight and length grew at a similar rate to the NCHS (1977) reference. Compared with the slope of the revised CDC 2000 reference between 6 - 12 months, both male and female breastfed infants gained weight at a *slower* rate, $p<0.05$. Using the statistical *t test* on the terminal figures at 12 months demonstrated that there was not a significant difference at 1 year between the mean weight of the breastfed infants group, the NCHS and the revised CDC 2000 reference - $p > 0.05$. It was assumed from

testing the null hypothesis at 12 months, that Australian breastfed infants when measured against the NCHS (Hamill et al. 1977) and the revised CDC 2000 reference do not vary at the age of 1 year as much as previously thought. This may be due to the possibility that previous research did not record the breastfeeding management of the infants in their studies.

Discussion: If infants were breastfed to a schedule of three or four hours they would not have the opportunity to gain weight at the same rate as infants who had 'free' access to breastfeeding. The infants in this study were recorded as having been exclusively breastfed, fully breastfed or breastfed to need and may have had the opportunity to gain more weight. Fewer observations were available for length than for weight as time progressed which implies that most infants are weighed, but only some are measured. The implication of these results - from the data presented in this study- is, if clinicians use the existing charts as a guide to monitor adequate ('good') weight gain of breastfed infants, that these infants will be seen as not gaining adequate weight or failure to thrive after the age of 3 months. This in turn has a potential to lead to the suggestion for offering breastmilk substitutes particularly after the age of three months, unless a thorough history is taken on the woman's breastfeeding management.

A serendipitous finding in this study was that Australian formula-fed infants may be heavier than breastfed infants. Two possible explanations for this were suggested - that parents are overfeeding, used heaped scoops of powder i.e. - 'intentional overfeeding' -, or that parents are following the guidelines on the label of the formula tins and these volumes are inflated.

Keywords: Breastfed; breastfeeding; NCHS; CDC; null hypothesis; confidence interval; *t test,* see Appendix IV for acronyms list and definitions.

Chapter 1 Introduction

The theoretical underpinning of this thesis is the belief that Australian breastfed infants have a different growth trajectory to the U.S. National Center for Health Statistics (NCHS) 1977 reference. The problem with the 0 to 12 month curve of the NCHS graph is that the data was collected at 3 month intervals and spline curve smoothing procedures were used (Hamill et al.1977). The spline method was accepted at the time because growth was considered as a smooth function and provided the best 'fit' for the data of the infants from the age of 2 years to 11 years. However the spline method was not capable of mathematically describing any outlying data or dependent variables. The National Health and Medical Research Council (NHMRC 2003) have suggested the use of the revised NCHS (Hamill et al.1977) growth chart for use by practitioners in Australia. This is called the 2000 CDC Growth Chart (Center for Disease Control 2002) and is based on a population of partially breastfed American subjects. Using the LMS Box-Cox mathematical formula to smooth the percentile curves may not be adequate to validate accurate clinical use (Center for Disease Control 2002). By using the NCHS 1977 data or the CDC 2000 revised data, there is the potential for 'error' if used to monitor the growth of breastfed infants in Australia. The 1977 American data was a convenience sample who lived in close proximity to the data collection centre, the U.S. NCHS. It was likely that the data used to produce the NCHS 1977 charts was based on predominantly formula fed infants who were fed on 'old style' formula between 1963 and 1975 when formula feeding rates were high. It was common practice to offer infants' cow's milk with sugar added which had a potential to add more calories. There is a potential to increase the error in judgement by comparing Australian breastfed infants with the U.S. CDC 2000 reference which is based on predominantly formula fed American infants. There will be a systematic error in judgement evident using the

revised NCHS 1977 standard even when a new mathematical formula was used to create improved smoothed percentiles, because the CDC 2000 chart was compiled from data where only one-third of infants were breastfed for 3 months (CDC 2002). This population may not only be scheduled breastfeeding but giving formula to infants that is not reconstituted according to the manufacturer instructions. The volumes of formula suggested by the manufacturers may exceed the Recommended Daily Allowances/Recommended Daily Intake (RDA/RDI) guidelines in Australia (Commonwealth of Australia 1998) and subsequently these infants may well be over fed. Therefore the reference is not an appropriate tool with which to compare the Australian fully breastfed infant. There is a potential for both clinicians and parents/carers to use the references to monitor the progress of the breastfed infants' growth and to make decisions on the breastfeeding performance by using it as a 'rule' rather than a 'tool'. In this study the definition of breastfeeding was, any infant who was documented in the files as being fully breastfed, exclusively breastfed, or breastfed only and this was interpreted to mean that, the infant never had formula as a main drink. In addition, the Early Childhood staff at each clinic were asked how they understood the meaning of fully breastfed and exclusively breastfed.

In the literature review, which follows this chapter, some of these themes are explored in more detail. Neither the NCHS (1977) nor the revised version - the CDC 2000 - is deemed suitable to monitor the growth of the Australian fully breastfed infants in the first year of life especially following the commencement with solids after the age of 4 months. Lactation advice based on the weight of the breastfed infant alone that is given without a thorough history of the breastfeeding management, has a potential to compromise the breastfeeding process. Paediatric community health practitioners who use this chart to guide infant feeding regimes are basing advice on misconceptions.

The aim of this study was to collect sufficient data from fully breastfed infants and to compare the aggregated data with the current NCHS (Hamill et al. 1977) and the CDC 2000 growth chart. The purpose was to establish if a difference in growth trajectory exists between current Australian breastfed infants and the standard references recommended for use.

The research hypothesis concluding the literature review is, that the mean weight and length of breastfed infants, is significantly less at 1 year than the NCHS reference (Hamill et al. 1977) in use at the time as well as the revised CDC (2000) reference chart. Therefore the null hypothesis is that the mean weight and length of breastfed infants at 1 year are equal to the "true" mean weight and length of the Hamill et al. (1977) NCHS reference currently used then.

The research methodology for the data collection is presented which describes the audit of a total of 3,523 files, from the years 1997-2000. This audit provided 397 files (or 11.2%) of suitable data for analysis. This figure does not represent all the breastfed infants but only those infants who met the fully breastfeeding criteria. The slopes of the graphs were compared mathematically using a confidence interval (C.I.) and were found to be significantly different ($p < 0.05$). The gradient was measured using the 95% confidence interval statistic on the slopes of the graphs for weight and length between 1 and 3 months, between 3 and 6 months, and, 6 and 12 months and compared with the NCHS (1977) data and the revised version CDC (2000). Segments of the graphs are shown between 1 month and 12 months comparing the data of 300 breastfed infants and the NCHS (1977) data and the CDC (2000) data.

In the results chapter using a 95% confidence interval for the three time periods in the first year - 1 - 3 months, 3 - 6 months and 6 - 12 months demonstrates the different growth trajectory between the breastfed group and the NCHS and CDC 2000 references.

The statistical results of the analysis on the slope of the graphs are further explained by using graphs to visually demonstrate the findings and to highlight the features of significant differences between the breastfed group and the NCHS standard (Hamill et al. 1977; Hamill et al. 1979). Further analysis is presented using a student *t test* to provide a *p* value to test the significant difference of the terminal figures at the age of 12 months. Using the statistical *t test* on the terminal figures demonstrated that there was not a significant difference at 1 year between the mean weight of the breastfed infants group, the NCHS and the revised CDC 2000 reference - $p > 0.05$. The terminal figures in the results chapter were found *not* significantly different at 12 months using the *t test* ($p > 0.05$). Therefore the null hypothesis was not rejected.

From the number of observations (n) in each of the categories of the slopes, the practice of clinicians can be observed. There are fewer subjects with length observations in the first 3 months, - n = 103 for male weight and n = 64 for male length, n = 108 for female weight and n = 82 for female length, implying that clinicians are more focused on the infants' weight gains than their length. The number of observations (n) in each of the categories of the slopes continues to decline throughout the first year of life. A serendipitous finding in the study was that in fact formula fed infants in Australia might well be over fed. This was observed while collecting the data. It became obvious during this process of auditing the files for feeding methods used, that infants who weighed 12kgs or more at the age of 1 year had been formula fed.

The discussion chapter takes in the four key findings and compares them to the findings in the literature. The Australian breastfed infants had a different growth trajectory when compared to the NCHS (1977) reference though it differs at various intervals.

The results from this study and from other researchers found a downward trend in breastfed infants' weight after the age of three months when the breastfed data was

compared to the NCHS (1977) reference. The findings were similar in the time periods between 1-3 months and 3-6 months when the results were compared with researchers in the U.K. (Paul et al. 1988) and the USA (Dewey et al. 1992; Dewey et al. 1995). The 'systematic error' present when using the CDC 2000 reference is demonstrated when similar results were also discovered using this revised version of the NCHS (1977), with the Australian breastfed group. The implications for clinical practice are discussed for clinicians that may have an over-reliance on using the reference chart for monitoring the weight gain of breastfed infants. The serendipitous finding that formula-fed infants in Australia may also be over fed is discussed. Further implications due to the fact that parents and caregivers may receive information and education on infant feeding practices from other sources such as advertising, as the infants grow older are presented. Recommendations are made for further research in the field following the presentation of each key finding. Executive recommendations are summarised at the end of the discussion chapter.

A concluding chapter reiterates the aims of the project, the results and the implications for clinical practice and the most important recommendations.

Chapter 2 Literature Review

Introduction

In this review of the literature several themes on variation in the growth of breastfed infants and how infant feeding mode is related to growth are presented. The main concepts and variables explored are listed below and discussed in that order. The search strategy for the review is outlined briefly and a definition for breastfeeding for the purpose of this review and research is given. Boundaries for the inclusion of articles in the review and the historical background of the NCHS (Hamill et el. 1977) reference as well as the revised version CDC 2000 (Center for Disease Control 2002) are submitted. The most relevant themes are presented with empirical research on their methodology for comparison and analysis and these main themes are summarised after each section. The purpose of this literature review is to define concepts and variables within the literature for the purpose of carrying out original research on the topic. The rationale for the review at this time is, to establish a framework around which any infant growth chart being used (or intended to be introduced for use) by practitioners, is appropriate for the population for which it is intended and is based on a reasonable proportion of this population. In addition, this chart is soundly based on evidence from a scientific as well the clinicians' perspective.

A further aim of this literature review is to explore a sample of literature and the methods recorded, which validate using growth charts to monitor breastfed infants' growth and progress, by using the chart to give advice to parents in relation to the method by which infants are fed. To explore this relationship further when breastfed infants are compared with the NCHS (Hamill et el. 1977) standard reference, which was adopted by World Health Organisation and recommended for use in Australia in1984 and used internationally to monitor infant growth(Hamill et al. 1979). Therefore the

context for this exploration of reviewing the literature, is the period during which time the NCHS (Hamill et al. 1977) chart has been in existence for monitoring the growth of infants progress over the last fifteen to twenty years. Finally, the main themes are summarised at the end with rationale for the research concluding with the research hypothesis and a statement on what the null hypothesis is.

Main concepts and variables explored

- the growth of breastfed infants in the first year of life;
- growth of breastfed infants compared to the NCHS (Hamill et el. 1977) reference;
- variation in growth in the first year between breastfed and formula-fed infants;
- Socio-economic status and infant feeding practices.

Factors associated with the growth of infants in the first year

- the introduction of solid foods;
- weaning practices - the influence of reconstituted infant formula on growth;
- current infant feeding practices and changes in socio-economic status (SES);
- the role of the Child and Family Health nurse.

The Search Strategy

One method suggested for refining a search topic is to graduate from a broad perspective - for example in this case breastfeeding - to defining terms closely associated with the topic (Hibbert & Crookes 1998). Fortunately the spelling for these terms is not dissimilar across databases between England and the USA except when using two words instead of one e.g. 'breastfeeding' or 'breast feeding'. Key terms used for searching were 'infant feeding and infant growth', 'breastfeeding and growth charts', 'infant weight gain and infant growth'. Searches of the literature included the Medline

and CINAHL databases between 1988 and 1998, as well as incremental searching (Hibbert & Crookes 1998, p. 62).

Definition of Breastfeeding

The definition of breastfeeding for the purpose of this research is based on Auerbach et al. (1991) and Labbok and Krasovec (1991) which is, that an infant is considered as fully breastfed, even if also taking solids (after the age of 4 months) until it could be unequivocally demonstrated that such an infant was definitely formula-fed with solids (Auerbach et al. 1991; Labbok & Krasovec 1991).

Boundaries for the inclusion of articles for this review.

Criteria selection for inclusion of articles for the review were primarily for their subject matter and research methods pertaining to the specific topic of breastfeeding, infant weight gain, growth charts and comparisons made between them, as well as with formula fed infants and the NCHS (Hamill et al.1977) chart. The DARLING Study (Peerson et al. 1993) consistently appears in the databases searched and during incremental searching. Literature from the U.K. and Europe, the USA as well as Australia is included in the review, as the Caucasian population in Australia upon which this research is based is predominantly of European descent. Comparative studies from non-industrialised countries are used to demonstrate more recent findings with studies from industrialised countries.

Historical Background

The NCHS Chart (Hamill et al. 1977)

The infant growth chart for monitoring infants was standardised following the collection of data in the U.S.A. between 1963 and 1975 by the U.S. National Centre for Health

Statistics (NCHS). 20,000 children from 0 to 18 years old were included in this survey. 867 infants from 0 - 2 years old were weighed without clothes. The infants' length lying down, was measured by two people. A self-balancing scale that printed out the weight was used in order to minimise recording error. The infants were followed longitudinally after birth at three monthly intervals in the first year and 6 monthly intervals in the second year. The sample was a convenience sample who lived in close proximity to the data collection centre. Data was presented in four categories – (i) Weight for Age (ii) Height for Age (iii) Weight for Height and (iv) Head Circumference for Age. Seven percentiles were demonstrated representing the 5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}, and 95^{th}, respectively (Hamill et al. 1977). The 50^{th} percentile (by definition) is called the median and represents 50% of approximately all values observed above and below this line. This measurement of growth and standardisation of charts is based upon the normal distribution. The arithmetic *mean* is in the centre of the bell curve. Approximately 68% of children's growth will theoretically be expected to fall within 1 standard deviations (S.D.) above or below the *mean* (+1 and -1 S.D.). Approximately 95% will theoretically fall between +2 and –2 S.D. and 99% will fall between +3 and –3 S.D. of the *mean.* Therefore half the children measured in the sample will be expected to fall between the 25^{th} percentile and 75^{th} percentiles and 80% will fall between the 10^{th} and 90^{th} percentiles (Riordan & Auerbach 1993). Prior to the development of the NCHS 1977 chart, smoothing of curves was performed by hand. However as this hand-method could not be easily duplicated a more mathematical approach was deemed appropriate. Two methods were considered for smoothing the curves on the NCHS 1977 chart - the first was a computerised curve-smoothing procedures of "spline polynomial smoothing of observed percentiles" and a second was smoothing by the use of Pearson's curve system (Hamill et al. 1977). The latter was considered skewed in favour of the outliers so a

modified version of the spline polynomial system was adopted by raising the degree from cubic to quartic which improved the intermix between the percentiles.

The 1977 NCHS chart for infants 0 – 3 years old was devised from data collected from a mainly homogeneous ethnic group in Yellow Springs Ohio, USA, between 1929 and 1975, this was the Fels Longitudinal Study of Growth (Hamill et al. 1977). The infants in these studies were predominantly formula fed particularly after the age of three months (Peerson et al. 1993; Dewey 1998). It is important to remember that this longitudinal study was carried out in an affluent society on well-nourished children. The limitations of this study - infrequent measurements at 3,6,9 and 12 months in the first year and twice in the second year (i.e. six monthly) are not truly representative of growth velocity in the young infant. It was adapted by W.H.O. for their international standard and used in Australia for the past 16 years (Hamill et al. 1979). It is noteworthy that the U.S.A. predominantly uses the Imperial system of measurement. It could be speculated that the measurements have been collected in Imperial and translated into Metric for adaptation by W.H.O. It is doubtful if the same researchers carried out these measurements over a period of 12 years. This also leads to some discrepancy in the consistency of measurements and the possibility arises for measurement and instrument error. At any given time there is an expectation that a percentage of infants will fall into a category of approximately 50% above the mean and 50% below the mean. It was likely that the data used to produce the NCHS 1977 charts was based on predominantly formula fed infants who were fed on 'old style' formula between 1963 and 1975 when formula feeding rates were high. It was common practice to offer infants' cow's milk with sugar added which had a potential to add more calories. It would not be surprising that these infants weight could be heavier than breastfed infants' weight, making this standard unsuitable for monitoring the progress of Australian breastfed infants.

The CDC 2000 chart

International research studies published over the last twenty years provide evidence of problems with the use of the NCHS 1977 chart on infants during the first year of life - in particular- the three monthly measurements and the curve smoothing procedures.

A new updated version called the 2000 CDC growth chart is a revised version of the NCHS 1977 growth chart (CDC 2002). The intervals between the three months where data was previous lacking have been filled. The new updated growth chart is based on USA national data collected between 1988-94 for infants aged 3 months- the NHANES III survey (Kuczmarski et al. 2002). This is reported as more representative of the nations' ethnic-racial diversity and has an improved combination of breastfed and formula -fed infants (Lindeke et al. 2002). The most noteworthy improvement in the new chart is the inclusion of the Body Mass Index (BMI- see Appendix IV p.140), which can only be used in the clinical setting after the age of 2 years when an accurate standing height can be easily measured.

An attempt was made to improve the validity of this chart by a mathematical re-modelling using the LMS (see Appendix IV) Box-Cox formula (Cole et al. 1995). Smoothed percentile curves were calculated by the use of the LMS method. The age appropriate percentiles are expressed using the Box-Cox power "L" required to normalise the distribution of the data. "M" represents the median and "S" the coefficient of variation within the distribution. To obtain a 'goodness of fit' for the data, LM and S values change at each age and are more easily expressed as smooth curves when measured at specific ages (Cole et al. 1995; Freeman et al. 1995). This LMS method is capable of converting any data to Standard Deviation (S.D.) scores using the formula SD (z-score) = $[X \text{ measurement}/M(t)]^{L(t)} - 1 \div S(t)L(t),\ L \neq 0$. Where X is the physical measurement of the infant - weight or length - and L, M and S are the

corresponding age appropriate values of the infant in months. L(t), M(t), S(t), means raising the value to the power of an exponential projected growth rate for the purpose of producing a visually smooth curve to represent the relevant percentiles (CDC 2002). The LMS approach was modified to produce the current USA growth charts as it was suggested this method assisted in fitting smoothed percentiles curves to the data and reduced skewness.

S.D. and *z*-scores are based on the normal distribution. The *z*-scores and their equivalent percentiles can be found in most statistical textbooks demonstrating the normal distribution. Software programs are also available which convert *z*-scores to percentiles. The normal distribution is based on the assumptions that the data comes from the bell shaped curve. Using the mean, the values of the outliers affect the result. However evaluating the *median,* which is the middle value when all the measurements are placed in order, in effect negates the outliers. Calculating the centiles based on the actual data is more *robust* than basing the centiles on the assumption that the data are dependent on the normal distribution or bell-curve. This allows for variability within the data. A conclusion that is *not* based on an assumption from the bell curve is stronger than one, which relies heavily on the assumption that the data is normally distributed.

Could it be surmised that in fact the mathematical re-modelling of the NCHS (Hamill et al. 1977) data, in conjunction with new data again of predominantly formula fed American infants (Dewey 1998) has a systematic error? The error being, that breastfed infants have a different growth trajectory to formula fed infants (Dewey et al. 1993; Dewey 2001). Therefore when a chart is compiled from the data of infants with mixed feeding practices e.g. CDC 2000 there is a less viable comparison when a breastfed group is compared with this data. This partly explains why the chart is an inadequate constant with which to compare the Australian breastfed infant.

Critique

Using the LMS Box-Cox formula based on the normal distribution in an attempt to improve the validity of the NCHS 1977 chart by mathematical re-modelling may not be the ideal. This method has a potential to increase the error in judgement by comparing Australian breastfed infants with the U.S. CDC 2000 reference based on predominantly formula fed American infants. There will be a systematic error in judgement evident using the revised NCHS 1977 standard even when using a new mathematical formula to create improved smoothed percentiles, because the CDC 2000 chart was compiled from data where only one-third of infants were breastfed for 3 months (CDC 2002). As the proportions of the young infant's body are changing so rapidly in the first year, the revised version of the growth chart would appear to have improved very little for the young infant, particularly if breastfed.

Empirical Research

Introduction

The current body of knowledge relating to breastfeeding and growth obtained from research articles are reviewed and critiqued in the following manner. The first study presented here is the Cambridge breastfed infants' growth study carried out by a group of researchers in the U.K. (Paul et al. 1988). This is followed by the DARLING study carried out in the USA in 1986 (Dewey et al. 1992) and which culminated in a pooled sample of breastfed infants' data (Dewey et al. 1995) for analysis and comparison with the NCHS 1977 reference. Further studies from Australia, South America and Europe are presented and comparisons are discussed where methodology is similar. Each study has an evaluation/critique and a summary of each theme is presented before the next theme is discussed.

Growth of infants who are reported as breastfed - a UK study

The Cambridge study (Paul et al. 1988) was researched in the U.K. based on 48 infants – 28 boys and 20 girls. This study was carried out because no studies had been carried out before 1980 on fully breastfed infants in the first 4 months of life or after the introduction of solids.

Methods: The infants were born between 1978 and 1980 and selected pre-natally. Selection criteria - being born after 37 weeks of gestation and weighing over 2.5 kg at birth. Social status was categorised into five groups based on fathers' occupation.

The volume of breastmilk was measured by home test-weighing carried out by the mothers after every feed over a 4 day period after 6 weeks of age. Missed feeds were calculated by an average over the period. The weight and length of the male and female infants was measured monthly from 6 weeks to 10 months as well as the mid-upper arm circumference and triceps skinfold thickness. Specialised equipment was obtained for this purpose and the American National Center for Health Statistics (Hamill et al. 1977) growth chart was used to plot the weight and length on the graphs.

The two major research aims were

1. To measure the growth, energy and nutritional status of infants under the age of 1 year who were fully breastfed between the ages of 2 to 10 months and to follow them longitudinally for 7 years.
2. To find out what factors influenced the intake of breastmilk and the volume of breastmilk ingested by the infant was of particular interest.

Results on growth

Boys weighed more than girls ($P<0.01$ to <0.02) and boys were longer than girls ($P<0.001$ to <0.02) throughout the study. At 2 months mean weights of boys and girls were higher than the NCHC 50^{th} centile. This peaked at 3 months and the slope

comparable to the NCHS line gradually decreased up to 10 months. The girls' gradual ‘downward’ trend was greater than the boys. Length graphs presented the same gradual slope decrease, which was more obvious in girls than boys. 19 women were breastfeeding at 10 months. Breastmilk was the main source of milk intake, but some infants drank formula from bottles.

Factors affecting breastmilk intake

The amount of breastmilk taken by each infant demonstrated considerable variation while the infants were fully breastfed. The gender and birth weight of the infant affected the volume of breastmilk taken at a feed. Boys drank more milk than girls did. The intake of breastmilk was higher for boys during the 2nd and 3rd months. In early lactation and early infancy, prior to the introduction of solids, the volume of breastmilk taken per feed was most positively correlated with the size and weight of the infant. In regard to the social class of the father, breastmilk intake was greater among infants from higher socio-economic status (SES) groups than infants from lower SES groups and this was more obvious among males than females.

After the introduction of solids this variation was more marked with the intake of breastmilk decreasing. The higher the volume of breastmilk ingested by the infant, the greater was mothers’ energy intake requirements. Infant demand for breastmilk was the dominant factor. Irrespective of class, boys were weaned before girls. Lower SES groups weaned their infants younger than higher SES groups but this difference was not statistically significant.

Critique: The small number of subjects in the study leads to less reliable statistical results. Mothers did their own test-weighing and documentation. Can this subjectivity be relied upon for accuracy, particularly in relation to amounts of formula given to infants? The maximum number of feeds is reported as 6.3 i.e. approximately a 4 hourly

schedule and not necessarily conducive to breastfeeding to meet the infants' appetite. It would appear that these infants did not have 'free access' to the breast. Regimes and restrictions in the timing of feeds as well as the length of feeding times at the breast could have been part of the breastfeeding management. The breastfeeding advice / management was not reported by the mothers or the researchers in this study. How did the mothers count any one feed? Once on each breast or were 'top-up' feeds also counted as one feed? Overall, the study posed some valuable questions for further research, in addition to adding information to a gap in the body of knowledge.

The DARLING study was carried out 6 years later in the USA

The Davis Area Research on Lactation, Infant Nutrition and Growth (DARLING) Study began researching the variation in growth between breastfed infants and formula-fed infants in 1986 (Dewey et al. 1992). The aim of the research was to compare the growth patterns and nutritional intake of a sample of breastfed infants with a similar sample of formula-fed infants. (This latter comparison is discussed in detail later in this review). At this point only the growth patterns of the breastfed infants are presented for comparison.

Methods: This research was carried out in California in the USA on two affluent groups who were matched for socio-economic factors. The weight and length of the infants at birth were collected from the parents' records. Monthly home visits were then made by four specifically trained assistants to weigh the infants and measure their length for 18 months.

Results: Of the 92 women recruited into the study who initiated breastfeeding, by 6 months there were 28 breastfed male infants and 34 breastfed female infants and at 12 months 24 breastfed males and 23 breastfed females -a total of 47 breastfeeding participants remained in the study.

Comparing the results of growth alone, between the UK Cambridge study and DARLING study revealed that breastfed male infants in the DARLING study were below the 50th percentile by 8 months when compared on the NCHS (Hamill et al. 1977) chart. As with the Cambridge study female breastfed infants were below the 25th percentile by 12 months. Differences in length were less pronounced between males and females.
In both of these studies the weight of female breastfed infants slows down when compared with the NCHS 1977 chart.

Critique: Again, no record of the breastfeeding management is noted in the DARLING study. Were arbitrary schedules for breastfeeding and timed feeds the norm and were pacifiers used? The researchers in the DARLING study did not record feeding patterns (Dettwyler 1997). The small numbers of infants remaining in the study could be misleading the results at the age of 12 months. The researchers considered the unadjusted means of this sample too high for comparison with the NCHS 1977 reference. Therefore they performed calculations to adjust the means of each infants' weight and length in order that a comparison could be made with the NCHS 1977 data. The purpose of the DARLING study was to provide a baseline for the comparison of breastfed infants from an affluent group with breastfed infants from lower socio-economic populations. This being the case, then affluent groups culturally breastfeed their infants to a schedule or routine of 3 to 4 hourly (as is seen in the Cambridge study of Paul et al. 1988) which is not comparable with cultures who breastfeed continuously. The ethical stance in the DARLING study may also be open to question as the Mead-Johnson formula company funded the research.

Breastfed infants pooled analysis on growth (Dewey et al. 1995)

Due to small numbers of breastfed infants in each of the studies, the World Health Organisation Working Group on Infant Growth, combined the data from 7 of these studies and compared the growth patterns (Dewey et al. 1995). This pooled group of Caucasian breastfed infants had to meet strict criteria for inclusion, in order to be compared with the standard reference chart used worldwide to measure infant growth. The purpose of the study was to compare the weight, length and head circumference of this pooled group of infants to the WHO/NCHS reference.

Methods: The anthropometric measurements were analysed using ANOVA statistical procedures to measure any correlation between infant growth, the number of months spent breastfeeding, weaning foods and commencing solids. The criteria used for inclusion of data in the study were that infants had to be exclusively breastfed for at least 4 months and no solids and no formula or other milk given until after 4 months. Measurement data had to be available for the first 12 months of life with intervals no greater than 2 months apart. Data was collected on normal term infants and was statistically analysed using z scores on the normal distribution to evaluate interpolation between these three nominated groups of measurement - weight-for-age (WA), length-for-age (LA) and weight-for-length (WL) in relation to the standard chart. A total of 226 infants who were breastfed for one year met these criteria and this total was measured in the three groups, WA, LA and WL and analysed.

Results on growth

For the first 5 months all three nominated measurement groups demonstrated a comparable growth pattern. Of particular interest was the growth pattern in the weight-for-age (WA). The longer the infant was breastfed the less the rate of weight gain

(p<0.0001) with adjustments made for other foods. When comparing these growth patterns of breastfed infants in the 3 groups with the standard reference chart used, a very obvious pattern was clear. Breastfed infants gained weight more rapidly than the chart recommends for the first three months of life. After three months the weight gain slowed down giving the appearance of "failing to thrive". The decreased rate of growth in length, in relation to weight is less obvious. This pattern of growth where the breastfed infants have lower weight-for-length indices than the current WHO reference continues until the age of 12 months.

Critique: This data was collected from developed countries that culturally breastfeed their infants on a schedule of 3 to 4 hourly regimes. The existing W.H.O. chart (Hamill et al. 1977) was originally based on infants who were not breastfed nor fed on modern formulas and this appears as a biased comparison for the breastfed infants. The conclusion of the authors from this study that a new reference chart is required for breastfed infants based on a comparison using the 'old style' chart without adequate reporting on the breastfeeding management seems unconvincing.

A study on Aboriginal infants (Smith et al. 2000) aimed to provide nutritional advice and support to pregnant Aboriginal women and mothers of children under 3 years old. Two groups were identified - a Pre-intervention group with the subjects' data collected from the child health records 1991- 1996 of 204 infants on birth weight, birth length and gestational age, which were used as a control group. The Intervention group 1996-97, consisted of 43 infants and children under 3 years old, who were followed prospectively and had their gestational age, birth weight and birth length data collected from the mothers obstetric discharge sheet.

Methods: Seven home visits were made at intervals, to provide nutritional advice and to take the bare weight and supine length measurements of the infants. Diet and breastfeeding was recorded from maternal recall. The researchers considered z scores "inadequate" for breastfed infants and used percentile charts to monitor the infants' growth. The means of the measurements of full term male and female infants were compared with (i) NCHS chart (Hamill et al. 1979) and (ii) the interim W.H.O. values for the fully breastfed infants pooled data (W.H.O. 1994) because breastfeeding rates were considered high in the intervention group.

Results on growth when compared with the NCHS (Hamill et al. 1979)

When the mean birth weights were compared, both groups were similar to the NCHS**.**

In the Pre-intervention group, female infants' growth trajectory in weight was above the NCHS reference 50th percentile for the first 6 months, after which time their weight slowed down to 1.14kg below the NCHS reference by 12 months of age. Male infants' weight in this group was faster than the NCHS reference for the first 4 months and then also slowed down to 1.37kg below the NCHS reference by 12 months of age.

In the Intervention group the weight gain was reported to be slower for both males and females for the first 6 months with a more marked improvement reported in the female infants weight than was reported for males infants after 6 months.

Critique: No definition of breastfeeding is recorded in the Smith et al. (2000) study. It could be possible that infants were also formula-fed especially in the Pre-intervention group, as methods of feeding are not noted. No definition of the nutritional advice is provided and no reports of what complementary solid foods were suggested or when solids were recommended to be introduced. The breastfeeding rate reported in this study was 95% of term infants being breastfed up to 6 months old and 85% were breastfed at

12 months. But was this exclusive breastfeeding or any breastfeeding? A very small number n = 43 infants participated in the Intervention group.

Breastfeeding and growth in South America

In a study on breastfeeding duration and growth on exclusively breastfed infants in Chile (Diaz et al. 1995), 1217 healthy women and their infants were selected. Infants who were term, healthy, and weighed between 2500 and 3850gms were chosen from a low-middle socio-economic status (SES) public hospital in Santiago.

Methods: The women were recruited in hospital and given verbal & written instructions to breastfed. They were given a calendar to document the number of suckling periods per 24hours. Follow up was after 1 week, at 3 weeks, one month and monthly until 6 months, then 1-2 monthly until 1 year. Specialised electronic scales were used to measure the weight. A Paediatrician and a research midwife recorded the medical history and breastfeeding management at each visit. Length was measured using an infant measuring board. The mothers were given food supplements in the form of rice and powdered milk in an effort to ensure adequate nutrition. Exclusive breastfeeding and avoiding all liquid or solid supplements for 6 months was advised. The first solids were suggested at 7 months with 2 meals commencing at 8 months. Adequate breastmilk was assessed on a weight increase of approx.20g/d in the first 6 months and 10g/d to 1 year as well as the mothers reporting of the infants' behaviour of satiation. Suckling was defined as a feed if it lasted for 15 -20 minutes and no suckling had occurred in the previous 30 minutes. All the weight and length measurements were compared to the WHO/NCHS growth chart as that was used then in Chile.

Results on growth

Of the 1217 subjects 48.4 % were females and 51.6% were males. 912 pairs completed the study to 1 year. Solids and milk supplements were not recommended for the infants

until 6 months. However only 63% of infants were fully breastfed at 6 months and only 24% were fully breastfed at 12 months. Therefore when the cohort was compared with the WHO/NCHS reference, the infants had mixed feeding practices with 37% receiving milk supplements at 6 months and 76% of infants at 12 months. Therefore when compared with the 50th percentile of the WHO/NCHS, these infants were showing adequate growth and the authors concluded that breastmilk for 6 months was adequate.

Critique: The results for growth are based on a comparison of infants with mixed feeding practices and not exclusively breastfed infants therefore the growth evaluation and recommendation is not accurate. It is commendable that an attempt was made to evaluate the breastfeeding management and it's relevance to growth.

Comparison of Diaz et al. 1995 and Smith et al. 2000.

When the Aboriginal study (Smith et al. 2000) is compared with the study in Chile (Diaz et al. 1995) both studies reported infant growth as comparable with the NCHS 50th percentile for the first 6 months because they both included results on infants with mixed feeding practices. The studies are similar in that the intervention was to give nutritional advice and support to breastfeeding women. Results are also similar, as infants who had mixed feeding practices (i.e. breastfed and formula-fed) were compared to the NCHS (Hamill et al. 1979) and included in the results. In the Pre-intervention group in the Smith et al. (2000) study, it is likely that infants had mixed feeding practices, as there is no record of exclusive breastfeeding.

Associations with a longer duration of breastfeeding (Diaz et al. 1995)

With multivariate analysis, there was a high association of breastfeeding for longer duration with more frequent suckling recordings ≥ 7 noted in the first month after birth. Maternal weight was also associated with breastfeeding for longer duration. Women who weighed 55kg or over had a lower risk of weaning. Infants' birth weight was also

associated with breastfeeding for longer duration- if an infant weighed >3.5kg they were less likely to be weaned. Boys' -being heavier at birth - were breastfed longer than girls were.

A comparison of the factors affecting breastmilk intake in the U.K. study (Paul et al. 1988) with the study in Chile (Diaz et al. 1995)

Both studies report that the gender and birth weight of the infant affected the number of breastfeeds. Boys drank more breastmilk than girls did possibly by the nature of their weight. Prior to the introduction of solids, the number of breastfeeds reported was higher in relation to the weight of the infant. The greater the volume of breastmilk ingested by the infant, the greater was the mothers' energy needs in the Cambridge study (Paul et al. 1988) and infant demand for breastmilk was a dominant factor. In the Diaz et al. (1995) study, mothers were heavier, breastfed for longer and were given food supplements, which may have helped maintain their energy needs. In the Cambridge study, boys were weaned before girls and Diaz et al. (1995) did not find this in their study, but boys were fed for longer, being heavier they demanded more breastfeeds/breastmilk.

It could be surmised from this that in developed countries, infant boys being heavier demand more breastmilk which depletes the mothers energy and leaves less time for household chores. Mothers in developed countries living in a nuclear family with little family support may wean earlier and return to work due to financial necessity. Paul et al. (1988) reported that the mothers gave 5 or 6 breastfeeds per day rather than breastfeed their infants to need. It could be speculated that if the Cambridge male infants had more access to the breast they too might have breastfed for a longer period of time as occurred in Chile - male infants who demanded more breastfeeds/breastmilk were fed for longer. In underdeveloped countries infants who demand less

breastmilk/breastfeeds, may be assumed ready to wean - in this study it was females- who are also lighter in weight. Poorer mothers in Chile possibly do not have access to cheap and safe formula feeding foods and devices, which may also encourage longer duration of breastfeeding.

Breastfed Australian infants' growth

In West Australia growth has been studied by a group of researchers in relation to the infants' feeding method (Hitchcock et al. 1981). The sample consisted of 104 males and 101 females randomly chosen from the State's Birth records and followed prospectively in the Community Child Health Services.

Methods: Subjects' chosen were second-generation Australian infants, but infants of Aboriginal ethnicity were excluded. Infants were full-term with normal pregnancy and delivery weighing 2500g or more at birth. Birth measurements were collected from hospital records and the infants were weighed at 6 weeks, 3, 6, 9, and 12 months using the national standards recommended for weighing at the time. The breastfeeding management - length and frequency -was recorded by the mothers as well as documentation of all food and drink taken by the infants for one week prior to the weight check.

Results: At 6 weeks, 83% of women were breastfeeding and this included 4% of infants who were receiving complements. By 6 months, 64% were breastfeeding and this included 8% drinking formula and by 12 months 25% were breastfed some of the time. Introduction of solids commenced at 6 weeks, 3 months and 6 months with 10%, 37% and 96% of parents respectively.

Growth comparisons with earlier Australian Studies

Hitchcock et al. (1981) compared the 1980 results with two other studies - one from 1933 almost fifty years previously and another from 1964. The researchers compared

the means of weight of the infants at the respective intervals to demonstrate a change in trend on growth, which they report, is the result of increased breastfeeding rates in their study. They found that birth weights were similar between all three groups. The means of weight are more closely related at the quarterly intervals in the 1980 and 1933 groups. More rapid weight gain was evident overall in the 1964 group and the researchers imply this is due to higher rates of women feeding their infants on cow's milk and sugar, as well as introducing solids earlier to infants.

Critique: Again infants with mixed feeding practices were included in the results. As the methodology of the other two studies is not recorded it cannot be concluded that the studies are comparable although interesting. Only one study for longer than 3 months (Shepherd et al. 1988) was available on the growth of Australian infants that is compared with the NCHS/WHO chart.

Summary of growth studies on breastfed infants.

In the above studies (Paul et al. 1988; Dewey et al. 1992; Dewey et al. 1995) it can be demonstrated from the results that those researchers who compared their data on fully breastfed infants with the NCHS/WHO chart, deviated from this chart and had a 'falling away' from the 50^{th} percentile from birth. However in those studies (Diaz et al. 1995; Smith et al. 2000) which included infants in their results with mixed feeding practices (i.e. breastfed and formula-fed), are compared with the NCHS/WHO chart, the infants continued to grow at the same rate as this chart. One possible reason for this is because the NCHS/WHO chart was originally based on predominantly formula-fed infants. Researchers who have reported that the outcomes of growth studies are conflicting (Lilburne et al. 1988), have perhaps not examined the methodology and realised this discrepancy when infants with mixed feeding practices are included in the results. It appears that male infants demand more breastmilk than females and this may

be related to their size and birth weight. The volume of breastmilk required by the infant is related to the breastfeeding mothers' weight and her energy needs and this in turn has an effect on the length of time the infant is breastfed. In those studies where feeds are recorded, infants who demand more breastfeeds/breastmilk are weaned earlier in the developed world but infants who demand more breastfeeds/ breastmilk are weaned later in the underdeveloped world. Given this and in the researchers clinical experience, it is congruent with more demanding breastfed infants who are frequently weaned earlier. Those studies (Diaz et al. 1995; Smith et al. 2000) who reported on breastfed infants and combined their results with formula-fed infants, stated that they found no significant difference between the NCHS (1977) reference and their breastfed group. It follows, that we cannot depend on any chart recommended for use to monitor infants, which is not based upon the clinical population for which it is intended.

Growth patterns of breastfed infants compared with formula-fed infants

From the USA - The DARLING study.

In the USA the DARLING Study (Dewey et al. 1992), researchers report that this was a study carried out on a group of very high socio-economic status women with infants who had very high birth weights. The purpose of this study was to use it to compare breastfed infants from an affluent society with infants from lower socio-economic status groups. The DARLING Study analysed many themes. These were the growth of infants who were breastfed and formula-fed, the measurements of skinfold thickness of these two groups and the effect on growth with the introduction of complementary foods. The latter of these three will be discussed later in this review.

Methods: 92 breastfed and 52 formula fed infants were recruited at one month old into the study. Criteria for the breastfeeding group were, to have the intention to breastfeed for 12 months and not offer more than 120mls of formula per day. Mothers, who did not

breastfeed and agreed to use the free Enfamil formula provided up to 12 months, constituted the formula-feeding groups' criteria. Neither group introduced solid foods prior to 4 months. Trained personnel recorded monthly measurements of weight and length at home visits. Due to the high birth weight of the infants in this study, the data was adjusted by weighting factors for every 250g difference between the sample and the NCHS reference, in order that a comparison could be made with the NCHS (Hamill et al.1977) reference.

Results: At 6 months, 60 breastfeeding subjects remained in the study and by 12 months there were 46 breastfeeding subjects. In the formula-fed group at 6 months there were 45 subjects remaining and 41 subjects at 12 months.

The researchers claim that using these adjusted means for weight, when they were compared to the NCHS reference, formula fed males were above the 50th percentile in the first year and breastfed boys were below this after the age of 8 months. These differences were not statistically significant at 6 months only at 12 months. Comparatively, female breastfed infants were below the 25th percentile by 12 months and formula-fed infants were above the 50th percentile. Difference in length was less noticeable by comparison between the two groups. The weight-for-length indices for breastfed males and females between 9 and 12 months showed the greatest variation in the breastfed group, which the authors claim, is suggestive that the breastfed infants were leaner than the formula-fed infants at the age of 1 year. The contrast in weight gain between the groups was more marked for breastfed females than for breastfed males.

Critique and implications: This group of researchers has been leading the rationale behind clinical practice for breastfeeding infants for the last decade. They concluded that the infants cannot be overfed on the breast and that they are leaner than formula-fed infants. It is not surprising that the researchers reported such outcomes. No record of the

breastfeeding management is noted. It is highly likely that the infants were regimented by 3 or 4 hourly feeding regimes and were not allowed free access to the breast i.e.- breastfed to need when the infant demanded feeding. If an infant is trained to feed every 3 or 4 hours from birth, it is most probable that such an infant has developed a smaller appetite than he/she would have if they had been breastfeed when they demanded food. Therefore it is not surprising that these infants ate less when they were offered solid foods because they had smaller appetites. Neither is there any reporting on how much formula this group of infants consumed at each feed per day. The numbers of infants in this study for the final analysis is small. Without any documentation on the method of breastfeeding management, this study needs to be replicated on a much larger sample to validate the assumptions reported. If a formula feeding mother noticed her infant was hungry, she may have offered more formula to her infant at the next feed. However unless mothers documented their breastfeeding management, we might assume that the breastfed infant was encouraged to go to sleep. Notwithstanding, if the formula-feeding mothers received free formula from Mead-Johnson Nutritional Group, they may be more likely to offer more formula if their infant was hungry. There may be a conflict of interest here due to the involvement of the formula company. Even though at the time the USA was not a signatory to the Joint 1989 Statement, we could ask is such a study ethical in view of the WHO / UNICEF agreement which recommends avoiding the promotion of breastmilk substitutes (WHO / UNICEF Statement 1989)? If mothers were provided with free formula, the researchers could confirm that the infants received appropriate food for the comparison of formula feeding infants in their study. The adjusted means continued to be calculated for each month of comparison throughout the first year and this further questions the credibility of this study.

In the USA Butte et al. (2000) contrasts some of these findings.

A more recent investigation on the affect of infant feeding habits on growth was carried out in a study of 40 breastfed and 36 formula-fed infants (Butte et al. 2000). Micronutrient body factors e.g. potassium, water, bone minerals and electrical conductivity were also analysed but only total body potassium (TBK will be used hereafter)) is discussed here within this context. TBK is a substance that can be easily measured in lean tissue therefore it was easier to detect a difference in the quality of weight gain between fat tissue and lean tissue which contains 99% of the TBK.

Methods for weighing infants were bare weights on electronic scales and length was measured lying down flat by two trained staff at the age of 2 weeks, 3,6,9,12, and 18months. Weight and length recordings were converted to z scores for comparison with the NCHS (1977) reference. Chest, arm, thigh and head circumference was recorded in addition to skinfold thicknesses of the triceps, subscapula, flank and quadriceps regions. TBK was measured in the research unit using dual-energy x-ray absortiometry (DXA) and the in vivo precision TBK measurement for infants and toddlers was used to minimise errors.

Infants were exclusively breastfed or formula-fed for the first 4 months after which time parents gave whatever food they wished. Parents used forms to record all foods being taken and documented the infant's feeding habits. Interviews were carried out at 3, 6, and 12 months in the first year and the frequency of breastfeeding was recorded, as well as amounts consumed of formula, milk, juice, solids, water and vitamin supplements.

Results: When both groups were compared with the NCHS (1977) reference, no statistically significant difference was noted for weight-for-age, length-for-age, or weight-for-length indices. The authors reported that 40% of *all infants* were given formula at 6 months; 48% at 9 months and 30% at 1 year. However cow's milk was

given to 80% of breastfed infants and 28% of formula fed infants at 9 months. By 1 year, cow's milk was given to 65% of breastfed and 67% of formula-fed infants. In the formula-fed group, there was no difference in body size after the introduction of solids or other milk when adjusted for sex of the infant. In the breastfed group after adjusting for sex of the infant, the age of commencing formula was associated with greater weight gains after 6 months. The rate of growth in the weight-for-length index was higher for formula-fed infants than for breastfed infants between 3 and 6 months and higher for formula-fed females than breastfed females between 6 and 9 months. By 1 year there was no difference in weight between the two groups. In this study the length of time that an infant was breastfed did not affect the growth of that infant - e.g. breastfed infants weight-for-length indices did not continue to decline the longer the infant was breastfed. This is in contrast with Dewey's pooled analysis (1995) or the DARLING study (1992), where the longer the infants were breastfed the more the weight-for-length indices continued to decline. TBK values were significantly lower in the breastfed than formula-fed group at all intervals throughout the study ($p = 0.04$). It was reported that this result surprised the researchers.

Critique: The extremely small numbers of breastfed infants in the final analysis of this study leaves the results open to scrutiny. The breastfed group had infants included in their final analysis who were also being formula-fed. Results are based on a final analysis of 100% breastfed at 3 months in the breastfed group ($n = 40$). By 6 months this had diminished to 80% still being breastfed ($n = 30$) therefore 20% were also receiving formula. By 9 months 58% were breastfed and only 38% ($n = 13$) at 1 year. Whether these infants in this study by Butte et al. (2000) had free access to the breast is not stated, even though amounts of food were measured it is not reported if women were advised or encouraged to breastfed continuously or if they scheduled breastfeeding. By

6 months 40% of *all infants* were being given formula and by 9 months 80% of breastfed infants and 28% of formula fed infants were receiving cow's milk. Certainly, if Dewey et al. in her studies (1995) and (1992) included only breastfed infants in her final analysis and Butte et al (2000) also included infants drinking formula, a different picture emerges. Butte reports here that formula affected the growth of breastfed infants notably that they gained more weight after 6 months when formula was introduced. It is understandable that if formula-fed infants were included in the final analysis with breastfed infants, no further decline in weight would be seen. The significantly lower TBK values reported in the breastfed rather than the formula-fed group throughout the study may have surprised the researchers but is suggestive of more weight gain due to fat mass than lean mass. Not surprisingly this may possibly be due to the fact that 80% of these infants were drinking cow's milk at 9 months and formula at 6 months. The authors thank Ross Laboratories for their formula donations in the acknowledgements!

The growth patterns of breastfed and formula-fed infants in Europe

A total of 138 infants in an Italian study (Agostoni et al. 1999) were compared to the NCHS/WHO reference data - 73 infants were fully breastfed, 36 males and 37 females and 65 were formula-fed - 35 males and 30 females. Criteria for inclusion in the breastfed group were normal, healthy, term infants weighing 2500g or over with healthy mothers. Infants were required to be fully breastfed and received no solid foods for the first 4 months of life.

Methods: The infants were measured bi-monthly for the first 6 months and thereafter every three months up to one year. Documentation was recorded on the length of time that infants were breastfed (although it is not clearly stated how this was done), the use of complementary formula and the infants' age when solids were introduced.

The formula-fed group was given the European standard formula and solid foods were commenced at 5 months. The mothers were given advice on the appropriate foods to introduce to the infants at the relevant age. The women were interviewed to evaluate if they had adhered to the advice that they were given. Bare weight and length was collected by two specially trained staff, monthly for 4 months, then at 6, 9 and 12 months. The study design necessitated 64 subjects in each group.

Results: Weight-for-age (WA); Length-for-age(LA); Weight-for-length(WL) indices were calculated, using the National Centre for Health Statistics – WHO data. Two groups were designated for analyses that were breastfed. - One group of 12 infants who were exclusively breastfed for 1 year and another group of 55 infants who were breastfed for 4 to 11 months. Both of the breastfed groups had higher growth indices in the first 3 months. Between 6 and 12 months, growth indices were lower for the breastfed group and higher for the formula-fed group. The formula-fed group had higher growth indices from 1 to 6 months overall and this group also demonstrated higher indices- though not statistically significant differences - for WA, LA & WL when they were compared with the both breastfeeding groups at the end of the first year.

Critique: 12 infants who were exclusively breastfed for 12 months and 31 infants in the combined breastfeeding group were compared at 9 months. Therefore after 6 months some of these results are based on infants who had mixed feeding practices i.e. were breastfed with formula complements. Three groups were identified for analysis - infants who were exclusively breastfed for 12 months, infants who were breastfed with complements of formula from 4 -11 months and formula-fed infants. The authors conclude that when the breastfed infants were compared with the WHO reference, that breastfed Italian infants do not slow down in growth at the end of the first year, as much as North American/European infants and this may be genetic or due to ethnicity.

However, it is more likely that their results may be due to very small numbers of exclusively breastfed infants in their analysis, in addition to the inclusion of infants who were also drinking formula in the final analysis.

Comparing the studies on infants' growth from the UK Cambridge, from the USA and from Italy in relation to feeding methods practised.

Dewey et al. (1992) and Paul et al. (1988) found a downward trend in breastfed infants' weight at the age of 1 year when they compared their subjects with the NCHS reference (Hamill et al. 1977). Both found this trend more evident in female infants' weight than in males. Neither of the studies reported on the breastfeeding management engaged in by the mothers and it appears that infants were breastfed on a 4 hourly regime. Hence it is probable, that this is the reason why their results are similar. When researchers in the Agostoni et al. (1999) study recorded the breastfeeding management and included infants with mixed feeding practices in the final analysis, they found that there was no significant difference at the end of the first year between Italian infants growth when compared with the NCHS (1977) reference. One possible reason for this result is that the comparison is similar to the basis of the NCHS (1977) chart that was based on mainly formula-fed infants. When breastfed and formula-fed infants were compared by Agostoni et al. (1999), researchers found that between 6 and 12 months, growth indices were lower for the breastfed group and higher for the formula-fed group similar to Dewey et al. (1992). In both of these studies, overall, formula fed infants had higher growth indices in the first 6 months though not statistically significant differences. Agostoni et al (1999) demonstrated higher indices in WA, LA & WL for formula-fed infants when compared with breastfeeding infants at the end of the first year. However Dewey et al. (1992) recorded statistically significant differences in weight-for-length

indices only, at the end of the first year. This could be due to the methodology calculated on adjusted means by Dewey et al. (1992). Neither study recorded nor monitored the amount of formula that the infants drank, per day. Perhaps the formula-fed infants were fed to appetite need every 4 hours and possibly breastfed infants were also fed every 4 hours (Paul et al. 1988) which is not conducive to the breastfeeding infant. The implications being that formula-fed infants received more kcals than the breastfed infants received. In the DARLING study Dewey et al. (1992) reported that the weight-for-length indices dropped dramatically in the second half of the first year for breastfed infants when compared with formula-fed infants. Dewey et al (1995) in the pooled analysis on Caucasian infants also reported this decline in growth for breastfed infants when compared with the NCHS reference. Similar methodology was present for both studies and no record was reported of the breastfeeding management. The implication here is that if the breastfed infants had more frequent access to the breast for breastfeeding then the decline in weight could be less noticeable.

Infant feeding recommendations in Australia

It is pertinent at this point to provide some information on the dietary guidelines that were suggested for infant feeding during the period in which some of the following research was carried out. In the 1980's the use of cow's milk for feeding infants was common practice. - Advice in *Our Babies* (Department of Health 1983) was to recommend to parents that infants be fed on suitable breastmilk substitutes which had been modified. For example, from one month to three months, the recipe was, - 120mls of fresh cow's milk, add 2½ teaspoons of lactose and 60mls of water to make up 180mls of suitable milk for the infant (Dept. of Health 1983, p.43). The total volume suggested, for any breastmilk substitute, was approximately 720mLs to 1125mLs between 3 and 4

months of age (Dept. of Health 1983, p. 45). In the researcher's clinical practice in western Sydney for the next five years it was very common for mothers to feed infants on modified cows milk and sugar. Research into iron deficiency anaemia from this practice of feeding infants led to the revised guidelines which recommended that cow's milk should not be given as a main drink before the age of 9 months and preferably not until 12 months (NSW Department of Health 1989). Breastfeeding or infant formula was subsequently recommended to be given as the main food for infant feeding for the first 12 months (NHMRC 1989). Studies subsequently carried out in Australia (Karr et al. 2001) and Europe (Male et al. 2001) have demonstrated that iron deficiency anaemia is still common among infants who have been fed by this method. This move away from modified cows' milk has led to a rise in the sale of infant formulas, from which the advertising of these products has a potential to undermine women's confidence to breastfeed.

Breastfed infants' growth compared with formula fed infants in Australia.

An Australian study compared the growth of 394 infants who were categorised into groups according to their feeding mode (Hitchcock et al. 1985). This study was an attempt to define some separate categories for infant growth in relation to their feeding practices, which had previously been ignored. These five groups were A = formula fed, B = breastfed for less than 3 months, C = partial breastfed for 6 months, D = exclusive breastfed on demand for 6 months and E = partial breastfeeding for 12 months. This was a prospective study on infant feeding practices, nutrition and growth on infants from 12 metropolitan Child Health Centres in Perth and 6 rural regions of Western Australia. Only those infants who had feeding methods recorded, were bare weighed at 3,6,9 and 12 months and their data was classified according to five specified feeding

groups. Formula-fed infants were fed on low solute formula and more than half of this group also took small amounts of solids by the age of 3 months. By 6 to 9 months of age this group began replacing formula with cow's milk, which it was observed, was introduced earlier to infants who began formula feeding.

Results are based on weight gain only but in separate groups for males and females and this was a novel approach at the time - to separate the sexes to view their growth patterns. In each of the feeding categories males gained more weight than females in the first 3 months with an average weight gain of 2.5kg regardless of feeding mode. Weight gain between 3 months and 6 months demonstrated that exclusively breastfed infants up to 6 months (or longer than 6 months) gained less weight than formula fed infants for both sexes. Between 3 - 6 months there is very little difference in the weight gain between the breastfed males and females during this time period in Hitchcock's study. Breastfed males gained an average of 1.63kg between 3 and 6 months and females gained the equivalent amount of weight. The infants in Hitchcock's study who were breastfed for 6 months or longer, gained less weight than the infants who had been fed on formula from birth or from 3 months onwards. It is regrettable that these infants were only compared to one another and not to any standard. However in both the Hitchcock et al. (1985) and Dewey et al. pooled analysis (1995) studies', researchers found that the longer infants were breastfed the more slowly they gained weight when compared to the NCHS/WHO reference or a formula fed group of infants. Since the NCHS 1977 reference is based primarily on formula fed infants both of these studies are comparable in their results, in that NCHS reference and formula fed infants are synonymous, meaning essentially the same comparison. Exclusively breastfed infants in the Australian study were reported as being fed according to appetite need (on demand) and when compared to the pooled analysis of Dewey et al. (1995) where the breastfeeding

management is not reported, the breastfed infants showed similar growth patterns. It could be concluded then, that breastfed infants weight gain slows down in the second half of the first year of life.

Body composition of breastfed compared with formula-fed infants.

In order to find out more about the differences in growth between these two feeding groups an Australian study was carried out on infants in the first 3 months of life to provide a more scientific basis for recommending low solute whey dominant formula (Shepherd et al. 1988). The aim of the study was to provide more evidence to describe the need for re-evaluating the energy requirements of very young babies. Out of 107 subjects enlisted, the final analysis was carried out on 34 fully breastfeeding and 48 formula feeding women and their infants.

Method: Two groups were established according to feeding method - fully breastfed infants and the formula fed infants who were provided with Nestle's NAN whey-dominant formula who also funded the research. TBK can be easily measured in lean tissue and was used to detect a difference in the weight gain between fat tissue and lean tissue, which contains 99% of the TBK. Variables of interest analysed were - mothers' age and education, family size, weight, length, and triceps skinfold thickness at 10 days and 90 days. Further follow up was approximately at 28, 42 and 56 days. The feeding regime for all infants was to be fed freely to meet their needs and no solids foods were given. One of three trained researchers recorded the measurements consistently. The weight and length as well as circumferences of the head, chest, arm, thigh, calf and the skinfold thickness of the triceps and subscapular regions were recorded. Mothers kept a diet diary after they received education and a history was taken on formula making procedures. Body composition was measured from the TBK found in lean body mass,

on standard laboratory equipment used for this purpose. A student *t test* or paired *t tests* were used for statistical analysis.

Results: For growth, both groups overall followed the NCHS 50th percentile in weight and length. No significant difference was evident in weight, length or skinfold thickness between the breastfed group and the formula-fed group when compared to the standard reference. Comparison between the groups for weight gain revealed that in the first 10 days, breastfed infants gained significantly more weight than formula-fed infants did. There was no significant difference in skinfold thickness and total body fat at 10 days old between the 2 groups. In both groups between 10 to 90 days, males gained more weight overall than females. The TBK values overall increased with age for both groups but were higher in males than females. The TBK/weight ratio decreased with age for both sexes, which suggested that, the percent of lean body mass decreased with age. Approximately 90% of body mass was lean tissue at 10 days and this fell to 70% at 90 days for both feeding groups. By 90 days the formula-fed group, both males and females, were similar in body composition - both had 69% lean tissue and 31% fat tissue. In the breastfed group, females had less lean mass and more fat mass than their formula-fed female counterparts. Males in this group had more lean mass and less fat mass than their formula-fed male counterparts. From these results the researchers conclude that normal growth and body composition was evident in the formula fed infants in this study. However it was noticed that the formula-fed infants drank less formula during this time period, than the recommended WHO/FAO 1973 guidelines which were indicated at the time of the study. The authors conclude that this study indicated further research and re-evaluation on lowering of the Recommended Daily Allowance and Recommended Daily Intake for infants.

Critique: Because the formula-fed infants compared favourably with the breastfed infants in this study for growth and body composition, the researchers consider this a reasonable conclusion. The diet diary and liberal breastfeeding are good points for assessment but three months is a very short time period to draw these conclusions. There was a tendency for formula-fed infants to gain more weight between one and three months and the formula-fed males had greater weight gains that were found to be due to increased body fat. This is camouflaged by inconsistent results which can been seen above in the TBK values which are opposite for males and females in the breastfed group. It could be surmised that Nestle wished to promote the idea that their formula was as good as breastfeeding and by reporting that the growth and body composition was comparable between the two groups, this gave the multinational company the evidence they required for advertising this product.

TBK results - a comparison between the study from Australia and the USA.

The significantly lower TBK values reported throughout the USA study by Butte et al. (2000) in the breastfed group rather than the formula-fed group is suggestive of more weight gain due to fat mass than lean mass. This may be due to the fact that 80% of these infants were drinking cow's milk at 9 months and formula at 6 months.

The Australian study is only comparable for the first 3 months. In Australia, Shepherd et al. (1988) found that the TBK values overall increased with age for both groups but were higher in males than females. At 3 months in the breastfed group, females had less lean mass and more fat mass than their formula-fed counterparts. Males in this group had more lean mass and less fat mass than their formula-fed counterparts. Only the females had similar results in both of these studies at the age of three months. Formula companies funded both studies. Further independent research without funding from a

formula company using a larger sample of subjects for a longer period of time is required to draw any extensive conclusions.

Summary of growth on breastfed compared with formula-fed infants

Statistical evidence exists to demonstrate a difference between the weight of breastfed infants and formula-fed infants at the age of 12 months (Hitchcock et al. 1985; Dewey et al. 1992). A difference in length between these two groups is more difficult to demonstrate. However some studies have also included infants who drank formula (Agostoni et al. 1999; Butte et al. 2000). If breastfed infants were lighter than formula-fed infants at 1 year, a likely reason for this may be due to regimented scheduled four hourly breastfeeds (i.e. the result of the breastfeeding management). When the breastfeeding management was recorded as given to the appetite needs of the infant (Hitchcock et al. 1985), the weight gain between 3 months and 6 months demonstrated that exclusively breastfed infants up to 6 months (or longer) gained less weight than formula-fed infants. However the formula-fed infants may have been overfed and/or fed on cows' milk with sugar thereby adding extra kcal.

In contrast with Dewey's pooled analysis (1995) or the DARLING study (1992), where the longer the infants were breastfed the more the weight-for-length indices continued to decline, in the USA Butte et al. (2000) presents different findings. When Butte et al. (2000) compared breastfed and formula fed groups with the NCHS (1977) reference, no statistically significant difference was noted for weight-for-age, length-for-age, or weight-for-length indices. However Butte (2000) reports that 40% of *all infants* were being given formula at 6 months; 48% at 9 months and 30% at 1 year. Not only were comparisons made on infants in the breastfed groups who also drank formula, (Agostoni et al. 1999; Butte et al. 2000) but Dewey's breastfed infants were also very likely to have been breastfed to a schedule / regime of 4 hourly feeds. Therefore it is not

surprising that results are significantly different. In the two studies on TBK (Shepherd et al. 1988; Butte et al. 2000) only the females had similar results in both of these studies at the age of three months. Further research is also required on TBK in Australia for longer than 3 months with independent funding. Shepherd (1988) noticed that the formula-fed infants drank less formula during the study period, than the guidelines recommended at the time. The authors concluded that further research and re-evaluation was required on lowering the Recommended Daily Allowance/ Recommended Daily Intake (RDA / RDI) for infants. The implications here are, that formula-fed infants have a potential to be over fed and breastfed infants may not be fed frequently enough to meet their needs. Therefore when compared with one another, they obviously demonstrate different growth patterns.

Infant feeding methods and socio-economic status (SES) in Australia

There had been speculation that breastfed infants are leaner than formula-fed infants due to over feeding with formula by women who come from a lower SES group. Hitchcock and Coy (1989) looked at a larger group of infants from a joint survey carried out in Western Australia and Tasmania in 1984 -1985 and analysed growth data in relation to feeding practice and social group. Both states evaluated their infant feeding methods and growth at five yearly intervals and the results provided data with which to report on change occurring over a 30 year period (Hitchcock & Coy 1989).

Methods: The design of the study from Western Australia was a retrospective survey of attendance of women and infants at Child Health Centres during 1984; the regions chosen were metropolitan Perth and rural areas. Infant Welfare nurses in each clinic were notified before the survey began to accurately record data for a 12 month period by bare weighing all infants and measuring their length lying flat. Infants who subsequently became ill, died or were transferred were omitted from the final analysis.

Once the infants reached the age of one year, the data was collected from the infants' health record by the researchers and entered onto a survey form.

In Tasmania all regions with Child Health Centres participated in the survey and the Infant Welfare nurses documented all the necessary information on to the survey form. Social data on the family, method of infants' feeding and growth measurements at birth, 6 weeks, 3 months, 6 months, 9 months and 1 year were recorded. The data from 694 males and 677 females were coded for the final analysis using the Statistical Program for the Social Sciences which was carried out in Western Australia. The social group categorisation was based on the fathers' education alone and this was based on an Australian tool made by Congalton in 1969 (Hitchcock & Coy 1988). Four groups were identified which ranged from Group A - professional and academic- to Group D - unskilled. Four feeding groups were identified in order to compare breastfed infants with formula fed infants -

Group 1 - infants who were formula fed from birth to 6 months and then fed on cows milk. Group 2 - infants briefly breastfed then formula fed. Group 3 - infants who were partially breastfed to 6 months, 70% of this group was fully breastfed on demand to 3 months and the remaining 30% were eating solid food from 3 months. Group 4 - infants who were partially breastfed to 1 year. They too were fully breastfed for 3 months and thereafter had a variety of food sources in addition to breastmilk.

Results: The results demonstrated a return to breastfeeding with infants gaining weight less rapidly than the previous 10year period. Over 90% of infants had two parent families and most were Australian born. In both states women who breastfed were ranked as being from higher SES group even though this was based on the fathers education and not directly related to the women themselves. Analysis of growth and infant feeding practices demonstrated that infants who were formula fed from birth or

breastfed for less than 3 months gained significantly more weight ($p < 0.05$) in the first year of life than those infants who were breastfed up to 6 months or up to 1 year. Most of this weight gain was evident after the age of 3 months. The greatest variation was evident between formula fed infants and fully breastfed infants in the first year of life. There was no correlation between a significant difference in weight gain and social group. The only correlation evident was weight gain in relation to infants' feeding practice ($p<0.05$).

Critique: The researchers concluded that their results were linked to the fact that women who breastfed were from higher SES groups and infants from lower SES groups had greater weight gains because they were fed on formula. Future breastfeeding research on socio-economic status (SES) should relate to the education level of the mother rather than the father. For example, reporting if the mother had finished school after her High School Certificate, School Certificate, or if she had participated only in a Life Skills program or completed tertiary education. Perhaps if a focus group had been conducted with health professionals from the Child Health Clinics in Western Australia and Tasmania, these states might find that health professionals were advising women how to reconstitute cow's milk with sugar as the researcher did during the same era.

Changes in socio-economic status and breastfeeding

It is not surprising that in a more recent study done in the U.K. a different story is emerging (Earle 2002). In contrast to Hitchcock and Coy (1989), Earle (2002) performed a health promotion research activity to find out what factors were linked to the initiation and duration of breastfeeding. The study aim was to explore women's personal decision to breastfeed. The research method used by Earle (2002) was a qualitative, prospective design study, on 19 primigravid women, using three interviews. The first interview took place between 6 - 14 weeks' gestation, the second between 34 -

39 weeks gestation and the third interview took place postnatally between 6 - 14 weeks after delivery of the infant. The ages of the women ranged from 16 to 30 years and included employed and unemployed women as well as women not seeking work. The occupations of those who were employed varied from professionals, managers, clerical assistants, waitresses, to manual workers and factory assembly workers. Open-ended questions on specific research themes were given to subjects to discuss their own perceptions and experiences. Analysis used was grounded theory. This is a method where theoretical development emerges from consistently modifying the data collected.

Results: Earle (2002) found no correlation between the decision to breastfeed /breastfeeding and socio-economic status (SES). Women in her study were just as likely to breastfeed regardless of their social class. The researcher concluded that while it may be reasonable to suspect that social class is correlated to higher rates of breastfeeding this was not the case and that there was a lack of statistical data to support her conclusion. Earle (2002) reported that a desire to share the parenting responsibility with the infant's father or a significant other, was more likely to affect the mothers' decision to breastfeed. The implications here could lead to a conclusion that further research is required with new SES guidelines to establish how / why women decide to breastfeed. SES guidelines should be made applicable to the breastfeeding woman rather than her partner.

Summary on SES groups and infant feeding practice.

In Australia any guidelines that are used to indicate occupational status should be made applicable to the breastfeeding woman rather than her partner. Further research is required with new SES guidelines for Australia to establish which SES groups now choose to breastfeed or formula feed.

Introducing solids

There is variability on the age of commencing solid food to infants as already discussed. In Australia the age recommended in 1989 for the introduction of solids foods to infants was between 4 and 6 months of age (NHMRC 1989).

There was disagreement among researchers whether solid foods given early results in greater weight gain - only observational studies have reported obesity. Commercial food is reported to be low in calories and protein compared with home cooked food (Mehta et al. 1998). Two studies are discussed here - one on solids in relation to formula-fed infants and one on solids in relation to breastfed infants.

Solids introduction and formula-fed infants

A randomised trial to establish if starting solid foods earlier or later affected growth in infancy was carried out in the USA (Mehta et al. 1998). Analysis was performed on infant growth and body composition to examine if there was any affect from using commercially manufactured infant foods as opposed to home cooking, on the infants' growth.

Methods: 165 Caucasian infants were randomly assigned to 4 groups -

1. Parents were advised to give only manufactured foods at 3 months (early)
2. Parents in this group were only to give manufactured foods at 6 months (late)
3. A choice of infants food to be given at 3 months (early).
4. A choice of food to be given at 6 months (late).

All the infants were formula-fed after randomisation at 3 months. Variables to be analysed included the education level and ethnicity of the parents. Two hypotheses were tested - (i) Infants commencing on solids at 3 - 4 months will produce more fat by 1 year old compared with infants who commenced taking solids at 6 months. (ii)Infants who ate only manufactured foods will have lower fat and protein consumption than

infants who ate home cooked foods but there will be no difference in the total energy consumption and fat mass between the 2 groups.

Weight, length and head circumference measurements were recorded at visits to the research unit at 3, 6, 9 and 12 months. Growth and body composition (fat and lean mass) was analysed by the use of dual energy x-ray absorptiometry. Parents documented a 3-day diet diary before each visit following instructions on how to record all food intakes. Foods and liquids were measured by parents and estimated for their energy content by a dietician. Verbal and written instructions were given to parents on how to record the infants' food intake in the diet diary.

Analysis of growth measurements between groups was estimated by using two-way ANOVA and t-tests. Food intake was analysed by multiple regression analysis using 3 months as a baseline to measure the difference between the groups.

Results: The results are based on 36 subjects who completed the study up to 1 year for group 1, 40 in group 2, 35 in group 3 and 36 in group 4. When the groups were compared, no significant difference in growth (weight gain, growth in length or head circumference) was found between infants who were given solid foods early or later. There was also no difference between the groups, in growth or total energy intake, of infants who were fed on manufactured or home cooked foods. At 6 months infants who had been on solid foods early, got more calories from solids, than the later group, and this was evident in both the manufactured and home cooked group. The conclusion reached by the researchers was that starting solids early in infancy does not change the pattern of infant growth in the first 12 months. This study concluded that the early consumption of solids replaces the energy that would be provided by formula. Therefore infants do not eat more food but self-regulate amounts of food consumed.

Previous non-randomised behavioural studies may not have controlled for such variables as socio-economic status, ethnicity and education level.

Critique: "Choice of food" may possibly mean home cooked, but this was not clarified. It was inadequately reported if fresh food was used. Was any advice given to the parents in this group on the choice of solid foods apart from how to record the diet in the diary? A clear explanation is not given on how the researchers actually measured differences in intake to draw a conclusion that solids foods displace formula (liquids) in the diet. The Gerber Infant Nutrition Company partly funded this research which may have a potential to create a conflict of interest in the reporting on the results of this study. The value of this study lies in the randomisation and variables analysed.

Solids introduction and breastfed infants

A similar study on the intake and growth of older infants who were fed on breastmilk was carried out in 1989 (Stuff & Nichols 1989). The aim of the study was to examine the growth of breastfed infants after the early introduction of solids to find out if it would minimise the appearance of growth faltering. The study design was by weekly measurements of growth on infants between birth and 9 months and monthly recordings of food intake between 4 months and 6 months. 58 city dwelling mother-infant pairs were enrolled and 45 pairs were included in the final analysis.

Methodology consisted of weight and recumbent length measured weekly for 2 months then second weekly for 3-4 months and weekly to 6 months which in total was for 10 weeks after the infants started eating solid foods. All of the infants were fully breastfed and a record of solid foods was documented on a monthly basis for 10 weeks after the starting date. Throughout the study, a lactation consultant gave advice on breastfeeding management - mothers were advised to offer solids after a breastfeed and to continue breastfeeding. Mothers could decide when to commence solids and what foods to offer.

Infants were breastfed in response to a desire to suckle and the infants' behaviour dictated the need to feed not a planned regime or schedule. Bare weight was recorded on electronic scales and length was measured lying flat.

Food consumption was estimated by test-weighing for five 24 hour periods. The mother performed this task at home to estimate the volume of breastmilk. The energy intake was measured from expressed breastmilk and the volume of breastmilk was established after test-weighing. Laboratory personnel weighed solid food before and after meals. The researchers provided all solid food consumed by the infants, which came from a commercial manufacturer.

Results: Infants were grouped into three categories according to the timing of introduction to solids. Group 1 was fully breastfed for 4 months, group 2 was fully breastfed for 5 months and group 3 was fully breastfed for 6 months after this period the diet was noted.

Breastmilk: Before solids were begun all infants drank similar amounts of breastmilk, but males drank more than females. After solids commenced the amount of breastmilk consumed each month decreased significantly. There was no difference in the decline of breastmilk ingested between infants who began eating solids early or later - all infants continued to drink similar amounts of breastmilk. There was also no significant difference in a decline in the number of breastfeeds that infants took whether they ate solids early or later. The number of breastfeeds decreased by 0.5/month after commencing on solid foods.

Growth: The weight of male infants when compared to the NCHS (1977) remained equivalent to the 50^{th} percentile until 6 months thereafter appearing to decline up to 8 months which was the end of this study. Female infants also had this pattern of growth up to 6 months after which time they dropped below the 50^{th} percentile between 6 and 8

months. Weight for length percentiles were above the 50th percentile between 2 and 3 months and by 6 months this remained around the 50th percentile. When the means of weight and length of the 3 groups of infants were compared with the NCHS (1977) reference, a similar pattern emerged for the 3 groups. Between birth and 9 months females were heavier than males in the first 2 months and lighter from 6 to 8 months. Therefore the introduction of solid foods early to infants did not minimise the decline in growth of breastfed infants. Energy consumption remained static after solids were commenced even though infants had free access to breastfeeding, the weight for age percentiles decreased.

Critique: Test-weighing is a less than ideal method with which to measure breastmilk intake. This is due to the potential to interfere with the milk-ejection reflex under adverse conditions that may lower the mothers' breastmilk supply (Royal College of Midwives 1991). The value of this study lies in the fact that infants had free access to breastfeeding.

Summary of the influence of introducing solids to infants

Mehta et al. (1998) reached the conclusion that starting solids early in infancy does not change the pattern of growth in formula-fed infants during the first 12 months. The study demonstrated that the early consumption of solids replaces the energy that would be provided by formula. Therefore infants do not eat more food but self-regulate amounts of food consumed. Similarly with breastfed infants (Stuff & Nichols 1989), after solids commenced the amount of breastmilk consumed each month decreased significantly regardless of starting solids early or later. In relation to the breastfed infant's growth, the introduction of solid foods early did not minimise the decline in growth of the breastfed infants. After solids were commenced even though infants had

free access to breastfeeding, the infants did not increase their energy intake but self regulated by consuming the same amount.

It is clear that infant's weight generally is not affected by the introduction of solid foods.

Weaning practices - the influence of reconstituted formula on growth

Overfeeding and inaccuracies in the reconstitution of formula will lead to extra kcals being given to formula fed infants (Bennett & Gibson 1990; Lilburne et al.1988; Fein & Falci 1999). Does this have an effect on growth?

Infant formula reconstitution practices in Australia

Lilburne et al. (1988) state that there is no clear evidence between obesity and bottle-fed infants and this is regardless of how the research is carried out i.e. weight gains or skinfold thickness being measured. However she does not report that methodologies used in the research were vastly different, - the DARLING study used z scores and the Euro-Growth Study used BMI for analysing their results. Her main findings were the mistakes made in reconstituting formula, and bacteria present in the bottle. The study was a survey to find out where parents look for advice on feeding their infants and the factors that influence the method of feeding chosen.

Methods: 274 mothers were surveyed at Child Health Clinics when their infants were under the age of 7 months old. She reports that 223 of these women were from working class areas in central Sydney but it is not stated what this fact was based upon. The remaining 51 women were chosen from the North Shore which is considered to be middle class, again it is not stated what status stratification this was based upon. The survey had 52 questions about breastfeeding, the reasons chosen for formula feeding, how they 'made-up' the formula and how they sterilised bottles.

Mothers were asked who provided the advice about introducing their infants to solids. Any parent who had a bottle of reconstituted formula with them was asked to give a sample of this for laboratory testing. The infants' triceps skinfold thickness was also measured and the comparisons were measured using the Statistical package for the Social Sciences.

Results: there was no correlation between social class and re-constituting of infant formula. 13% of the mothers prepared over-concentrated formula. 21% used the microwave for heating the formula. 14% used boiling water to make up the formula (this destroys Vitamins) and 48% received their knowledge & education from the instructions on the can. 22% learned from the Hospital; 14% from the Child Health nurse; 9% from relatives & friends and 2 % from the family doctor. 36% of the mothers in the study changed brands of formula at least once in the first 7 months. 30% of mothers had made errors in making up the formula. The most influential source was not noted. 82% of mothers who attempted breastfeeding, weaned at the end of one month.

Fatness: There was no statistical significant association between the skinfold thickness of the infants and the early introduction of solid food or over-concentration of formula.

Solids: Out of 145 participants, 108 had started solids by the age of 4 months. 21% of mothers put cereal in the bottle and 29% of infants had eaten other foods regularly by 4 months.

The researchers concluded that the mothers reported they frequently made up over-concentrated formula and this was clearly evident by the laboratory test results performed on the milk samples they provided. The samples had higher osmolalities than the manufacturer's recommendations. Reconstitution of formula varied greatly between the samples collected, the researchers hospital diet kitchen, the manufacturers and even

between different batches of the same brand. In fact the recommended scoop was more inaccurate than weighing the powder separately.

Critique: One measurement of the skinfold thickness alone may not be an adequate assessment to find out if the infants had a tendency to become obese at a later stage in childhood. The duration of the study is not noted nor was it stated if further research would be carried out on these infants for growth evaluation in the long-term. This research needs replication longitudinally. The study has value to assist in the recognition that formula reconstitution is frequently inaccurate and laboratory testing showed the inaccuracies. There are implications for any Australian national growth surveys that may be performed which included this population of infants, as it would be based on a mixture of infants who are not necessarily being fed according to the NHMRC guidelines in Australia.

A survey on formula preparation in Adelaide

In South Australia another survey was carried out to establish the concentration level present in bottles of formula that were intended to feed infants, which had been prepared by caregivers (Bennett & Gibson 1990). The study aim was to examine the range of inaccuracies in reconstituted infant formula and to find out how parents/caregivers make up this formula.

Methods: 109 parent/caregivers were recruited from clinics and shopping centres in Adelaide, that met the criteria for formula feeding and who could also provide a sample of 5-10mLs of their reconstituted formula. A questionnaire was used to gain the following information- the brand of formula being used, who made it up, who taught the person the method of reconstitution and which method of reconstitution had the strongest influence. Variables included were the infant's age, number of children in the family, the occupation and education level of the person making up the formula.

Feasibility had been tested by a pilot study. The samples of formula were freeze-dried and weighed for residual solids to find out their concentration levels. The residual solids levels were then compared with the levels obtained from accurately reconstituted formula, which was prepared according to the manufacturers instructions.

Results: 88% were mothers who reconstituted the formula and 44% had education levels to the end of high school. Only 9% had third level education. Out of 105 subjects, 96% reported following the instructions on the label of the can and this was rated as having the strongest influence on formula making preparation. The two main brands - S26 and Nan - from Wyeth and Nestlé food corporations respectively were the most popular formulas used.

Accuracy: The analysed samples had a range of accuracy between 67-153%. The key finding was an over-concentration of formula preparation and this was more common among the less educated mothers. The researchers conclude that scoops of powder have limited accuracy and pre-packed ready-to-feed formulas are preferable.

Critique and implications for breastfed infants

The authors did not note the correct preparation of formula. Nan reconstitution is 1 scoop of powder to 30mls of water; S26 is 1 scoop to 60mls of water and Karicare is 1 scoop to 50mls of water, it is not surprising that mothers are confused. To standardise one scoop for all powders may help to regulate this practice. Corporate food manufacturers are likely to charge a lot more for pre-packed formula. Given that only 10 subjects had tertiary qualifications the results may be biased. However if the lower SES groups are more likely to use formula, they will also pay more for this product. Given that the risks of hypernatremia from feeding infants with high solute loads have been documented for more than 20 years (Paneth 1980) it is surprising that this practice continues. It could be surmised that the instructions on the can might also be biased to

selling more formula and tending to be over-concentrated even when made up according to the instructions on the label. An opportunity exists to market new products to young and vulnerable mothers. We need to examine the advertising schemes. Are the recommended RDA/RDI's on the can excessive and do they require evaluation?

The implication again, of over feeding, is that any national survey performed in Australia will have a percentage of infants who may be over fed. If 96% of parents/carers follow the instructions on the label of the can (and this was rated as having the strongest influence on formula making preparation), if the RDA/RDI is excessive, then any growth chart derived from this population would not be suitable for comparing the breastfed infant. Notwithstanding that any partially breastfed infant who also consumes formula will be consuming unnecessary kcals which has consequences for the long-term breastfeeding process.

Infant formula reconstituting practices in the USA

Researchers looked at the data retrieved from a national longitudinal survey of infant feeding practices on over 1,000 subjects who had infants under 1 year of age (Fein & Falci 1999). One of the aims of the study was to examine the compliance with reconstituting formula by mothers and to find out if this was related to instructions given by a health professional.

Methods: Mothers had filled in a self-reported questionnaire on formula making preparation from their recall over the past month. The subjects were not nationally representative but were mainly white, married, had higher education and were from higher SES groups.

Results: 90% of mothers reported that they had used formula in the first year of the baby's life. 80% of mothers, who mainly formula-fed commenced prior to 2 months old, only 20% commenced formula after this age. By the age of 2 months 21% of mothers

had been given advice on formula making preparation by a health professional and by 7 months this increased to 35%. In the USA, ready-to-feed, liquid concentrate and powder formulas are all available with powder being the most common form used. By the time the infants were 2 months old, 20% of mothers reported that they were diluting formula. This practice ranged for a period of time from 4 days with younger infants to every feed for infants over 5 months old. Some of the reasons given for dilution were constipation, congestion, possetting (spitting-up) and controlling the infants' weight, to making the infants hungry, the cost of formula and starting solids. The reasons given for deliberately feeding infants on over-concentrated formula were - to make the infants sleep through the night, to thicken the formula, make infants grow, possetting and difficulty reconstituting formula. The time period for this practice was similar to that for diluting formula. 35% of mothers reported adding food to bottles of which infant cereal was the most frequently added food. Advice given to mothers on formula making preparation by health professionals had a positive effect on the compliance with the recommendations for reconstituting infant formula.

Critique: Self reporting questionnaire is not ideal and maternal recall may be less reliable especially if sleep deprived in the early months.

Summary of reconstitution of formula between Australia and the USA

In the Australian surveys, the key finding was an over-concentration of formula. This preparation was more common among the less educated mothers in one study (Bennett & Gibson 1990) but numbers are biased in favour of this class. In the other, there was no correlation between social class and reconstituting infant formula but social status was only reported on geographical location (Lilburne et al. 1988). This is in contrast with the USA where 35% of mothers add cereal to bottles of formula for feeding their infants and this entire group were considered high SES (Fein & Falci 1999). Australian

caregivers ten years ago also carried out this practice - Lilburn et al. (1988) reported that 21% of mothers put cereal in the bottle and 29% of infants had eaten other foods regularly by 4 months although numbers in Australia are small compared with the USA. If the new CDC 2000 reference chart is based on 35% of formula feeding mothers who also add cereal to bottles, is it suitable then for all Australian infants?

Current infant feeding practices in Australia and changes in SES

Two further studies are worthy of note on infant weaning practices and foods which were carried out on women in shopping complexes in metropolitan suburbs, of Victoria and South Australia, which provide a snapshot of current trends in Australia.

Melbourne Survey

The first survey to be discussed here is the Victorian study on weaning from western metropolitan Melbourne (Graham et al. 1998). Researchers examined the data obtained from two groups and analysed it by using the Statistical Package for Social Sciences. The authors found minimal Australian research available on infant weaning and the aim of the study was to fill this gap in the research.

Methods: Group 1 was all the attendees of Maternal Child Health centres who had infants aged 0-2 years. They were given a pre-tested survey. The area chosen had a proportionately high number of non-English speaking clients of varying ethnicity. The questionnaire was in English and it asked for nutrition information. Interpreters were used when necessary. Group 2 was 12 of the Maternal Child Health nurses who received a questionnaire. Five of those nurses were randomly chosen for comprehensive interviews subsequently.

Results: 115 surveys were analysed from parents and eleven surveys from the Child Health nurses. 57% of mothers and 50.4% of fathers were born outside Australia. 58% of infants were 8 months and younger. Out of the parents' 115 responses - 28% had

given cows' milk before the age of 12 months in place of breastmilk or formula. 30% had given solids by 3 months and 96% by 6 months. The mean age for introducing solids was 4.3 months with Child Health nurses reporting that younger first time mothers or non-English speaking mothers were more likely to commence solids before their infant was 4 months old. Juice was given by 85% of mothers by 6 months. Child Health nurses did not advise juice before 6 months and two nurses never advised using it. (Juice is not required in the infants diet (NHMRC 1989)). The attendance of mothers and infants at Victorian child health centres is estimated to be 98.6% of all births and 91% of 8month-old infants attend. Therefore the authors conclude that there is a need to maintain up to date education for child health nurses as well as parents.

This survey on parents is strengthened by the interviews and feed back from the Child Health nurses and gives both quantitative and qualitative information on weaning practices in Victoria. The value of this survey is that it acts as a baseline for further research with which to compare future data where little existed previously.

Adelaide survey

The second study in Australia is a qualitative survey from 5 shopping complexes in Adelaide South Australia (Retallack et al. 1994). The researchers aim was to find out if infants in Adelaide were following current dietary recommendations and to compare socio-economic status (SES) of breastfed and formula fed infants' weaning practices.

Methods: Five shopping complexes with a wide range of SES groups as per the 1990 South Australian Health Commission (cited in Retallack et al 1994) were surveyed over four weeks with a short questionnaire (South Australian Health Commission 1990). Some of the data, which was recorded, included the infant's milk type and if solids had commenced. The information required was qualitative data, which was recorded by

maternal recall of the infants' intake -food and fluids - in the past 24 hours. The data was analysed in age groups, which was used to demonstrate changes in infant feeding practices over time. SES was based on the mothers and fathers occupation using a 6-point scale of social stratification (Daniel 1983). 1 was ranked as professionals and academics and 6 was unskilled, the researchers included their own rank of 7 which represented home duties, a student or unemployed person. Information was analysed using KWIK-STAT statistical package.

Results: Of the 258 mothers who were interviewed, 91% lived with a partner and there were almost twice as many respondents from lower rather than higher SES groups. In the first age group 0-2 months, 62% were fully breastfed and 38% were formula fed. In the second age group 2-4 months 52% were breastfed and 48% were formula fed. In the third age group 4-6 months, 38% were breastfed and 62% were formula fed. Only between 2 and 4 months was there a significant difference evident between the feeding practices of higher and lower SES groups. At that time period, 71% of higher SES groups breastfed but only 37% of lower SES groups ($p< 0.05$). Of the formula feeding infants, all were fed on formula up to six months. By 8 months old, 10% of infants were being fed on cows' milk and 44% used cows milk by ten months. 33% of 2-4 months old infants had taken solids and 90% of 4-6 months old. Only in the 2-4 months old age group was a significant difference evident between SES groups in the percent of infants taking solids. - All the infants in this age group who were taking solids were from lower SES groups. The food type recorded was mainly milk-based dessert compared with breastfed infants who ate more fruit. The authors concluded that the numbers of women fully breastfeeding came from both SES groups in equal numbers in all age groups except the 2-4 months age groups which they believe indicated more women in lower SES groups are initiating breastfeeding.

Critique: This last statement could also be viewed as - more women and families are falling into this category by the fact that the middle class is becoming poorer (Daniel 1983). Or more women in the higher SES group gave up breastfeeding after 4 months to return to work in order to maintain their lifestyle, which would account for the fact that less women of higher SES participated in the shopping complex survey because they were at work. More research is needed to find out why women are giving up breastfeeding using more up to date guidelines for assessing their socio-economic status. The value in this survey is the new SES guidelines that were used on both the women and her partner for assessing her socio-economic status in relation to breastfeeding.

Summary of infant feeding practices and changes in SES

Only between 2 and 4 months was there a significant difference evident between the feeding practices of higher and lower SES groups. At that time period, 71% of higher SES groups breastfed but only 37% of lower SES groups ($p < 0.05$). Are more women in higher SES groups giving up breastfeeding after 4 months to return to work in order to maintain their lifestyle? More research is needed to find out.

All of the infants in 2-4 months old age group who were taking solids were from lower SES groups (Retallack et al. 1994). Is advertising responsible for this? A walk through any supermarket will clearly show jars of infant food with "*around 4 months"* on the front of the jar? More research is also needed to investigate this sales promotion.

The Victorian study on weaning practices from Melbourne (Graham et al. 1998) reported that 28% of parents had given cows' milk before the age of 12 months in place of breastmilk or formula and 30% had given solids by 3 months and 96% by 6 months. The mean age for introducing solids was 4.3 months. Child Health nurses did not advise solids before 4 months. The attendance of mothers and infants at Victorian child health

centres is estimated to be 98.6% of all births and 91% of 8month-old infants attend. There is a need to maintain up to date education for child health nurses as well as parents.

Child and Family Health nurses role.

This last statement is supported by evidence from an investigation in Central Sydney Area Health Service on the nutrition advice given by Child and Family Health nurses (Patwardhan et al. 1994). These two studies (Patwardhan et al. 1994; Graham et al. 1998) which also included the role of the Child and Family Health nurse, are both related to nutrition advice and infant feeding.

Nutritionists in Central Sydney set up a research protocol, for observational data to be collected during interviews, between women/carers who visited the Early Childhood Centres and the Child and Family Health (CAFH) nurses who were in attendance on that day (Patwardhan et al. 1994).

Methods: A student nutritionist was the observer and collected that data during the interviews. All the advice given by the CAFH nurses was grouped according to whether it was appropriate, appropriate with rationale, misleading or inappropriate. A questionnaire was distributed separately to each CAFH nurse (n = 35) and the aim of the questionnaire was to find out if the advice given by the CAFH nurses was appropriate and in line with the infant feeding guidelines recommended at that time. Pamphlets and educational material, which was on display at each centre, were reviewed and critiqued.

Results: From 103 observation interviews, twenty CAFH nurses were observed giving advice to parents/carers on 111 topics. The mean age of the infants was 6 months. 70% of advice given on general nutrition was deemed appropriate. The remaining 30% consisted of misleading advice, which related to the need for extra protein. The inappropriate advice related to the use of low iron formula being suggested for infants at

any age who were constipated and recommending that low fat dairy products be used when introducing infants to solid foods. (Low fat products are not recommended for children under two years old (Australian Nutrition Foundation Inc. 1987)).

Response rate to the questionnaire was almost 90%. Over 80% of the responses given in relation to general diet of the breastfed infant, how to manage an infant with cows' milk allergy and the use of low fat dairy products in infants, was appropriate. Of concern to the researchers was that 20% of respondents suggested the use of low fat dairy products when commencing solids in the infants diet and the use of iron-reduced formula for infants. The researchers recommended that all the literature available to clients at the centres be kept up to date.

Critique: Given the paucity of research carried out on CAFH nurses in Australia, it provided a basis for further education on nutrition. The research observer did not report on the CAFH nurses' use of growth charts although nutrition is intimately linked with growth. Central Sydney has also a diverse SES group and this was not recorded or reported upon even though the centres were coded as well as the respective CAFH nurse who worked there. Why was a low iron formula available if it was potentially dangerous for young infants? Interestingly, this product was subsequently discontinued and removed from circulation (Norberg et al. 1995). It could also be surmised that CAFH nurses are prone to the advertising schemes of the formula companies. It is also interesting to note the authors reported that the responses in the questionnaire demonstrated that the CAFH nurses were unclear about the use of reduced-iron formula. Yet some nurses suggested it to relieve constipation, without evidence to support this advice. Further research is required on parents and CAFH nurses to find out what influence advertising has on their nutrition ideology.

Summary of the Child and Family Health nurse role

The mean age for introducing solids to infants was 4.3 months in Victoria. Child Health nurses there, reported that younger first time mothers or non-English speaking mothers were more likely to commence solids before their infant was 4 months old. CAFH nurses may be prone to the advertising schemes of formula companies - low iron formula was available and was recommended even though it was potentially dangerous for young infants. More research is needed to investigate the formula companies' sales promotion. Infants in the 2-4 months old age group (Retallack et al. 1994), who were taking solids were all from lower SES groups. Is advertising responsible for this? Jars of infant food in any supermarket clearly advertise "*around 4 months"* as suitable to begin feeding infants? More research is also needed to investigate the sales promotion of infant foods. Regrettably, researchers did not report on the CAFH nurses' use of growth charts although nutrition is intimately linked with growth.

Implications for clinical practice

Considering the diversity of the role of the CAFH nurse it is admirable that out of 111 nutrition topics, 70% of advice given on general nutrition was deemed appropriate (Patwardhan et al. 1994). Child and Family Health nurses are caught between their clientele (the consumer with their needs and wants), nutritionist, breastfeeding promotion and associates, paediatricians, the formula companies and their advertising, the anthropologists promoting co-sleeping with increased breastfeeding at night and the Sudden Infant Death Association who recommend solitary sleeping. Research in this area is complicated due to the fact that randomisation is impossible. Agostoni et al. (1999) suggest that weaning practices affect growth and follow cultural ideas rather than scientific evidence but how much of Western culture is influenced by advertising? A visit to the supermarket in August 2003 revealed that several brands of infant formula

namely S26, Karicare, Enfalac, and SMA still recommend that volumes of formula between 960mLs to 1200mLs are suitable for feeding infants between 4 and 6 months. In addition, Governments are implementing change without any focus groups on CAFH nurses - e.g. Families First project (NSW Government 2003).

A summary of unanswered questions

Why are women giving up breastfeeding early and from which SES groups are they? What do women want? What is reasonable to expect of women in today's developed world? How can the CAFH nurse provide the best assistance to women to meet their needs apart from nutrition advice alone? Is advertising responsible for the early introduction of solids foods to infants given the conspicuous advertising on jars in supermarkets? What influence does advertising have on the nutrition ideology of parents and CAFH nurses in relation to infant feeding practice? Are CAFH nurses influenced by the schemes of the formula companies? Has the Baby Friendly Hospital Initiative (WHO / UNICEF Statement 1989) assisted in promoting breastfeeding? Apart from education what is it that we need to address next to increase breastfeeding rates?

Summary of results on growth

Studies who compared their data on fully breastfed infants with the NCHS/WHO chart, found that the infants deviated from this chart and had a 'falling away' from the 50th percentile from birth. However, when a comparison was made between the results of studies on infants with mixed feeding practices (i.e. breastfed and formula-fed) and the NCHS/WHO chart, this comparison showed, that infants with mixed feeding practices continued to grow at the same rate as this chart. These researchers stated that they found no significant difference between the NCHS reference and the breastfed group. One possible explanation for this is that the breastfed infants who were lighter than formula-

fed infants at the age of 1 year are likely to have been fed according to a regimented schedule of four hourly breastfeeds (i.e. they are lighter as a result of the breastfeeding management). When the breastfeeding management was recorded as given to the appetite needs of the infant (Hitchcock et al. 1985), the weight gain between 3 months and 6 months demonstrated that exclusively breastfed infants up to 6 months (or longer) gained less weight than formula fed infants. Regrettably, these groups of infants were only compared to one another and not to any standard in Australia at the time. However in the Dewey et al. pooled analysis (1995) studies', researchers found that the longer infants were breastfed the more slowly they gained weight when compared to the NCHS/WHO reference or a formula fed group of infants. The NCHS 1977 reference is based primarily on formula fed infants. However the formula fed infants may have been overfed on formula and/or fed on cows' milk with sugar thereby adding extra kcal. Shepherd (1988) noticed that the formula-fed infants drank less formula during the study period, than the guidelines recommended at the time. The implications here are that the formula-fed infants have a potential to be over fed and the breastfed infants may not be fed frequently enough to meet their needs. Therefore when compared with one another and the NCHS (1977) chart - which may be based on over fed infants -, the groups will obviously demonstrate different growth trajectories. Therefore it could be concluded, that if a fully breastfed group of Australian infants were now compared with the NCHS (1977) chart, a difference will be evident in the growth trajectory between them.

Summary of results of solids introduction

In the USA formula-fed group of Butte et al. (2000), there was no difference in body size after the introduction of solids or other milk when adjusted for gender of the infant. These are similar findings to Mehta et al. (1998) after the analysis of formula-fed

infants following the introduction of solids. Both studies found that the infants did not increase their appetites and eat more, but regulated their appetites to accommodate the intake of energy from another source. Stuff and Nichols (1989) found similar results with breastfed infants - the introduction of solid foods early to breastfed infants did not minimise the decline in growth of breastfed infants. Energy consumption remained static after solids were commenced even though infants had free access to breastfeeding. Therefore it appears that infants will self-regulate with solid foods regardless of feeding method because it displaces breastmilk or formula. Infant's weight generally is not affected by the introduction of solid foods. Hence the reason to suggest breastfeeding exclusively for 6 months (W.H.O. 2002). However such advice could be inappropriate if given to parents who breastfeed their infants to a schedule and for those infants who do not have free access to the breast. Careful assessment of each individual mother-infant pair by taking a thorough history on the management of breastfeeding needs to occur before arbitrary advice is given by the health professional.

Summary of feeding practices

Hitchcock et al. (1981) reported that cow's milk with sugar was common in Australia for feeding infants twenty years ago. This had the potential to make infants gain weight rapidly and studies done at that time were probably carried out on infants who were fed on fresh cow's milk with sugar added. This certainly was part of education for the Child and Family nurse at Tresillian Family Care Centres in 1985. Advice in *Our Babies* (Department of Health 1983) was to recommend to parents that infants be fed on suitable breastmilk substitutes which had been modified namely cow's milk. The move away from modified cows' milk led to a rise in the sale of infant formulas, from which the advertising of these products has a potential to undermine women's confidence to

breastfeed. In addition, larger volumes are recommended on the label than are required to meet the RDA/RDI. The World Health Organisation issued guidelines on the advertising of breastmilk substitutes in hospitals and other marketing venues (WHO / UNICEF Statement 1989). There may be a link between higher and lower SES groups and the infant feeding practices of parents and carers, but advertising in Western culture may also influence this practice. Breastfeeding women who are in the high SES group may also be returning to work early and not be well represented in some surveys.

Summary of themes and rationale for this research.

The NCHS (1977) reference may not be suitable for monitoring the growth of breastfed infants. The revised CDC (2000) reference may also be unsuitable. With such a wide variety of infants feeding methods being practised by parents and carers it is difficult to compare infants feeding groups adequately. Notwithstanding, changes in infant feeding guidelines and recommendations have also changed during the last twenty years. However a new Australian reference chart if based on inaccurately reconstituted formula fed infants may not be the best solution for monitoring breastfed infants growth in the first year of life. Therefore it is difficult to form a hypothesis about an ideal growth chart with which to monitor breastfed infants growth in Australia. Prior to drawing any comprehensive conclusions on this topic, it was decided by the researcher to form a hypothesis on breastfed infants and the NCHS 1977 chart currently used at the time. It was decided to carry out some research on data collected from a sample of Australian breastfeeding women and their infants in the area of my clinical practice - Child and Family Health. This study is not representative of all breastfeeding mothers as all the subjects were attendees of Child Health Clinics who were following the advice of Child and Family Health nurses. There were no published studies at the end of the

twentieth century on Australian breastfed infants who had been compared with the NCHS (1977) reference for longer than three months. It was decided therefore, to explore a sample of breastfeeding women of European descent and their infants from metropolitan Sydney and semi-rural NSW. It had been almost 20 years since the last Australian research was published on the topic of infant feeding methods and growth. Following twenty years of promoting breastfeeding in clinical practice, the researcher decided to find out how infants who were now reported as fully breastfed or exclusively breastfed, compared with the NCHS 1977 reference and the revised CDC 2000 reference and when solids were being introduced to breastfed infants.

The research hypotheses

The hypothesis is that there is a difference in growth between breastfed infants and the NCHS (1977) reference at the age of 12 months. It follows then that there will also be a difference in the growth of breastfed infants when compared with the revised CDC (2000) reference chart at the age of 12 months.

The research hypothesis is, that the mean weight and length of the breastfed infants, is significantly less at 1 year than the NCHS reference (Hamill et al. 1977) currently in use. Therefore the null hypothesis is that the mean weight and length of breastfed infants at 1 year are equal to the "true" mean weight and length of the Hamill et al. (1977) NCHS reference currently used at the time.

Chapter 3 Methods

Introduction

The aim of this study was to collect data on the weight and length of fully breastfed infants during the first year of life. This study is an audit. Ethics approval was required from respective organisations in keeping with the NHMRC guidelines for human ethics research approval. In an attempt to audit files from the Early Childhood Clinics, weight and length measurements were collected from the files of infants reported to be fully/exclusively breastfed. Criteria for inclusion and exclusion of breastfed infants were defined and a definition of breastfeeding for this study was established.

Study Aim

The aim of this study was to collect data on weight and length from the Child Health records in metropolitan Sydney and semi-rural New South Wales, from a large number of infants who were reported as fully/exclusively breastfed. The intention was to compare the aggregated data with the current NCHS (Hamill et al. 1977) reference and the revised version - the CDC 2000 growth chart. The purpose was to establish if a difference in growth trajectory existed between current Australian breastfed infants and the standard references recommended for use in Australia.

The research hypothesis

The research hypothesis was, that the mean weight and length of the breastfed infants, is significantly less at 1 year than the NCHS reference (Hamill et al. 1977) currently recommended for use at the time.

The null hypothesis

Therefore the null hypothesis is that the mean weight and length of breastfed infants at 1 year are equal to the "true" mean weight and length of the Hamill et al. (1977) NCHS reference currently used at the time. The fact that a number is contained in a 95% confidence interval for the mean implies that a test of the null hypothesis that the mean is equal to this number, would not be rejected at the 5% level of significance (Griffiths et al. 1998, p.303). Confidence intervals give a clearer understanding of the comparisons between two sets of data, in particular when comparing this breastfed group with the population mean - in this case the NCHS (Hamill et al.1977) standard reference (Griffiths et al. 1998).

Ethics

Approval for the study was sought from the Ethics Committee of the University of Wollongong, NSW; the Central Sydney Area Health Service (CSAHS) and the Illawarra Area Health Service (IAHS), NSW. Copies of approval letters provided by these Ethics Committees in July 2000 are available at the end of the Appendix.

Early Childhood Health Centres

These centres are part of the NSW Department of Health Service and provide advice on up to date research guidelines for evidence based practice (NHMRC 1996; NHMRC 2003). Historically, clinics were established for the prevention of infant mortality more than 75 years ago. Since then the role has changed into a sophisticated service providing clinics and home visitation by highly trained health professionals. It is the practice in Early Childhood Health Centres to weight the infants in clothes. This includes the undergarments - a nappy and singlet / vest - and one layer of outer clothing, usually an ‘All-in-one- suit’. When these garments are weighed alone this is approximately 150g.

Where bare weights existed n = 97, the difference between bare and clothed weights had a mean difference of 54 grams with a range between 159gms at 2 months and 130gms at 4 months, for the infants in this study. Child protection is now a primary function of the Child and Family Health nurse as well as offering advice and support to families with the care of infants from birth to 5 years old.

Definition of breastfeeding

In this study the definition of breastfeeding was, any infant who was documented in the record as being fully breastfed ("F.B.F.") or "exclusively breastfed", or breastfed only ("B/F only"). Fully breastfed was interpreted to mean that, the infant never had formula as a main drink, as far as the notes provided this information. This was additional to discussions with the Early Childhood nurses, also known as Child and Family Health (CAFH) nurses. Screening for formula given in cereal was not evaluated. Once the documentation stated that the infant was drinking formula from a bottle in addition to breastfeeding, no further data was collected on that infant. Whether mothers gave formula and did not discuss this with the Early Childhood nurse and whether such formula was omitted in the documentation is unknown.

Exclusion Criteria

This included any identifying material, which would preclude anonymity. Also excluded were prematurity, small for gestational age infants as well as mixed feeding practices, once this was documented in the file. The definition of 'mixed feeding practices' in this study was any infant who was documented in the file as having had a bottle of formula in addition to breastfeeding. Infants were excluded who were noted as having any underlying disease e.g. congenital dislocation of hips as some of these early weights were carried out with the infant wearing a harness.

Inclusion Criteria

The age of the woman/mother, her ethnicity, parity and the type of delivery were collected. Well infants were chosen of gestational ages between 38-42 weeks, their apgars at 5 minutes were documented as well as gender, birth weight and length and the age that solids commenced.

Methodology of data collection

The weight and length of the infant was collected for each month in the first year of life for fully breastfed infants. The age of the infant at each month of measurement is accurate to within 1 week (7 days) of their actual age in months. In the first audit of 2584 infant files, the total number of breastfed infants who met the criteria for recording weight and length was 351 subjects. All of the subjects were weighed but only sometimes also measured in length. There was insufficient data available for the statistical analysis of infants over the age of 6 months (14 females and 20 males) after the first audit. Therefore a further audit of 939 infant files took place in early 2002, of the remaining files from 1999, 2000- and early 2001. This provided a total audit of 3,523 files from the years 1997-2000, giving adequate data on the weight and length recordings of breastfed infants under and over the age of 6 months for the final analysis. A total of 915 files were audited from IAHS and 2608 files were audited from CSAHS. This audit provided 397 files (or 11.2%) of suitable data for analysis. This figure does not represent all the breastfed infants but only those infants who met the criteria as fully/exclusively breastfed. The final analysis was carried out on a group representing Australian fully breastfed infants of European descent.

Methodology for the inclusion of data for analysis

Forty-two ethnic groups were identified from the collection of 397 subjects' data for analysis. These were divided into the following four sub-groups: European, Asian, Middle East/African and the Pacific Islands. Adequate numbers for statistical analysis were collected only for the European /Australian group, a total of 300 subjects. The sample size of the Asian, the Middle East/African and Pacific Islands group -97 subjects, was too small for a statistical test. Further subdivision was carried out into genders for the purpose of analysis. The European/Australian group means of weight and length and their standard deviations were calculated using the statistical program JMP version 3.2.2, for males and females for each month of the first year of life. (See Table 2 Appendix II - means of weight and length).

Methodology for statistical analysis

The slopes of the graphs were compared mathematically using a statistical format and a p value of <0.05 was considered significantly different. A time series for 0 - 1 month was not included, as full-term infants lose between 5% and 10% of their birth weight and regain this weight by their second or third week of life (Riordan & Auerbach 1993; NHMRC 1996). The gradient was measured using a 95% confidence interval statistic on the slopes of the graphs for weight and length between 1 and 3 months, between 3 and 6 months, and, 6 and 12 months and compared with the NCHS (1977) data and the revised version CDC (2000). To calculate the interval of slope 1, the mean at 1 month was subtracted from the mean at 3 months and divided by 2. To calculate the interval of slope 2, the mean at 3 months was subtracted from the mean at 6 months and divided by 3. To calculate the interval of slope 3, the mean at 6 months was subtracted from the mean at 12 months and divided by 6. Segments of the graphs are shown between 1 month and 12 months comparing the data of 300 European/Australian breastfed infants

and the NCHS (1977) data and the CDC (2000) data (See Appendix III). From this comparison, differences in the sections shown in the graphs are visible. Mathematical calculations for the slope of the graph were carried out which indicated the difference in the relative rate of the growth of the breastfed group when compared with the two suggested references. When males in the breastfed group were compared to males on the NCHS (1977) between 1 month and 3 months, the rate of growth on the slope was 0.9274 kg/month for the breastfed group and 0.845 kg/month for the NCHS (1977). Observing this figure, the rate of growth for the males in the breastfed group is obviously faster than the NCHS (1977) data. When compared using a 95% confidence interval there is a significant difference, which is significantly faster. Referring back to the chart, it can be reflected by the slope of the chart.

Comparisons of statistical significance

In order to compare the breastfed group with the NCHS (1977) data and revised version - the CDC (2000), the mean, using the normal distribution was required, otherwise it is not an accurate comparison. However this could be viewed as an unfair representation for the breastfed infant whose growth rate is physiologically disadvantaged using the normal distribution.

Chapter 4 Results

Introduction

Three groups are compared, the Australian breastfed group, the NCHS group and the CDC 2000 group. The comparison of the overall results of breastfed infants with NCHS and CDC 2000 does not present much obvious difference on first observations. On closer inspection the figures contained in the confidence intervals (C.I.) are significantly different at particular intervals. Paediatric health professionals use the reference charts at monthly intervals or specific times in the infants first year to plot the weight and length wherever the infants' measurements occur on the graph. Therefore it makes sense to compare the monthly measurements with the NCHS and CDC 2000 data.

From the graphs presented below Figure 1a - 1h, visually it appears at first that there is not much difference evident between the slopes of the Australian breastfed group, the NCHS group and the CDC 2000 group. However when the data was analysed using confidence intervals, it became apparent that a significant difference ($p<0.05$) existed in the gradient of the slopes at particular intervals. These intervals were calculated as three slopes. Slope 1 represents the gradient between 1 and 3 months, slope 2 represents the gradient between 3 and 6 months and slope 3 represents the gradient between 6 and 12 months (See Appendix III).

Individual tables and explanations below of the confidence intervals show this significant difference ($p<0.05$). The methodology included showing a comparison between 1 month and 12 month segments of the graphs, from the data of 300 breastfed infants, the NCHS (1977) and the CDC (2000) data. Mathematical calculations for the slope of the graph were carried out which indicated the difference in the relative rate of growth of the three groups. From this comparison, differences in the sections shown in

the graphs are visible. When males in the breastfed group were compared to males on the NCHS (1977) between 1 month and 3 months, the rate of growth on the slope was 0.9274 kg/month for the breastfed group and 0.845 kg for the NCHS (1977). When compared using a 95% confidence interval, there is a significant difference ($p<0.05$) in breastfed infants. The slope of the line reflects this difference. The researcher decided to measure the gradient of the slopes. To test, at the 5% level of significance, whether the true slope for breastfed infants is equal to the "true" slope for all infants (NCHS 1979; Hamill et al. 1977), a 95% confidence interval was used. The shape was measured at the 3 intervals and this method enabled comparisons to be made between the three groups - the breastfed, NCHS and CDC 2000 group at these intervals. The statistical results of the analysis on the slope of the graphs for three time periods in the first year are explained using a 95% confidence interval. Graphs are used to visually demonstrate the findings and to highlight the features of significant differences between the breastfed group and the NCHS reference (Hamill et al. 1977; Hamill et al. 1979). Further analysis is presented using Student's *t test* to test the significant difference of the terminal figures at the age of 12 months. The results compared were based on the value worked out from the NCHS 1977 Table (Hamill et al. 1977). Table 1 in Appendix III for the NCHS 1977 and CDC 2000 respectively has been represented below by individual comparisons to demonstrate the differences in the confidence intervals of slopes 1,2 and 3. At the end of each section a summary of the results is presented. The null hypothesis follows the CDC 2000 summary with an introduction and explanation on testing the hypotheses. A conclusion is presented at the end of the chapter re-iterating the most important results.

The Analysis

The following Tables 2a - Table 2*m* show the mean weight and length rate of growth between males and females in the breastfed group and the NCHS (1977). Also included is the 95% confidence interval (C.I.) for the breastfed group by which the mean rate of growth of the NCHS is significantly different (or not) by the *p* value. A '*p* value' of less than 0.05 is accepted as significantly different on statistical analysis, a '*p* value' greater than 0.05 is not. The first Table 2a shows, - if 0.9274 kg/month which is the mean weight gain of male breastfed infants in this group, is compared with the NCHS- 0.845 kg/month, that the growth rate of the breastfed infants is significantly faster than the NCHS reference. A 95% C.I. was used to demonstrate this difference. To continue this analysis of comparison, it is necessary to compare the average NCHS (1977) value with the average weight and length of the mean of the breastfed group to establish if it is greater or less. If the value of the NCHS (1977) table lies outside the 95% C.I, this is shown to be significantly different and is represented by the *p* value as being greater or less than 0.05. Figures 2a, 2b, 2c, 2d, and Figure 2e, demonstrate the difference in the gradients between the breastfed group and the NCHS when a trendline was calculated to show the projection in growth of the two groups. The remaining Tables 3a - Table 3f follow the same pattern for the comparison of the breastfed group with the CDC 2000 and can be read accordingly. Table 4 demonstrates no significant difference is evident in length between the breastfed infants' group when compared with the CDC 2000 data. A summary of the CDC 2000 results is presented. The null hypothesis is explained with a demonstration on testing the hypothesis at 12 months using the terminal values for the NCHS and CDC 2000. A Student's *t test* on the terminal figures at 1 year demonstrates that there is no significant difference ($p>0.05$) and the null hypothesis is not rejected.

A serendipitous finding of this study was that Australian formula-fed infants might be heavier than their breastfed counterparts at the age of 12 months. This was evident by reflecting on the process of auditing the files in the Early Childhood Health Centres. During the first week of collecting the data, a systematic approach of auditing the files from birth to 12 months looking for infants' weight and length seemed to be the appropriate method. However after the first week it became apparent that formula-fed infants, on average, all weighed approximately 12kg or above at 12 months, whereas breastfed infants weighed 10kgs or less. It was quicker thereafter, to begin the audit at 12 months and observe this terminal weight. If at 12 months an infant weighed 12kg or more, a quick glance at the preceding entries typically revealed that the infants had been drinking formula for at least 6 months.

During the audit process to obtain data for the analysis of weight and length, it became apparent that many infants were weighed but only some of those infants were also measured.

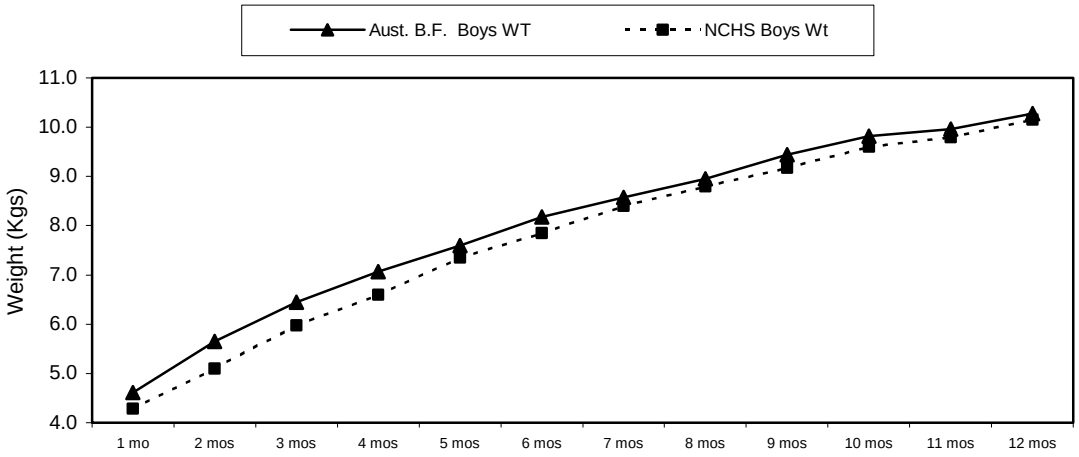


Fig 1a.
A comparison of the mean weights of the breastfed boys group with the means of the NCHS data at monthly intervals in the first year of the infants' life. A significant difference is evident ($p<0.05$) in the gradient between 1-6 months - see Table 2a and 2e. No significant difference is evident between 6-12 months ($p>0.05$) - see Table 2i.

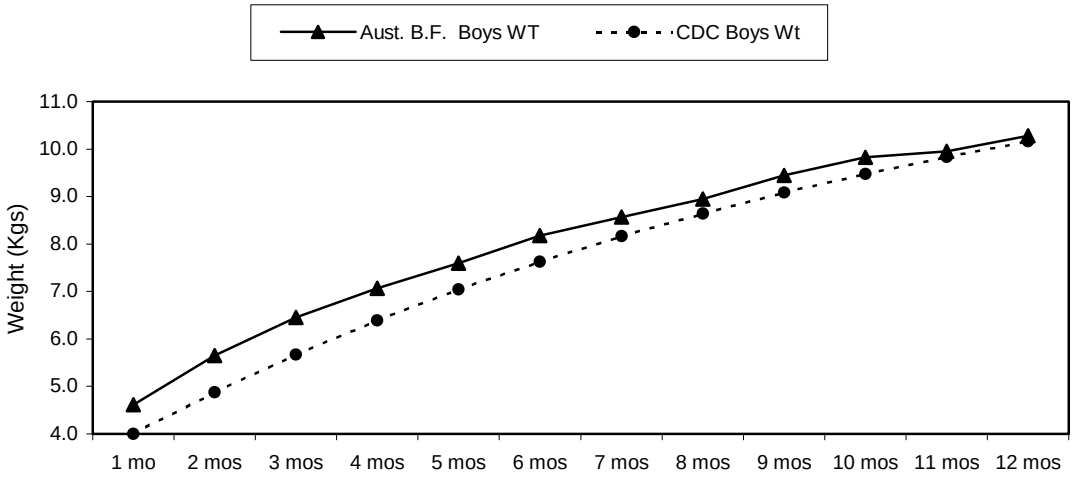


Fig 1b.
A comparison of the mean weights of the breastfed boys group with the mean weights of the CDC 2000 data at monthly intervals in the first year of the infants' life. A significant difference ($p<0.05$) is evident in the gradient between 1-12 months - see Tables 3a, 3c, 3e.

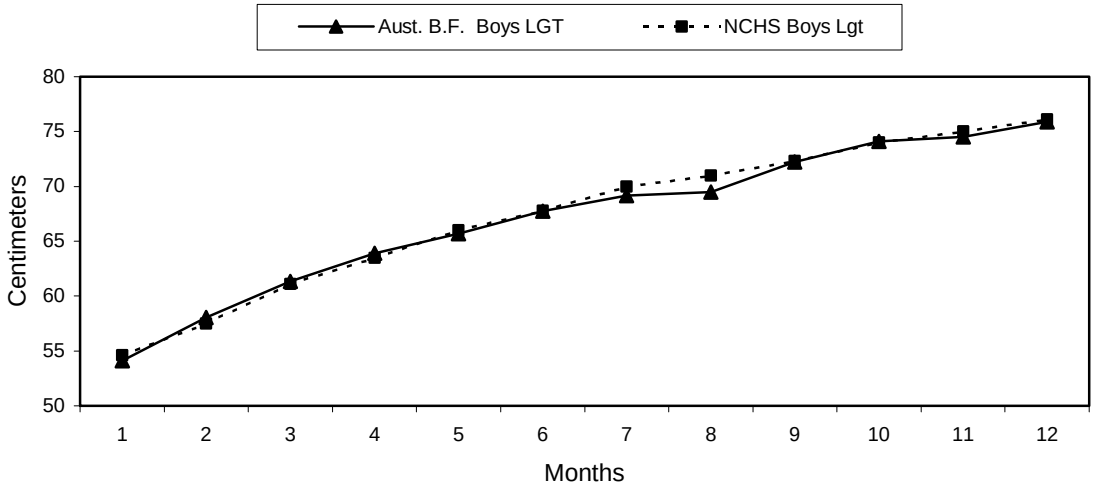


Fig 1c.
A comparison of the mean length of the breastfed boys group with the mean lengths of the NCHS data at monthly intervals in the first year of the infants' life. A significant difference ($p<0.05$) is evident only between 1-3 months - see Table 2b.

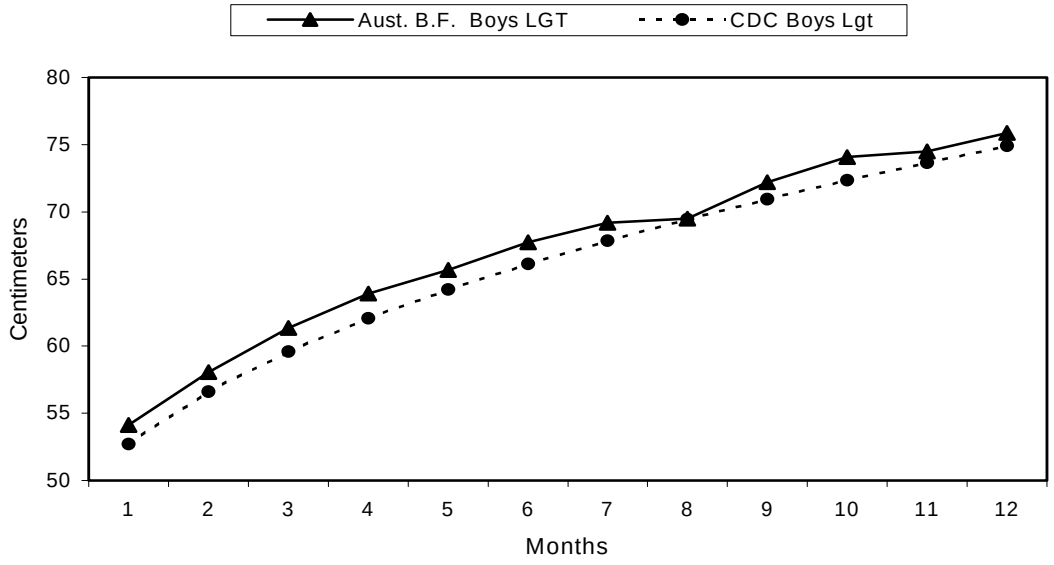


Fig 1d.
A comparison of the mean length of the breastfed boys group with the mean length of the CDC 2000 data at monthly intervals in the first year of the infants' life. No significant difference is evident for length between 1-12 months ($p>0.05$) - see Table 4.

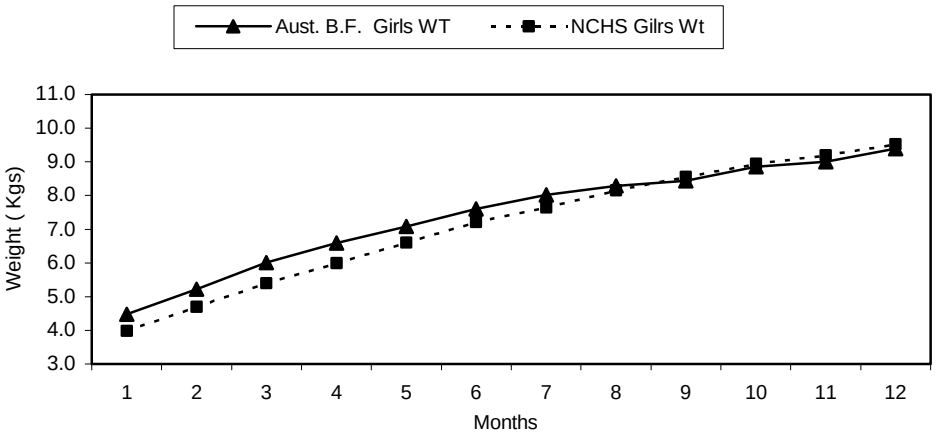


Fig 1e.
A comparison of the mean weights of the breastfed girls group with the means of the NCHS data at monthly intervals in the first year of the infants' life. A significant difference is evident ($p<0.05$) between 1-12 months. For further explanations see Tables 2c, 2g, 2k.

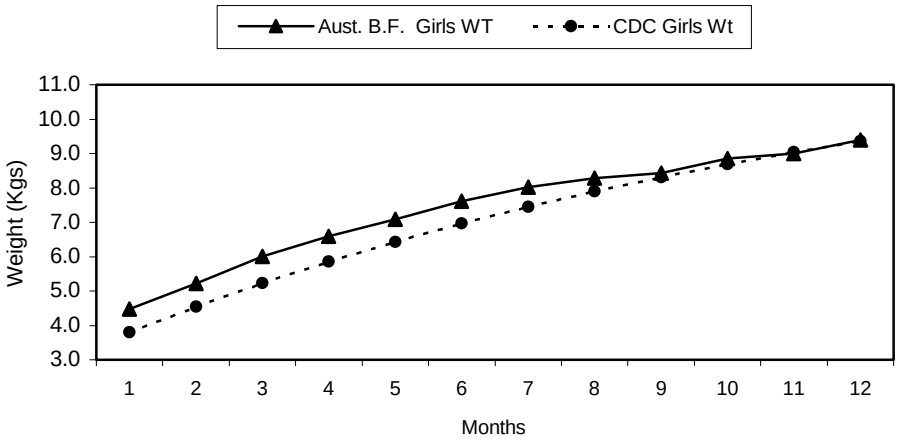


Fig 1f.
A comparison of the mean weights of the breastfed girls group with the means of the CDC 2000 data at monthly intervals in the first year of the infants' life. A significant difference is evident ($p<0.05$) between 1-12 months. For further explanation see Tables 3b, 3d, 3f.

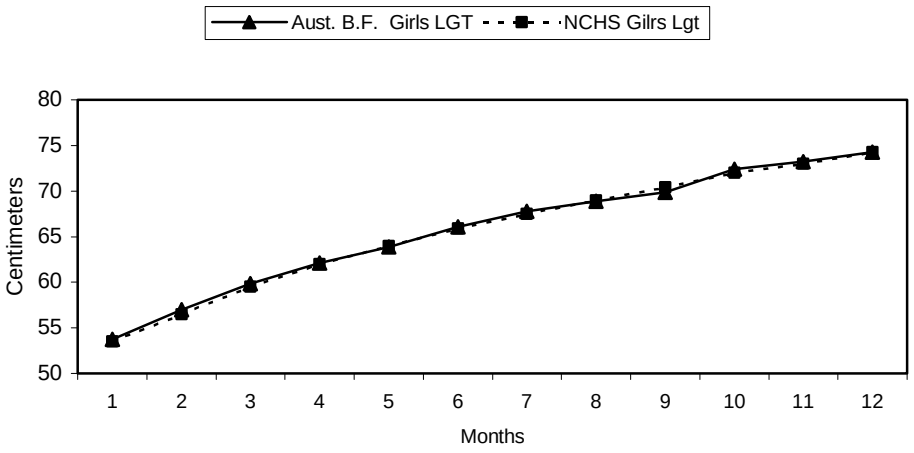


Fig 1g.

A comparison of the mean length of the breastfed girls group with the means of the NCHS data at monthly intervals in the first year of the infant's life. No significant differences are evident in length (p>0.05) - see Tables 2d, 2h, 2*m*.

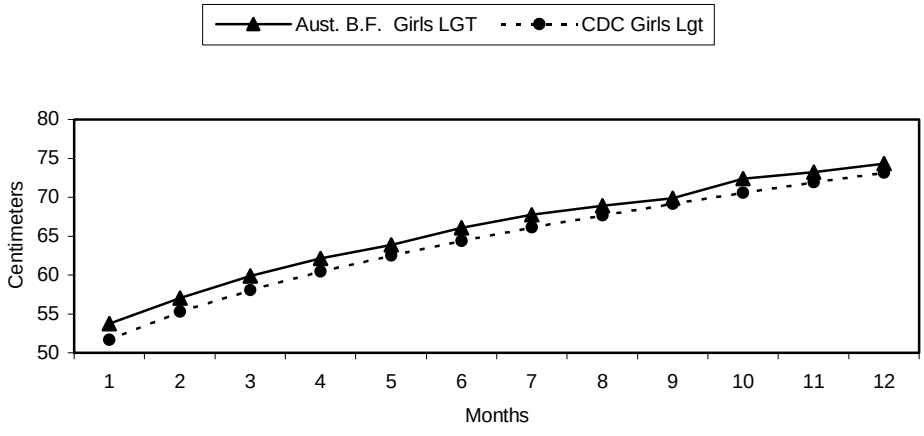


Fig 1h.

A comparison of the means of length of the breastfed girls group with the means of the CDC 2000 data at monthly intervals in the first year of the infants' life. No significant differences are evident in length (p>0.05) - see Table 4.

Male 1 - 3 month Weight

The value given by the NCHS table lies outside the 95% C.I. and is shown to be significantly different by the *p* value, therefore the average gain of the breastfed male infants in this study is greater than the NCHS reference.

Table 2a Male 1-3 month Weight

Males Weight	Slope1: 1mth - 3mth
Mean	0.9274 kg/mth
95% CI	0.8762 - 0.9786
n	103
NCHS (WHO) Table	0.845 kg/mth (p<0.05)

The breastfed group has a steeper gradient when compared to the NCHS, using a graph to represent this difference.

This graph demonstrates the differences in the gradient for boys weight 1-3 months between the group of breastfed infants and the NCHS (Hamill et al. 1977) using a 95% C.I. for this time period. The trendline shows the linear growth projection for weight.

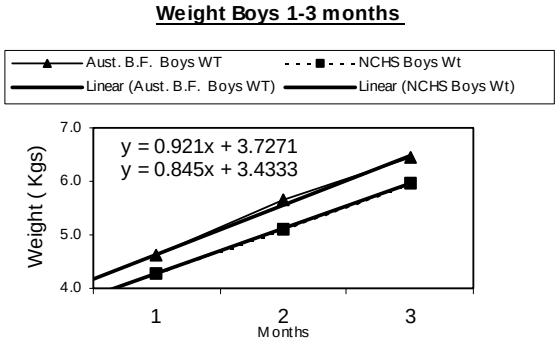


Fig. 2a. Graph illustrating the difference in slope 1

Male 1 -3 month Length

The value given by the NCHS table lies outside the 95% CI and is shown to be significantly different by the *p* value, therefore the male breastfed infant's growth in length in this study is greater than the NCHS reference.

Table2b Male 1-3 month Length

Males Length	Slope1: 1mth - 3mth
Mean	3.5344 cms/mth
95% CI	3.2629 - 3.8059
n	64
NCHS (WHO) Table	3.25 cms/mth (p<0.05)

Female 1 -3 month Weight

The value given by the NCHS table lies outside the 95% CI and is shown to be significantly different by the *p* value. This demonstrates that the average gain of female breastfed infant's weight in this study is also greater than the NCHS reference.

Table 2c Female 1-3 month Weight

Females Weight	Slope1: 1mth - 3mth
Mean	0.7896 kg/mth
95% CI	0.7454 - 0.8338
n	108
NCHS (WHO) Table	0.710 kg/mth (p<0.05)

Showing girls weight 1-3 months

This graph demonstrates the difference in the gradient between female breastfed infants' weight being faster than the NCHS reference.

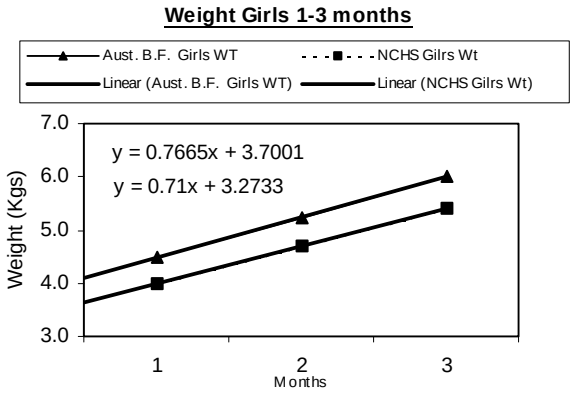


Fig.2b. Graph illustrating the difference in slope 1

Female 1-3 month Length

The value given by the NCHS table lies *within* the 95% CI and therefore is not significantly different by the *p* value in this study.

Table 2d Female 1-3 month Length

Females Length	Slope1: 1mth - 3mth
Mean	3.0878 cms/mth
95% CI	2.8623 - 3.3134
n	82
NCHS (WHO) Table	3.0 cms/mth (p>0.05)

Summary of males and females weight and length between 1 month - 3 months.

Male and female breastfed infants in this study follow a similar growth pattern during this time period in that they grow at a faster rate than the NCHS reference. Except for female length where there is no significant difference. Interestingly it is notable that there are fewer observations - n - for the length of infants and more observations for weight suggesting than clinicians focus more on weight than length in slope 1.

Male 3 - 6 month Weight

The value given by the NCHS table for this period lies outside the 95% CI and is significantly different by the *p* value. The weight of the male breastfed infant begins to slow over this time-period in this study. Therefore male weight gain between 3 - 6 months is slower in breastfed infants.

Table 2e Male 3-6 month Weight

Males Weight	Slope2: 3mth-6mth
Mean	0.5794 kg/mth
95% CI	0.5405 - 0.6184
n	89
NCHS(WHO) Table	0.623 kg/mth (*p*<0.05)

The graph below demonstrates the differences in the weight gradients for the two groups between 3 and 6 months.

This graph shows how the breastfed boys' weight begins to slow down at this time, now being slower than the NCHS. Only the weight of both genders is significantly different at this time.

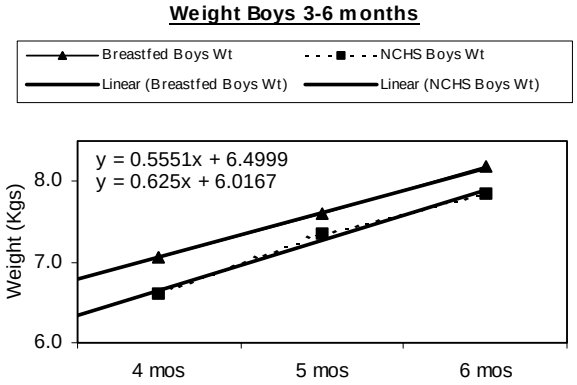


Fig. 2c. Graph illustrating the difference in slope 2

Male 3 - 6 month Length

The value given by the NCHS table lies *within* the 95% CI and is shown to be *not* significantly different by the *p* value.

Table 2f male 3-6 month length

Males Length	Slope2: 3mth- 6mth
Mean	2.2600 cms/mth
95% CI	2.1082 - 2.4118
n	70
NCHS (WHO) Table	2.23 cms/mth (p>0.05)

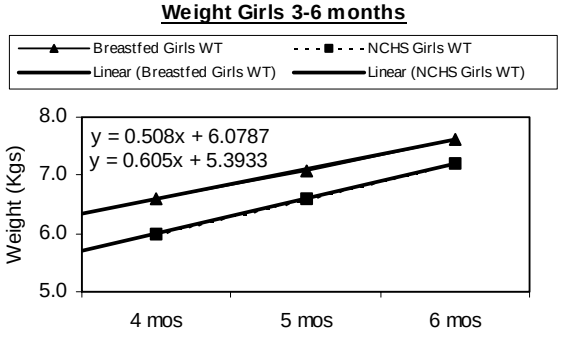
Female 3 - 6 month Weight

The value given by the NCHS table lies outside the 95% CI and is shown to be significantly different by the *p* value, demonstrating that the female breastfed infant's weight also begins to slow over this time period, when compared to NCHS reference.

Table 2g female 3-6 month weight

Females Weight	Slope2: 3mth - 6mth
Mean	0.5414 kg/mth
95% CI	0.5131 - 0.5696
n	99
NCHS (WHO) Table	0.603 kg/mth (p<0.05)

This graph Fig. 2d demonstrates the slowing down in this study of the growth of female breastfed infants weight gain by using a graph for visual purposes.



Female 3 - 6 months Length

The value given by the NCHS table lies within the 95% CI and is shown to be not significantly different by the *p* value.

Table 2h female 3-6 month length

Females Length	Slope2: 3mth- 6mth
Mean	2.0651 cms/mth
95% CI	1.9305 - 2.1998
n	87
NCHS (WHO) Table	2.13 cms/mth(p>0.05)

Summary of 3 - 6 months weight and length

The weight only, of both genders is significantly different from the NCHS reference in this time period. The figures show that the rate of weight gain begins to slow down at this time, now being slower than the NCHS average. In length is there no significant difference when compared to the NCHS. Again there are more observations -n- for weight, recorded by clinicians than are recorded for the infants' length in slope 2.

Males 6 - 12 months Weight

The value given by the NCHS table lies within the 95% CI and is shown to be not significantly different by the *p* value.

Table 2i male 6-12 month weight

Males Weight	Slope3: 6mth-12mth
Mean	0.3506 kg/mth
95% CI	0.3148 - 0.3865
n	41
NCHS (WHO) Table	0.383 kg/mth(p>0.05)

Males 6 -12 months Length

The value given by the NCHS table lies within the 95% CI and is shown to be not significantly different by the *p* value.

Table 2j male 6-12 month length

Males Length	Slope3: 6mth-12mth
Mean	1.3816 cms/mth
95% CI	1.2894 -1.4738
n	39
NCHS (WHO) Table	1.38 cms/mth(p>0.05)

Female 6 - 12 month Weight

The value given by the NCHS table lies outside the 95% CI and is shown to be significantly different by the *p* value. Only the female breastfed infants' weight gain is significantly different than the NCHS reference during this time period.

Table 2k 6-12 months weight

Females Weight	Slope3: 6mth - 12mth
Mean	0.3494 kg/mth
95% CI	0.3154 - 0.3835
n	40
NCHS (WHO) Table	0.386 kg/mth (p<0.05)

This graph shows that only the female breastfed infants' weight gain is significantly different to the NCHS reference during this time period. The female breastfed infant is growing at a slower rate as she approaches the end of the first 12 months with average weight gain less than the NCHS reference.

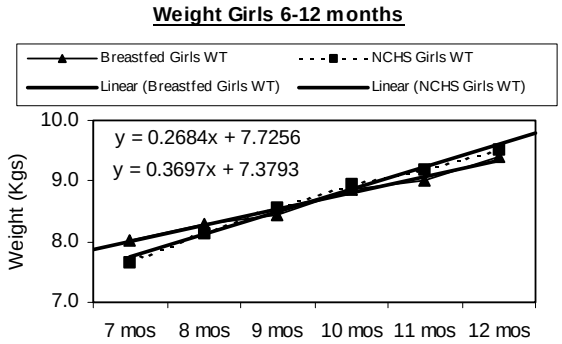


Fig.2e. Graph illustrating the difference in slope 3

Female 6 - 12 month Length

The value given by the NCHS table lies within the 95% CI and is not statistically significant by *p* value.

Table 2*m* 6-12 month length

Females Length	Slope3: 6mth -12mth
Mean	1.3987 cms/mth
95% CI	1.3126 - 1.4849
n	39
NCHS (WHO) Table	1.4 cms/mth (p>0.05)

Summary of 6 -12 months weight and length

When the breastfed group is compared to the NCHS reference, the female breastfed infant is growing at a slower rate as she approaches the end of the first 12 months with average weight gain less than the NCHS reference. Only the female breastfed infants' weight gain is significantly different during this time period. Male weight and length alter at a similar rate to the current NCHS reference.

Summary of the comparison between breastfed group and NCHS group

The gradient was measured using a 95% confidence interval statistic on the slopes of the graphs for weight and length between 1 and 3 months, between 3 and 6 months, and, 6 and 12 months and compared with the NCHS (1977) data. Overall the researcher found that between 1 month and 3 months, male and female breastfed infants in the study follow a similar growth pattern, in that they grow at a faster rate than the NCHS reference. The exception is for female length, where there is no significant difference. Between 3 months and 6 months only the weight of both sexes is significantly different. The figures show that the rate of growth in weight in breastfed infants begins to slow down at this time with both sexes growing slower than the NCHS average. In length there is no significant difference when compared to the NCHS 1977. During the time period between 6 months to 12 months when the breastfed group is compared to the NCHS reference, the female breastfed infant is growing at a slower rate at the end of the first 12 months with average weight gain less than the NCHS. Only the female breastfed infants' weight gain is significantly less during this time. Male weight and length grow at a similar rate to the current NCHS (1977) standard. Therefore the slope of the breastfed group is more rapid in the first 3 months. It then slows down and females grow at a slower rate until 12 months of age. However for predominantly formula fed infants the slope remains at a more constant rate of continual growth.

There are fewer observations on slope 1 than slope 2 for length for both genders, but more for slope 1 than slope 2 for weight. This implies that most infants are weighed, but only some are measured, particularly at the age of 1 month. Using the statistical *t test* when comparing the terminal figures of this study with the NCHS at 12 months, the mean weight and length of the male and female breastfed infants group and the

NCHS demonstrated that there is not a significant difference at 1 year between the mean weight and length of the breastfed infants for both genders and the NCHS reference.

Comparison of the slopes for breastfed group and the revised CDC 2000 slopes.

In order to find out if the latest CDC 2000 reference being suggested for use in Australia will acknowledge the difference in growth trajectory of breastfed infants when compared with the data of infants who had mixed feeding practices, a similar comparison follows for the same time periods. The slope of the breastfed infants group is compared with the revised CDC 2000 data. This revised data was collected from infants who had mixed feeding practices. Only one third of infants in the USA were breastfed for more than 3 months (CDC 2002).

Male 1 - 3 month Weight

The male breastfed infants are growing faster than the new CDC 2000 reference. This is evident by the value given by the CDC table which lies outside the 95% C.I. This is shown to be significantly different by the *p* value.

Table 3a male 1-3 month weight and CDC

Males Weight	Slope1: 1mth-3mth
Mean	0.9274 kg/mth
95% CI	0.8762 - 0.9786
N	103
CDC 2000	0.8349 kg/mth $p<0.05$

Female 1-3 month Weight

The female breastfed infants are also growing faster than the new CDC 2000 reference guide. This is evident by the value given by the CDC table which lies outside the 95% CI. This is shown to be significantly different by the *p* value.

Table 3b female 1-3 month weight and CDC

Females Weight	Slope1: 1mth - 3mth
Mean	0.7896 kg/mth
95% CI	0.7454 - 0.8338
N	108
CDC 2000	0.7165 kg/mth $p<0.05$

Summary of male and female weight between 1 - 3 months

Both male and female weight gain of the slope in the breastfed group continues to be above the average weight gain of the slope suggested by the new CDC 2000 reference guide. This is similar to the comparison with the NCHS 1977 reference. Revised data was collected from infants who had mixed feeding practices.

Male 3 - 6 month Weight

Growth rate of the breastfed group begins to slow down. The value given by the CDC 2000 table for this period lies outside the 95% CI and is significantly different by the *p* value.

Table 3c male 3-6 month weight and CDC

Males Weight	Slope2: 3mth - 6mth
Mean	0.5794 kg/mth
95% CI	0.5405 - 0.6184
n	89
CDC 2000	0.6525 kg/mth $p<0.05$

Female 3 - 6 month Weight

The value given by the CDC 2000 table lies outside the 95% CI and is shown to be significantly different by the *p* value, demonstrating that the female breastfed infant's weight, also begins to slow again over this time period.

Table 3d female 3-6 month weight and CDC

Females Weight	Slope2: 3mth - 6mth
Mean	0.5414 kg/mth
95% CI	0.5131 - 0.5696
n	99
CDC 2000	0.5791 kg/mth $p<0.05$

Summary of 3 - 6 months weight

Only the weight of both genders is significantly different in this time period. The figures show that the rate of growth in weight for the slope of the breastfed group begins to slow down at this time. The CDC 2000 guide remains faster than the breastfed group. There is no significant difference in length for both genders. This is also similar to the NCHS 1977 data for the same time period.

Males 6 - 12 months Weight

Between 6 and 12 months the slope of the CDC 2000 for male weight, remains faster than the slope for the breastfed group. This is evident by *p* value, which lies outside the CI and is significantly different.

Table 3e male 6-12 month weight and CDC

Males Weight	Slope3: 6mth-12mth
Mean	0.3506 kg/mth
95% CI	0.3148 - 0.3865
n	41
CDC 2000	0.4219 kg/mth $p<0.05$

Female 6 - 12 month Weight

The value given by the CDC 2000 table lies outside the 95% CI and is shown to be significantly different by the *p* value. The slope for female breastfed infants' weight remains slower than the new CDC 2000 revised chart.

Table 3f female 6-12 month weight and CDC

Females Weight	Slope3: 6mth - 12mth
Mean	0.3494 kg/mth
95% CI	0.3154 - 0.3835
n	40
CDC 2000	0.3998 kg/mth $p<0.05$

Summary of 6 -12 months weight

When the slope of the breastfed group is compared to the revised slope of the CDC 2000 reference guide, both male and female breastfed infants are gaining weight at a *slower* rate between 6 and 12 months. Both genders average weight gain is significantly different which is evident by *p* value.

Summary of male and female lengths between 1 - 12 months comparing the breastfed infants group with the CDC 2000 data.

The slope of the male and female gradient for CDC length between 1 and 12 months is not significantly different by *p* value when compared with the confidence interval for the breastfed group - see Table 4 below.

Table 4

Males Length	**Slope1: 1mth - 3mth**	**Slope2: 3mth - 6mth**	**Slope3: 6mth - 12mth**
Mean	3.5344 cms/mth	2.2600 cms/mth	1.3816 cms/mth
95% CI	3.2629 - 3.8059	2.1082 - 2.4118	1.2894 -1.4738
n	64	70	39
CDC 2000	3.4565 cms/mth *p*>0.05	2.1721 cms/mth *p*>0.05	1.466 cms/mth *p*>0.05
Females Length			
Mean	3.0878 cms/mth	2.0651 cms/mth	1.3987 cms/mth
95% CI	2.8623 - 3.3134	1.9305 - 2.1998	1.3126 - 1.4849
n	82	87	39
CDC 2000	3.2052 cms/mth *p*>0.05	2.1042 cms/mth *p*>0.05	1.4631 cms/mth *p*>0.05

This demonstrates no significant difference evident in length between the CDC and the breastfed infants

Summary of comparison between breastfed group and CDC 2000 group

Between 1 - 3 months both male and female weight gain of slope1 for the breastfed group continues to be above the average weight gain of the slope suggested by the new CDC 2000 reference guide. This is similar to differences found with the NCHS 1977 standard. Between 3 - 6 months only the weight of both genders is significantly different in this time period. The figures show that the rate of growth in weight for slope 2 in the breastfed group begins to slow down at this time. The slope of the CDC 2000 guide remains steeper than the breastfed group. This is also similar to the NCHS 1977 data for weight during the same time period. Between 6 - 12 months when the slope of the breastfed group is compared with the CDC 2000 revised slope, both male and

female breastfed infants are gaining weight at a *slower* rate between 6 - 12 months. Both genders average weight gain is significantly lower than the reference guide. In length, the slope of CDC 2000 reference guide is not significantly different by *p* value ($p>0.05$) when compared with the confidence interval for the breastfed group. There are no differences evident in length for the CDC 2000 reference at the three intervals - slope 1, slope 2 and slope 3 for male and female between 1 month and 12 months.

Testing the null hypothesis

A test of the null hypothesis that the mean is equal to a number, would not be rejected at the 5 % level of significance if that number is contained within a 95% confidence interval for the mean (Griffiths et al. 1998, p.303).

The mean weight and length of male and female infants in the breastfed group and the NCHS reference were compared using the *t test* on the terminal figures at 12 months. This demonstrated that there is *not a significant* difference between the mean weight of breastfed infants for both males and females ($p>0.05$). This is also true for the infants' length ($p>0.05$). (See Table below)

Testing the hypotheses at 12 months on terminal values using NCHS (1977)

At 12 months	B.F. Sample means	NCHS Mean	P-value t test	Significant
Males	Weight 10.27 kg	10.15 kg.	0.8082	No
	Length 75.86 cms	76.1 cms	0.2382	No
Females	Weight 9.39 kg	9.53 kg	0.2731	No
	Length 74.29 cms	74.3 cms.	0.4957	No

From the above calculation, the null hypothesis is not rejected, since there is *no* significant difference between the mean weight and length of breastfed infants, when compared with the values in the NCHS reference, at one year using the *t-test*.

Testing the hypotheses at 12 months on terminal values using CDC 2000

At 12 months	B.F. Sample means	CDC 2000	P-value t test	Significant
Males	Weight 10.27 kg	10.162 kg	0.7864	No
	Length 75.86 cms	74.921 cms	0.9965	No
Females	Weight 9.39 kg	9.367 kg	0.5458	No
	Length 74.29 cms	73.185 cms	0.9980	No

Again there is no significant difference between the values on the terminal figures of the CDC 2000 data and the Australian breastfed group at 12months. This is evident using the *t test* ($p > 0.05$).

Conclusions

The overall pattern of growth of breastfed infants when compared with the NCHS and CDC 2000 on first observations does not present much obvious difference. However on closer inspection the figures contained in the confidence intervals are significantly different at particular intervals. It can be assumed from testing the null hypothesis at 12 months, that Australian breastfed infants when measured against the NCHS (Hamill et al. 1977) and the revised CDC 2000 growth chart, do not vary at the age of 12 months as much as their predecessors varied (Paul et al. 1988; Dewey et al. 1992; Dewey et al. 1995). The results of weight and length at 12 months are not significantly different. However, using the 95% confidence interval for specific time periods it was possible to

compare the slopes of the Australian breastfed group and the current references. The Australian breastfed group grew significantly faster in weight than the current NCHS 1977 reference including the revised CDC 2000 reference, in the first 3 months. Thereafter the Australian breastfed group slowed down significantly in rate of gaining weight, growing more slowly when compared with the NCHS 1977 and the CDC 2000 reference. In length there was no significant difference. Weight observations are more frequently recorded by clinicians than length observations. A serendipitous finding of this study suggests that Australian formula-fed infants might be heavier than breastfed infants at the age of 12 months. This became evident in the process of collecting the data.

Chapter 5 Discussion

Introduction

There are four key findings in this study: -

1. The slope of the breastfed infants' growth trajectory differs at various intervals when compared to the NCHS 1977 and to the revised CDC 2000 growth charts. This is significantly different for weight in the first 12 months and not different in length.
2. The modification of the NCHS (Hamill et al. 1977) data in conjunction with new data has a systematic error whereby the data used still comes from infants who were mainly formula-fed. The revised version - the CDC 2000 reference - contains data of only 21% of fully breastfed infants and 24% of partially breastfed infants at the age of 4 months. 45% were formula-fed from birth (Hediger et al. 2000). Mathematical re-modelling of the NCHS 1977 chart would appear to have compounded existing errors in the revised CDC 2000 version.
3. Clinicians appear to have an over-reliance on weight (only) as a basis for feeding recommendations. This is evident by a greater number of weight observations with comparatively fewer observations for length. This may also have implications for clinical practice when advising women on breastfeeding management.
4. Australian formula-fed infants may be heavier than breastfed infants, as the guidelines for reconstituting formula appear not to have been updated for twenty years.

In this chapter the four key areas of data on the findings will be discussed. Each finding is discussed in the light of literature relevant to the topic within the limitations of this study. An introduction to each key finding is presented followed by a comparison with related literature and a conclusion. Similarities, as well as differences between the

findings of these studies are evaluated and conclusions are assimilated. Implications for clinical practice are presented in the light of relevant literature after this discussion, followed by recommendations. That Australian formula-fed infants may be heavier than their breastfed counterparts is a serendipitous finding of this study and is discussed in the light of literature available. A summary of the conclusions for the chapter and executive recommendations is summarised at the end of the chapter.

Limitations of the study

After 6 months numbers declined which renders statistical analysis less reliable. There are limited numbers for statistical analysis at 12 months. Mothers' responses to breastfeeding are only reliable according to their memory and recall ability. The study had a retrospective data collection. Original data was collected by clinicians in each centre therefore it can only be presumed that each clinician followed the guidelines for anthropometric data collections according to the NHMRC (2003) guidelines. It was not the intention of the researcher to collect data on formula-fed infants therefore the finding that formula-fed infants may be heavier than breastfed infants during the auditing process is considered serendipitous or 'fortunate by accident'.

Breastfed infants' growth trajectory differs at various intervals

Introduction

The breastfed infants in this study were found to have different growth trajectories at various intervals when compared to the two Reference Standards suggested for monitoring the growth of infants in Australia by paediatric clinicians. This is significantly different for weight in the first 12 months but not for length. The theoretical underpinning for this study lies in the belief that Australian breastfed infants have a different growth trajectory to the NCHS reference used (Hamill et al. 1977;

Hamill et al. 1979). Using the 95% confidence interval it was possible to determine if the differences were statistically significantly different in the slopes of the Australian breastfed group by comparing the *p* value. If the *p* value is less than 0.05 then the difference in the angle of the slopes is considered to be statistically significant. The first comparison to be discussed here involves the results of the breastfed infants' data when compared with NCHS 1977 reference, a comparison of these results with relevant literature, conclusion and recommendation.

The Australian breastfed group compared with the NCHS 1977 reference

The Australian breastfed group both males and females grew significantly faster in weight in the first 3 months than the NCHS 1977 reference ($p< 0.05$). In the next three months (3-6 months), both sexes of the Australian breastfed group slowed down significantly in rate of gaining weight, now being slower when compared with the NCHS 1977 ($p< 0.05$). In the next six months (6-12 months) the males' growth trajectory remains the same as the NCHS reference and the females were significantly slower ($p< 0.05$). In length between 6-12 months there was no significant difference when compared to the NCHS 1977 ($p > 0.05$.) - both groups grow in length at a similar rate. Males' weight and length between 6 and 12 months remained at a similar rate to the NCHS 1977. Only the female breastfed infant was growing at a slower rate as she approached the end of the first 12 months when compared with average weight gain of the NCHS 1977 reference. Therefore the breastfed infants in this study demonstrated a difference in growth trajectory when compared to the NCHS 1977 reference. In the first three months the breastfed infants' growth trajectory was faster than the NCHS1977. Thereafter, they slowed down between 3 and 6 months and only the female breastfed

infants continued to gain weight at a slower rate to the NCHS 1977 reference at the end of the first 12 months.

Studies with similar findings

The Australian breastfed group is compared with similar studies from the UK and the USA in their overall findings. Statistical comparisons are not directly possible as some studies used *z* scores based on the standard deviation whereas this Australian breastfed study used confidence intervals based on three gradients in time on those respective growth trajectories. Methodological comparisons therefore, are limited.

In the first 3 months Paul et al. (1988) found in their Cambridge-based study on 48 breastfed infants when they compared them to the NCHS, that by 2 months of age, the mean weight of both sexes was above the 50th percentile. This reflects the findings in the Australian breastfed infants' study over the same time scale. Comparing the means in both of these studies it can also be noticed that the Australian breastfed infants are significantly heavier than the English breastfed infants' by almost one kilogram for weight and more than one centimetre in length. Paul et al. (1988) collected their data in 1978 -80 a time difference of 22 years from this Australian study. (See Appendix I for graphs of visual comparison). Therefore it may be conjectured that over the last 20 years the secular trends of Australian infants have continued to increase. This secular trend may be due to a potential for children to increase in growth in developed countries of the world (Loesch et al. 2000). An explanation for this is offered by Loesch et al. (2000). They concluded in their study on the body height and weight of Australian children and adolescents over the last century that adult stature had increased by up to 2.1cm/decade for males and up to 1.6cm/decade for females. In the last 20 years height has slowed but increases in body weight are continuing at a disproportionate rate and are more obvious in adolescent males and females. It can be seen from this comparison

above, that this trend may also be appearing in infancy. If Paul et al. (1988) collected data on a specifically heterogeneous group in Cambridge, then they are not representative of a diverse population. The Australian breastfed data was collected from a diverse area stretching between metropolitan Sydney and rural Australia and is more likely to have first and second generation ethnic subjects who may have a genetic tendency to be bigger. Could it also be that the Australian breastfed infants are not regulated by 3 or 4 hourly breastfeeds but have "unrestricted" access to the breast as recommended by the WHO guidelines (WHO 1998, p.68)? Alternatively, Paul et al (1988) reported an average of less than 6 breastfeeds per 24 hours in her study, which suggests that infants were regimented to a four hourly breastfeeding schedule. It could also be assumed that the breastfed infants in this study who were recorded as fully/exclusively breastfed, may in actual fact have had 'free' access to breastfeeding and not been scheduled breastfed. Therefore by having more frequent breastfeeds, Australian infants are able to gain more weight at the age of 1 year.

Comparing the Australian breastfed and the Cambridge breastfed infants group between 3 and 12 months revealed some similarities. At 3 months of age the Cambridge infants' growth rate in weight peaked for males and for females after which time a gradual decline in weight was noticed for the next 8 months. Both sexes had gained almost 2kg in the first 3 months and only 1extra kilo in the next 3 months. Compared with the Australian breastfed males in the present study a similar pattern was reflected. In both studies the females' weight declined more noticeably after 6 months up to the age of one year. This may be due to sampling error i.e. limited numbers for statistical analysis at the age of 12 months in both studies.

The Cambridge male and female infants followed a similar growth trajectory in length as they did for weight, where again the females' pattern of gradual decline in growth for

length was more obvious. This pattern of decline in length trajectory was not found in the Australian breastfed infants' study for either sex. When compared with the NCHS 1977 reference in length there is no significant difference. This difference may be due to the limited numbers of subjects' length recorded in this study, in particular after the age of 6 months. This study had a retrospective data collection, which also has limitations. The NCHS 1977 growth reference was produced from the data of infants who were most likely fed 'old style' formula. Measurements were taken three monthly and smoothing of percentile curves were performed manually. The Australian breastfed infants grew faster than this reference in the first 3 months and then grew at a similar rate to the reference except female breastfed infants who slowed down in their rate of growth in weight. When compared with a similar study by Paul et al. (1988) in the U.K. 22 years ago, the growth patterns of both groups were similar. The weight of female infants in both studies declined noticeably towards the end of the first year. Australian breastfed infants were much heavier than their UK counterparts.

Dewey et al. (1995) compared 226 breastfed infants from a pooled North American and north European Caucasian group, with the WHO (1986) standard based on the NCHS 1977 data. Using *z* scores Weight for age (WA) and Length for age (LA), the indices were measured to the nearest month and compared to the WHO/NCHS data.
Infants who were recorded as being breastfed for up to 12months had WA *z* score indices which dropped below the mean of the WHO/NCHS from 3 months onwards. Therefore breastfed infants grew faster than the WHO/NCHS standard for the first 2-3 months after which time the infants' growth rate started to decline up to the age of one year. This reflects the Australian breastfed infants in the present study. Using a confidence interval to compare the NCHS 1977 data between 1 and 3 months, the

breastfed group showed an average weight gain for the time period of 0.9274kg/month for males which was significantly different (p <0.05) from the NCHS value of 0.845kg/month. For breastfed females the average gain per month of 0.7896kg/month which was also significant different (p <0.05) - the NCHS value was 0.710kg/month. The Australian breastfed group grew significantly faster in weight than the NCHS 1977 reference in the first 3 months. Only Australian breastfed males were significantly different in length when compared to the NCHS /WHO data during this time period. Dewey's cohort slowed down in growth between 6 and 12 months and was noticeably below the median for males and females. The longer the infants were breastfed the greater the decline in the z score. The gradient of the decline when compared with the WHO/NCHS was less evident in LA. This slower growth rate after 6 months was more marked for weight than for length. Variation between males and females was not noted for weight or length. Australian breastfed infants vary in this regard as to sex specific trajectories whereby only female infants were seen to be slower between 6 and 12 months.

Conclusion

The breastfed infants of Paul et al. (1988) in the U.K. and the Australian breastfed infants in this study have a different growth trajectory in the first 3 months when compared with the NCHS 1977 reference growth chart used (Hamill et al. 1977; Hamill et al. 1979). In both studies, the breastfed infants' growth trajectory was faster than the NCHS 1977 reference in the first 3 months. Infants in both studies slowed down after 3 months in the rate of growth when compared to the NCHS reference. The female breastfed infants' weight in both studies slowed down after 6 months below the NCHS 1977 reference towards the end of the first year. In length there were differences between the studies, only the Australian breastfed infants length grew at the same rate

as the reference and this may be due to a secular trend in Australian infants or the retrospective collection of data in this study. Australian breastfed infants and the pooled cohort of North American and north European breastfed infants (Dewey et al. 1995) have a similar pattern of growth when compared with the WHO/NCHS reference. In the pooled cohort, the breastfed infants grew faster when compared to the WHO/NCHS standard in the first 2-3 months but the longer the infants were breastfed the more the weight-for-age indices declined. This decline after 3 months was evident for males and females but less evident in length. When compared with Australian breastfed infants in the first 3 months, the patterns of growth between both studies are similar when compared to the NCHS reference. After 3 months, only Australian female infants' growth rate in weight slowed down when compared with the same reference.

Modification of the NCHS reference - the revised version - the CDC 2000.

Mathematical re-modelling of the NCHS 1977 chart would appear to have compounded existing errors in the revised CDC 2000 version. The new *Infant Feeding Guidelines for Health Workers* (NHMRC 2003) just released, suggests the use of the CDC 2000 chart for use in Australia. As the NHMRC (2003) have recommended the use of the revised version of the NCHS 1977 reference - the CDC 2000 - it seemed pertinent therefore to compare the data with the CDC 2000 data. The second key finding to be discussed is the results of the breastfed infants group when compared with the revised version of the NCHS 1977 data - the CDC 2000 reference. As there are no other studies known to be available for similar comparisons, literature in support of the use of the CDC 2000 is presented. Implications for clinical practice and further research follow this literature review and recommendations are presented.

Comparison of the breastfed infants group with the CDC 2000 reference

This comparison demonstrated that when the Australian breastfed infants were compared with the re-modelled version the CDC 2000, an even greater disparity in weight was evident. The Australian breastfed infants between 3 and 12 months gained weight more slowly (were significantly lighter) than the revised CDC 2000 reference. The Australian breastfed group gained significantly more weight in the first 3 months when compared with the revised CDC 2000 reference. During the time period 3 to 6 months, the Australian breastfed group gained weight more slowly, now being significantly slower when compared with the CDC 2000 reference. In length there was no significant difference on any time scale when compared with the CDC 2000. The rate of growth in the slope between 6 months and 12 months for Australian breastfed infants when compared with the CDC 2000 slope shows that both male and female Australian breastfed infants gain weight more slowly than the revised slope. This comparison demonstrated an even greater disparity in weight compared to the previous NCHS (1977). The Australian breastfed group between 6 and 12 months in this study, when compared with the slope of the CDC 2000 gradient remains steeper in weight for *both* male and female infants. There is no significant difference in length for male or female, when compared using the CDC 2000.

Breastfed infants have a different growth trajectory to formula-fed infants (Dewey et al. 1993; Dewey 2001). Breastfed infants' data in this study and breastfed data from other studies indicates that there is a difference evident in the growth trajectory when compared with the data of infants with mixed feeding practices i.e. breast and formula-fed. It could be surmised that in fact the mathematical re-modelling of the NCHS (Hamill et al. 1977) data, in conjunction with new data has a consistent error, which is that the CDC 2000 includes the data of formula fed infants. This partly explains why the

chart is an inadequate constant with which to compare the Australian breastfed infant. This has a potential to increase the error in judgement by comparing Australian breastfed infants with the U.S. CDC 2000 reference, which is based on predominantly formula-fed American infants.

Literature which supports the use of the Revised Version

International research studies published over the last twenty years provided sufficient evidence on the problems with the use of the NCHS 1977 chart. An attempt was made to improve the validity of this chart by a mathematical re-modelling using the LMS Box-Cox formula (Cole et al. 1995). Lindeke et al. (2002) advise us that the new updated growth charts have the benefit of being based on USA national data collected on infants from the age of 3 months- the NHANES III survey -(Kuczmarski et al. 2002) and this is more representative of the nations' ethnic-racial diversity. Smoothed percentile curves were calculated by the use of the LMS method. These researchers argue that there is very little difference in weight gain between breastfed infants when compared with formula-fed infants and that these differences are negligible. Even when ethnicity is taken into account they will also argue that all children will thrive with good nutrition and health care and that growth variability is mainly attributed to environmental and socio-economic factors (Kuczmarski et al. 2002). For this reason Kuczmarski et al. (2002) recommend that 'one chart fits all' and reflects all infants. This may be acceptable for the USA but does this truly reflect Australian infants? The most noteworthy improvement in the new chart is the inclusion of the Body Mass Index (BMI) which can only be used in the clinical setting after the age of 2 years when an accurate standing height can be easily measured.

Conclusion

When the Australian breastfed infants were compared with the CDC 2000 reference, the difference in growth trajectory between the breastfed infants and the revised reference was more consistently demonstrated by statistical analysis reinforcing the NCHS differences. Between 6 and 12 months, the CDC 2000 slope for weight gain is steeper for both male and female infants' when compared with the slope of the Australian breastfed group. This shows an even greater disparity between weights than the NCHS (1977) comparison. The Australian breastfed group slowed down significantly in rate of weight gain after 6 months, now being slower when compared with the CDC 2000. This difference in growth trajectories between the Australian breastfed group and the NCHS (1977) and the CDC 2000 chart has implications for clinical practice.

Implications for clinical practice when using the NCHS reference

The difference in growth trajectories between the Australian breastfed infants group and the NCHS 1977 have implications for clinical practice, which relate to how infants are seen to progress i.e.- thriving or not thriving. This will be seen as the result of comparing breastfed infants with the data of infants who had mixed feeding practices. In particular, the consequence related to scheduled breastfeeding regimes if a history of the breastfeeding management is not obtained is that, by using these charts there is a potential for poor decision making on the part of the novice clinician. For Australian clinicians who weigh breastfed infants clothed and either subtract the difference in weight between bare and clothed weights for assessment, or, who may bare weigh breastfed infants, the following implications could be drawn. After 3 months when the breastfed infants' weight slows down below the current NCHS (1977) reference, this may lead to solids being introduced too early or additional bottles of formula being

offered. It would seem pertinent to use any chart only as an indicator within a complete range of other clinical indicators to decide on the nutritional status of an infant. Thereby using the chart as a 'tool' not a 'rule'. Caution needs to be exercised by clinicians in thoroughly understanding this point.

Implications for clinical practice when using the revised CDC 2000

The new *Infant Feeding Guidelines for Health Workers* (NHMRC 2003) just released, suggests the use of the CDC 2000 chart for use in Australia based on the research by Smith et al. (2000). The guidelines report that these "exclusively breastfed" Aboriginal infants have the same growth rate as the WHO/NCHS reference for the first 6 months of age before the growth rate declines. Based on this article, it also suggests that the differences between breastfed infants and the CDC/WHO chart are "not very significant for Australia" (NHMRC 2003, p.348).

Therefore the use of the NCHS 1977 Revised Version the CDC 2000 reference based on the research of Smith et al. (2000) as suggested by the NHMRC (2003) guidelines, is seriously flawed. This research is not based on appropriate research methodology i.e. it is based on the results of infants with mixed feeding practices notwithstanding it is also based on an ethnic minority group. There will be a systematic error in judgement evident using the revised NCHS 1977 reference, even when using a new mathematical formula to create improved smoothed percentiles, because the CDC 2000 chart was compiled from data where only one-third of infants were breastfed for 3 months (CDC 2002). The data presented in this study demonstrates that the Australian breastfed infants between 3 and 12 months when compared with the revised CDC 2000 reference, were significantly slower to gain weight.

Implications for further research on a chart for Australian infants

A national survey on growth in Australia could establish if the ethnic diversity in the Australian population is the same as that found in the USA population. A national growth survey of Australian infants would seem more appropriate than adopting an American standard where less than one third of the infants are breastfed (CDC 2002). The different growth trajectory between breastfed and formula-fed infants when compared with the NCHS 1977 reference and when compared with one another is reported in the literature on small numbers of infants. By comparing totally breastfed infants with totally formula-fed infants with a large enough number, this may allow for the smoothing effect not obtained with a small sample such as this study on n = 300 or Dewey et al. (1993) n = 87 and Hitchcock et al. (1985) n = 394. Inconsistencies present in this study may be due to sample error. With a larger sample it may be possible to demonstrate that these two groups have quite different growth trajectories. In order to examine this fact, a larger sample may allow such inconsistencies to be established fundamentally. Using a national survey to produce a growth reference that combines the data of infants who are both breastfed and formula-fed may smooth the variations in these infants' growth trajectories. Recently published breastfeeding statistics in the Report of the NSW Chief Health Officer suggests that 43% of infants in NSW in 2001 were breastfeeding at 6 months. This 43% included partially breastfed infants. Only 15% of infants were reported to be fully breastfeeding at 6 months (Public Health Division 2003). This figure of 15% more closely resembles the percentage of infants who were fully breastfed and met the inclusion criteria for this study. Out of 3,523 files audited from the years 1997-2000, only 397 files (or 11.2%) provided suitable data for analysis.

Recommendations for an Australian growth monitoring chart

- Provide an 'ideal chart' which is totally separate for the breastfed infant. However any chart being implemented for use in monitoring the growth of breastfed infants needs to be based on the population for which it is intended for use. This means that breastfed infants' feeding management should be recorded as part of any survey in collecting the data.
- An Australian national survey of growth may provide a more accurate mix of Australian infants under the age of one year who are fed according to the recommended WHO guidelines (WHO 1998). The mix of Australian breastfed infants and formula-fed infants may not be comparable to the USA population.

Numbers of observations for weight are greater than numbers for length

Introduction

The use of the charts by clinicians who may have an over-reliance on weight (only) as a basis for feeding recommendations may also have implications for clinical practice when advising women on breastfeeding management. The results of the data collected in this study are presented which demonstrate this finding. Using the charts to guide advice on lactation and feeding after the age of 3 months is discussed in the light of available literature. The consequences of scheduled breastfeeding regimes are discussed with relevant literature to explain current scientific knowledge on the adverse effect of this practice. Implications for clinicians' practice and recommendation for further research on this topic are presented.

Data observed which may reflect clinicians practice

As demonstrated from the collection of data in this study, clinicians were more focused on the infants' weight gains than their length. This conclusion was reached from observing the number of observations (n) in each of the categories of the slopes. For example, there are less observations (n) for length than weight in slope 1 - males weight n = 103 and males length n = 64. This is similar for females - n = 108 for weight and n = 82 for length. Slope 2 is similar with n = 89 for male weight and n = 70 for male length and female weight n = 99 and female length n = 87. Debate continues among paediatric health professionals, both nationally and internationally, as to the use of the term 'growth reference' and 'growth standard'. The former is suggested for the assessment of infants by the NHMRC guidelines (1996). The term "growth standard" has the potential to be used by paediatric health professionals as a prescriptive device with which individual infants can be compared. Without a thorough knowledge and understanding of infant growth and nutrition, in particular the physiological process of

breastfeeding, any advice given on lactation and feeding using the current charts alone may be inappropriate. In the Central Sydney based survey on CAFH nurses (Patwardhan et al. 1994), though nutrition is linked with growth, the researcher did not report on the CAFH nurses' use of growth charts. However the CAFH nurses reportedly gave inappropriate advice on the use of low iron formula and recommended low fat dairy product is used when introducing infants to solid foods, without evidence to support this advice. From the observations on data collected in this study that clinicians focused more on infants' weight gain than infant length, suggests, all clinicians should act carefully in regard to using growth charts. The consequences of using the chart to assess lactation between 3 months and 6 months when the weight gain begins to slow down, is likely to be the early introduction of solid foods and/or complementary feeding. The implication for clinicians using NCHS 1977 and CDC 2000 charts is, if they see an infant's weight gain begin to "fall off" they may suggest that parents offer bottles of formula or solid foods. Complementary feeding with breastmilk substitutes has been associated with early weaning from the breast (Perez-Escamilla et al. 1996).

Scheduled breastfeeding regimes

Clinicians also need to obtain a history on the breastfeeding management for each mother-infant dyad prior to giving advice on feeding the infant, which may be based on the chart, as the consequences of scheduled breastfeeding regimes may be inadequate weight gain. Australian breastfed infants in this study are heavier than both the Cambridge infants (Paul et al. 1988) and the pooled data set (W.H.O. 1994; Dewey et al. 1995). Dettwyler (1997 p.60) reported that Dewey conceded more than likely the breastfed infants of the DARLING study (Dewey et al. 1992) were also scheduled to four hourly breastfeeds and slept alone in cribs. This suggests that in fact if breastfed infants had more access to the breast they would gain more weight. McKenna (1997) in his

study on Mother and breastfed infant-pairs, reported that the infants who co-slept with their mothers, breastfed more frequently. He concluded that solitary sleeping restricted breastfed infants feeding patterns (McKenna et al. 1997).

Woolridge (1995) has suggested from his studies on breastmilk constitution, that the fat content in breastmilk is the most important factor for the infants' satiety and ultimately the weight gain. The frequency of the breastfeeds affects the concentration of fat in the milk. - The greater the space between the breastfeeds the lower the level of fat in the breastmilk ($p<0.001$) (Woolridge 1995). Therefore it is more than likely that scheduled breastfeeding reduces the weight gain of breastfed infants. Clinicians need to understand these facts before giving advice to breastfeeding women, which may be based on an inappropriate growth chart.

Conclusion

From the researchers clinical experience as well as being demonstrated from the collection of data in this study - clinicians are more focused on the infants' weight gains than their length. A thorough knowledge and understanding of infant growth and nutrition is required by paediatric health professionals, in particular the physiological process of breastfeeding. Any prescriptive advice given on lactation and feeding using a chart alone may be inappropriate. Whether infants are compared individually or in a group, using the NCHS chart (Hamill et al.1979), or the CDC (2002) revised growth chart, all conclusions reached, using weight alone for assessment, should be viewed cautiously. Paediatric health professionals must first consider any scheduled feedings or timed feeds in addition to the use of pacifiers and obtain a history of the breastfeeding management.

Implications for clinicians' practice

From the data presented in this study, if clinicians use the existing charts as a guide to monitor adequate ('good') weight gain of breastfed infants then these infants will be seen as not gaining adequate weight, or "failure to thrive" after the age of 3 months. It follows that clinicians also using the CDC 2000 chart, as a guide for 'good' weight gain for breastfed infants will also view them as not gaining satisfactory weight. This in turn has a potential to lead to the suggestion for offering breastmilk substitutes, with which it has been demonstrated to be associated with early weaning from the breast. Parents and caregivers need advice about offering bottles of formula to breastfed infants between 3 months and 6 months when they appear to be slowing in growth. This has a potential to occur when the infant is compared to the NCHS 1979 chart or the revised CDC 2000 chart. Individual infants may be incorrectly viewed as "failing to thrive" when in fact they are naturally slowing down in growth. Any complementary foods have the potential risk of compromising milk supply if offered prior to the WHO (2002) recommendation at 6 months (Stuff & Nichols 1989).

Implications for further research

Research is required on clinicians who use weight performance charts on breastfed infants. This research may help to establish the vigilance of clinicians to bear in mind the variation in growth trajectory, especially when using their clinical judgement that a breastfed infant is over nourished, undernourished or well nourished. If novice practitioners are shown how to use the chart by exercising their clinical judgement, this has the potential to avoid referring breastfed infants for intervention or further investigations, when in fact they are following an established growth trajectory. This may only be possible by reflecting on practice, as such an understanding is only gained

from experiential knowledge, rather than formal theoretical education (Schon 1987). Parents who use these charts in their infants' Personal Health Record book also need guidance and advice on this aspect of their infant's growth.

Further research is needed to find out how/if Child and Family Health nurses use these charts and what advice they provide in relation to complementary foods and the introduction of solid foods to breastfed infants.

Recommendations

- Qualitative research on all community paediatric health professionals who use weight/growth performance charts on breastfed infants. Use Focus Groups to find out, if/how they use weight and length charts in relation to infant feeding recommendations. How are infants weighed - bare or clothed? Are charts used for client satisfaction, history taking or referral criteria? What advice do health professionals give to parents on breastmilk substitutes (extra bottles of formula), schedule and night-time breastfeeding?
- Use Focus Groups with parents and caregivers to establish if CAFH nurses meet their needs and to find out whose advice they seek and readily accept in regards to infant nutrition. Do the groups match in outcomes?

Australian formula-fed infants may be heavier than breastfed infants

Introduction

Australian formula-fed infants may now be heavier than breastfed infants, as guidelines recommend volumes of formula on the label of tins that appear not to have been up dated for twenty years. This was a serendipitous finding in this study and is discussed in the light of literature available. The discussion here includes the topics of 'intentional overfeeding' and social class, excessive guidelines on the label of the tin versus the suggested lowering of the RDA/RDI for infants and the influence of advertising formula on health care professionals as well as parents and caregivers.

Discussion

Research literature has demonstrated that there is a difference between the growth of formula-fed infants and breastfed infants. In the DARLING Study by Dewey et al. (1993) the researchers found that at 12 months, 15% of formula-fed infants (n = 41) had weight-for-length standard deviations over the 90th percentile when compared with only 7% of the breastfed infants (n = 46). The researchers concluded in this study that breastfed infants were leaner than formula-fed infants were. Hitchcock et al. (1985) and Agostoni et al. (1999) demonstrated in their studies that the longer the infant was breastfed the more slowly the infant gained weight. It is reasonable to suspect that the formula-fed Australian infants are also, on average, heavier than their breastfed counterparts at the age of 12 months. This was evident by reflecting on the process of auditing the files in the Early Childhood Health Centres. During the first week of collecting the data, a systematic approach of auditing the files from birth to 12 months looking for infants' weight and length seemed to be the appropriate method. However after the first week it became apparent that formula-fed infants, on average, all weighed approximately 12kg or above at 12 months, whereas breastfed infants weighed 10kg or

less. It was quicker thereafter, to begin the audit at 12 months and observe this terminal weight. If at 12 months an infant weighed 12kg or more, a quick glance at the preceding entries typically revealed that the infants had been drinking formula for at least 6 months. It is reasonable to assume then, that there is still a difference in the weight gain trajectory of breastfed infants when compared with formula-fed infants in Australia. However the limited data available for analysis at one year in this retrospective study suggests, that further research is required with larger numbers to finally establish these two feeding groups' different weight gain trajectories.

If the differences in the weight /growth trajectories between the breastfed infants and formula-fed infants are not demonstrated by sampling error -(using a larger sample)- another possibility is that formula-fed infants actually are heavier and tend to gain more weight over the age of 6 months than breastfed infants. There are two possible reasons for this

(i) Parents are overfeeding by using heaped scoops or extra scoops or

(ii) Parents are feeding according to the guidelines on the label of the tin and these guidelines are excessive.

'Intentional overfeeding' and social class

'Intentional overfeeding' by parents has consequences for infant health. Overfeeding and inaccuracies in the reconstitution of formula will lead to extra kcals being given to formula fed infants. This subsequently has an effect on growth.

Fein and Falci (1999) in their USA study found high levels of non-compliance with the manufacturers instructions for reconstituting infant formula. Mothers came from a higher SES group and had higher education. Reasons given by mothers who gave concentrated formula were:

- To get baby to sleep through the night
- To thicken the formula as the baby was possetting
- To make the baby grow

Lilburn et al. (1988) found there was no change in social class on the re-constituting of infant formula with over-concentration as the most likely error. The researchers concluded that the mothers reported they frequently made up over-concentrated formula and this was clearly evident by the laboratory test results performed on the milk samples they provided. In fact the recommended scoop was more inaccurate than weighing the powder separately. Bennett and Gibson (1990) in their South Australian study reported 96% of parents as being self-taught and most subjects learned their instructions from following the recommendations on the can. The authors reported that over-concentrated reconstitution of formula as the most prevalent finding. Lilburne et al. (1988) reported that the scoop was the most inaccurate method with which to prepare the formula. It is not surprising that mothers are confused as the variations in making up formula range considerably - Nan reconstitution is 1 scoop of powder to 30mls of water; S26 is 1 scoop to 60mls of water and Karicare is 1 scoop to 50mls of water. To standardise one scoop for all powders may help to regulate this practice however corporate food manufacturers are likely to charge a lot more for pre-packed formula. However if the lower SES groups are more likely to use formula, they will also pay more for this product. Given that the risks of hypernatremia from feeding infants with high solute loads have been documented more than 20 years ago (Paneth 1980) it is surprising that this practice continues. It could be surmised that the instructions on the label of the tin might also be biased to selling more formula and tending to be over-concentrated even when made up according to the instructions on the label. An opportunity exists to market new products to young and vulnerable mothers. We need to examine the

advertising schemes. Are the recommended RDA/RDI's on the label of the tin excessive and do they require evaluation? If 96% of parents/carers follow the instructions on the label of the tin (and this was rated as having the strongest influence on formula making preparation), if the RDA/RDI is excessive, then infants drinking formula will be consuming unnecessary kcals which has consequences for growth.

In the present study on breastfed infants the time solids commenced was

Age	**No (n)**
3 months	6
4 months	163
5 months	135
6 months	41
Total	345

Therefore 88% of the breastfed infants in this study were on solids before 6 months. Mehta et al. (1998) reported that the early consumption of solid foods replaces the energy that would be provided by formula and reached the conclusion that starting solids early in infancy does not change the pattern of infant growth for formula-fed in the first 12 months. Researchers Stuff and Nichols (1989) reported similar findings with breastfed infants - the introduction of solid foods early did not minimise the decline in growth of the breastfed infants. After solids were commenced even though infants had free access to breastfeeding, the infants did not increase their energy intake but self regulated by consuming the same amount of kcals. We can presume then, that the infant's weight generally is not affected by the introduction of solid foods, consequently, we may also presume that the formula consumed by infants must make the difference to weight gain. Shepherd (1988) noticed that the formula-fed infants drank less formula during the study period, than the guidelines recommended at the time. The authors concluded at the time that further research and re-evaluation was required on lowering RDA / RDI for infants.

Conclusion

In the Australian surveys reported in the literature review presented in Chapter 2, the key finding presented was an over-concentration of formula. This preparation was more common among the less educated mothers in one study (Bennett & Gibson 1990) but numbers are biased in favour of this class. In the other, there was no change in social class on the reconstituting of infant formula but social status was only reported on geographical location (Lilburne et al. 1988). This contrasts with the USA where 35% of mothers add cereal to bottles of formula for feeding their infants and this entire group were considered high SES (Fein & Falci 1999). Introducing solids early to infants has not been associated with greater weight gain in the first year. The recommended guidelines on the label of the tin appear to have remained unchanged for twenty years.

Excessive guidelines on the formula tin

Whitehead (1995, p.243) recommended that the RDA/RDI be lowered from 70 kcal/100mL to 60 kcal/100mL and he suggested that 850mL of breastmilk is a "reasonable average" for an infant at 4 months. In Australia, the instructions for parents/caregivers on the tins of formula have been recommending the same quantity of formula for infants for the last twenty years. As the popularity of infant formula-feeding grew through the 1980's the total volume suggested, for any breastmilk substitute, was approximately 720mLs to 1125mLs between 3 and 4 months of age (Dept. of Health 1983, p. 45). Today a visit to the supermarket in August 2003 revealed that several brands of infant formula namely S26, Karicare, Enfalac, and SMA still recommend that volumes of formula between 960mLs to 1200mLs are suitable for feeding infants between 4 and 6 months. It follows that infants would be overfed from following the guidelines on the can, using the outdated inflated values for nutritional intake. Questions must be raised about the reluctance of these companies to investigate the implications of

the RDA/RDI recommendations (Whitehead 1995) of Infant Nutritional values. Modifications to labelling would be relatively easy for these companies to administer. Realistically, an infant following the 1995 RDA/RDI (Whitehead 1995) recommendations would consume less formula. To categorically answer this question - if formula-fed infants are overweight -, further research is required. Further research is also needed to survey the behaviour of many more parents/caregivers who feed infants on formula and solid foods. We need to find out whose advice they most readily accept i.e. - a chemist, a health professional, the instructions on the tin of formula, advertising on packets and jars, their own parents or another source. If by following 2000 parents, who feed their infants on formula exactly according to the guidelines on the tin, we find 75% of these infants are on the 90^{th} percentile, it could be concluded that these infants are overweight. Therefore we could also conclude that this is the result of recommendations on the tin as well as calculations. We are seeing the implications of this in a clinical population.

Advertising may promote overfeeding

In Central Sydney (Patwardhan et al. 1994), researchers reported that CAFH nurses' responses demonstrated that they were unclear about the use of reduced-iron formula and suggested it for constipation without evidence to support this advice. CAFH nurses may be prone to the advertising schemes of the formula companies. Further research is required to find out what influence advertising has on parents and CAFH nurses' nutritional ideology. This low iron formula was available even though it was potentially dangerous for young infants but the product was subsequently discontinued. More research is needed to investigate formula products' sales promotion. Infants in the 2-4 months old age group who were taking solids were all from the lower SES group (Retallack et al. 1994). Is advertising responsible for this? Observe infant food

advertising in any supermarket. On the front of every packet and jar of baby food can be seen in large letters suitable for 4 months, etc. This seductive advertising also promotes the early introduction of solids foods, which many parents will interpret to mean "in or near 4 months" and begin offering solid food at 3 months. This early introduction to solid foods can be seen in this study where 88 % of the breastfed infants were consuming solid foods before the age of 6 months. However not being present at each interview it may be that CAFH nurses recommended this practice and the SES of this breastfed group was not a variable selected for this study. Infant food advertising may be playing a role in undermining the importance of breastfeeding exclusively up until 6 months. Research is also needed to investigate the sales promotion of infant foods. In the Bennett and Gibson (1990) study, 96% of carers reported that they taught themselves how to make formula. It is reasonable to suggest that a focus of research be recommended to target the manufacturers and advertisers of both infant formula and infant solids foods. Palmer (1993, p.208) describes what she perceives to be a "medical/commercial" relationship between manufacturers and medical personnel. This has blossomed to target a vulnerable market of new and young families unfamiliar with the indiscreet marketing of formula in the underdeveloped world. However while our attention has been distracted towards the Third World, markets closer to our local supermarkets are also being targeted and she suggests that the medicalisation of childbirth has undermined women's confidence (Palmer 1993). We can speculate that in relation to breastfeeding the taboo called "losing my breastmilk" is a self-fulfilling prophecy.

Conclusion

Whitehead (1995) recommended that the RDA/RDI be lowered and an infant following the 1995 RDA/RDI recommendations would consume less formula. The popularity of infant formula feeding has grown throughout the 1980s and 90s. Parents/caregivers have been following instructions on the labels of tins of formula, to offer volumes to infants that have not changed for the last twenty years. Further research is required to establish if formula-fed infants are overweight. Further research is also needed to survey the behaviour of many more parents/caregivers who feed infants on formula and solid foods. By following a larger sample of parents who feed their infants according to the guidelines on the tin and whose infants are overweight it could be concluded therefore, that we are seeing the implications of this in a clinical population. Health professionals too, may be prone to the advertising schemes of the formula companies. Further research is required on parents and health professionals to find out what influence advertising has on their nutrition ideology. Weaning practices among the lower SES group, reflect the early introduction of solid foods (Retallack et al. 1994) and this group may be receptive to advertising rather than advice on good nutrition that is given by health professionals. In this study 88 % of the breastfed infants were consuming solid foods before the age of 6 months. The SES of this breastfed group was not a variable selected for this study and not being present at each interview lessens efficacy.

Recommendations

- A larger scale research project is required to find out if Australian formula-fed infants are overweight when compared to Australian breastfed infants.
- Further investigation by the use of an enquiry into the regulation of formula companies who continue to recommend the same volume of formula on their tins for the last twenty years. This last recommendation follows from practising in the area of infant nutrition since 1985. Lowering the recommended volumes on the tins of formula following this research.
- Banning the advertising of solids foods to infants under the age of 6 months by manufacturers, urgently needs to be researched and implemented.
- Measure the influence of advertising on parents and CAFH nurses and it's relation to infant nutrition.

Summarising the discussion conclusions

Paul et al. (1988) in the U.K. and the researcher in this study on Australian breastfed infants both found that breastfed infants' growth trajectory was faster than the NCHS 1977 reference in the first 3 months. After 3 months the rate in growth of the infants in both studies slowed down below the NCHS 1977 reference but only the female breastfed infants' weight in both studies continually slowed down after 6 months towards the end of the first year. This may be due to sample error. When the Australian breastfed infants and the pooled breastfeeding cohort (Dewey et al. 1995) were compared using the WHO/NCHS reference, both groups of breastfed infants grew faster in the first 3 months. After 3 months, only Australian female infants' growth rate in weight slowed down when compared with the same reference. When the Australian breastfed infants group were compared with the revised version - the CDC (2000) reference - between 6 and 12 months, they slowed down significantly in rate of gaining weight after 6 months, now being slower when compared with the CDC (2000). This comparison in weight showed an even greater disparity statistically, when compared with the NCHS (1977). Therefore the mathematical re-modelling of the existing NCHS (1977) reference would appear to have compounded existing errors in producing the CDC (2000) reference. From the data collected in this study, clinicians appear more focused on the infants' weight gains than their length. A thorough knowledge and understanding of the physiological process of breastfeeding is required by health professionals before any prescriptive advice is given on lactation and feeding without using a chart alone. The implications for clinical practice are if clinicians use either of the existing charts as a guide to monitor adequate ('good') weight gain of breastfed infants then these infants will be seen as not gaining adequate weight, or "failure to thrive" after the age of 3 months. This has a potential to lead to the suggestion of

offering breastmilk substitutes. A serendipitous finding in this study is that Australian formula-fed infants may be heavier than breastfed infants. One possible explanation is that formula company manufacturers recommend volumes of formula on the label of tins that appear excessive. Whitehead (1995) recommended that the RDA/RDI be lowered therefore an infant following the 1995 RDA/RDI recommendations would consume less formula. Differences in the growth trajectories between the breastfed infants and formula-fed infants reported in the literature to date may be due to sample error. Further research is required with larger numbers to finally establish if formula-fed infants are overweight when compared with breastfed infants. The literature reports mixed outcomes in relation to 'intentional overfeeding' and social class. In a survey by Bennett and Gibson (1990), 96% of carers reported that they taught themselves how to make formula. Over-concentration in formula reconstitution was the most common finding in Australian surveys and this was more common among the less educated mothers in one study but the opposite is reported in the USA. One standard scoop for all powders may help to regulate this practice. The SES of this breastfed group was not a variable selected for this study. 88% of breastfed infants in this study were consuming solid foods before 6 months. Advertising infants' formula may be impacting on health care professionals as well as parents and caregivers. Further research is needed to find out how this affects infant nutrition. Infant food advertising may be playing a role in undermining the importance of breastfeeding exclusively up until 6 months. Further research is also needed to investigate the sales promotion of infant foods.

Executive Recommendations

- Provide an 'ideal chart' which is totally separate for the breastfed infant. This means that breastfed infants feeding management should be recorded as part of any survey in collecting the data.
- An Australian national survey of growth may provide a more accurate mix of Australian infants under the age of one year who are fed according to the recommended WHO guidelines (WHO 1998).
- Qualitative research on community paediatric health professionals who use weight/growth performance charts on breastfed infants. Are charts used for client satisfaction, history taking or referral criteria? What advice do health professionals give to parents on breastmilk substitutes (extra bottles of formula), schedule and night-time breastfeeding?
- Use Focus Groups with parents and caregivers to establish if CAFH nurses meet their needs. Do the groups match in outcomes?
- A larger scale research project is required to find out if Australian formula-fed infants are overweight when compared to Australian breastfed infants.
- Further investigation by the use of an enquiry into the regulation of formula companies who continue to recommend the same volume of formula on their tins for the last twenty years. Lowering the recommended volumes on the tins of formula following this research.
- Banning the advertising of solids foods to infants under the age of 6 months by manufacturers, urgently needs to be researched and implemented.
- Measure the influence of advertising on parents and CAFH nurses and it's relation to infant nutrition.

Chapter 6 Conclusion

The aim of this study was to collect sufficient data on the weight and length of a large number of infants who were reported as fully/exclusively breastfed. The intention was to compare the aggregated data with the current NCHS (Hamill et al. 1977) reference and the revised version - the CDC 2000 growth chart. The purpose was to establish if a difference in growth trajectory existed between current Australian breastfed infants and the standard references recommended for use in Australia. The study was not representative of all breastfeeding mothers because subjects were attendees of a Child Health Service and only those women reported as exclusively breastfeeding their infants by the Child and Family nurses met the criteria for inclusion in this study. The research hypothesis was, that the mean weight and length of breastfed infants, was significantly less at 1 year than the NCHS reference (Hamill et al. 1977) currently in use and with the revised CDC (2000) reference chart. Therefore the null hypothesis was that the mean weight and length of breastfed infants at 1 year are equal to the "true" mean weight and length of the Hamill et al. (1977) NCHS reference currently used at the time. The results at 12 months were *not significant* using a *t test* and the null hypothesis was not rejected. It was assumed from testing the null hypothesis at 12 months, that Australian breastfed infants when measured against the current NCHS (Hamill et al. 1977) and the revised CDC 2000 growth chart, did not vary at the age of 12 months as much as their predecessors varied. There may be a secular trend for children to increase in growth in developed countries of the world (Loesch et al. 2000). Also, if the breastfed infants in this study who were recorded as fully/exclusively breastfed, had more access to breastfeeding and had not been scheduled breastfed, they may have gained more weight by the age of 1 year.

However, using the 95% confidence interval for specific time periods it was possible to compare the slopes of the Australian breastfed group and the current references by comparing the *p* value. This demonstrated that the Australian breastfed group grew significantly faster in weight than the current NCHS 1977 reference including the revised CDC 2000 reference, in the first 3 months. Thereafter the Australian breastfed group slowed down significantly in rate of gaining weight, growing more slowly when compared with the NCHS 1977 and the CDC 2000 reference. In length there was no significant difference. It could be surmised that in fact the modification of the NCHS (Hamill et al. 1977) data, in conjunction with new data has a consistent error. The revised version - the CDC 2000 reference, contains the data of only 21% of fully breastfed infants and 24% of partially breastfed infants at the age of 4 months and 45% were formula fed from birth (Hediger et al. 2000). This may explain why the chart is an inadequate constant with which to compare the Australian breastfed infant and it may also have implications for clinical practice. The theoretical underpinning for this study lies in the belief that Australian breastfed infants have a different growth trajectory to the NCHS reference used (Hamill et al. 1977; Hamill et al. 1979). Comparisons of the results from this study made with literature in the UK (Paul et al. 1988) demonstrated that the breastfed infants' growth trajectory was faster than the NCHS 1977 reference in the first 3 months. After this time these breastfed infants slowed down in the rate of growth when compared to the NCHS reference. The female breastfed infants' weight in both studies slowed down after 6 months below the NCHS 1977 reference towards the end of the first year. In length there were differences between the studies, only the Australian breastfed infants length grew at the same rate as the reference and this may be due to a secular trend in Australian infants or the retrospective collection of data in this study.

When the pooled cohort of breastfed infants (Dewey et al. 1995) was compared with the Australian breastfed infants in the first 3 months, the patterns of growth between both studies are faster when compared to the NCHS reference. After 3 months, the pooled cohort continued to decline in rate of growth up to one year and this may be due to scheduled breastfeeding management. The Australian female infants' growth rate in weight slowed down after 3 months when compared with the NCHS reference. When the Australian breastfed infants were compared with the CDC 2000 reference between 6 and 12 months, the CDC 2000 gradient now remained faster in weight for both male and female infants' when compared with the slope of the Australian breastfed group. This showed an even greater disparity in weight statistically, than the NCHS (1977). The Australian breastfed group slowed down significantly in rate of gaining weight after 6 months, now being slower when compared with the CDC 2000.

The collection of data in this study demonstrated that clinicians were more focused on the infants' weight gains than their length. This conclusion was reached from observing the number of observations (n) in each of the categories of the slopes where there were more observations available for weight than there were for length. There are implications for clinical practice with this ideology when combined with the difference in growth trajectories between the Australian breastfed group and CDC 2000 chart. From the data presented in this study, if clinicians use the existing charts as a guide to monitor adequate ('good') weight gain of breastfed infants then these infants will be seen as not gaining adequate weight or as "failure to thrive" after the age of 3 months. This in turn has a potential to lead to the suggestion for offering breastmilk substitutes.

A serendipitous finding in this study was that Australian formula-fed infants might be heavier than breastfed infants may. Two possible explanations for this were suggested - that parents are overfeeding used heaped scoops of powder i.e. 'intentional overfeeding'

or that parents are following the guidelines on the label of the formula tins and these volumes are inflated. Whitehead (1995) recommended that the RDA/RDI be lowered therefore an infant following the 1995 RDA/RDI recommendations would consume less formula. Over-concentration in formula reconstitution was the most common finding in Australian surveys and this was more common among the less educated mothers in one study. One standard scoop for all powders may help to regulate this practice. 88% of breastfed infants in this study were consuming solid foods before 6 months, however the SES of this breastfed group was not a variable selected. Advertising infants' formula may be impacting on health care professionals as well as parents and caregivers but further research is needed to find out.

Further research is needed to provide an 'ideal chart' which is totally separate for the breastfed infant that takes account of the breastfeeding management. A national survey of growth in Australia may provide a more accurate mix of Australian infants under the age of one year rather than an American growth chart. Qualitative research with community paediatric health professionals who use weight/growth performance charts on breastfed infants is required to establish their use of charts. What advice do health professionals give to parents on breastmilk substitutes (extra bottles of formula), schedule and night-time breastfeeding? A large-scale research project is required to find out if Australian formula-fed infants are overweight when compared to Australian breastfed infants. Further investigation by the use of an enquiry into the regulation of formula companies who continue to recommend the same volume of formula on their tins for the last twenty years and lowering the recommended volumes on the tins of formula following this research. Banning the advertising of solids foods to infants under the age of 6 months by manufacturers, urgently needs to be researched and implemented.

References

Agostoni, C., Grandi, F., Gianni, M. L., Silano, M., Torcoletti, M., Giovannini, M. & Riva, E. 1999, 'Growth patterns of breast fed and formula fed infants in the first 12 months of life: and Italian study.' *Archives of Disease in Childhood,* vol. 81, pp. 395-399.

Auerbach, K. G., Renfrew, M. J. & Minchin, M. 1991, 'Infant feeding comparisons: A Hazard to infant health?' *Journal of Human Lactation,* vol. 7 (2), pp. 63-71.

Australian Nutrition Foundation Inc. 1987, *Food for Kids,* The Australian Nutrition Foundation, Sydney.

Bennett, J. & Gibson, R. A. 1990, 'Inaccuracies in reconstituting infant formulas', *Australian Journal of Nutrition and Dietetics,* vol. 47 (1), pp. 27-30.

Butte, N. F., Wong, W. W., Hopkinson, J. M., O'Brian Smith, E. & Ellis, K. J. 2000, 'Infant Feeding Mode Affects Early Growth and Body Compostition', *Pediatrics,* vol. 106 (6), pp. 1355-1366.

Center for Disease Control 2002 "CDC Growth Charts: United States Comprehensive Report on 2000 Growth Charts Available", http://www.cdc.gov/nchs/about/major/nhanes/growthcharts/datafiles.htm. **26/10/2002**.

Cole, T. J., Freeman, J. V. & Preece, M. A. 1995, 'Body mass index reference curves for the UK, 1990', *Archives of Disease in Childhood,* vol. 73, pp. 25-29.

Commonwealth of Australia 1998, *Recommended dietary intakes - is it time for a change?* Commonwealth Department of Health and Family Services, Canberra, ACT.

Daniel, A. 1983, *Power, Privilege and Prestige: Occupations in Australia,* Longman Cheshire, Melbourne.

Department of Health 1983, *Our Babies from birth to school,* Health Promotion, in collaboration with Maternal and Child Health, New South Wales State Health Publication No. (HSU) 82-005.

Dettwyler, K. A. 1997, *Throwing a Curve at Growth Charts*, NMAA International Conference, Breastfeeding -The Natural Advantage-, Royal Randwick Racecourse, Sydney, NSW, Australia, NMAA now known as Australian Breastfeeding Association.

Dewey, K. G. 1998, 'Growth Patterns of Breastfed Infants and the Current Status of Growth Charts for Infants', *Journal of Human Lactation,* vol. 14 (2), pp. 89-92.

Dewey, K. G. 2001, 'Nutrition, Growth, and Complementary Feeding of the Breastfed Infant', *Pediatric Clinics of North America,* vol. 48 (1), pp. 87-104.

Dewey, K. G., Heinig, M. J., Nommsen, L. A., Peerson, J. M. & Lonnerdal, B. 1992, 'Growth of Breast-Fed and Formula-Fed Infants From 0 to 18 Months: The DARLING Study', *Pediatrics,* vol. 89, June (6), pp. 1035-1041.

Dewey, K. G., Heinig, M. J., Nommsen, L. A., Peerson, J. M. & Lonnerdal, B. 1993, 'Breast-fed infants are leaner than formula-fed infants at 1 y of age: the DARLING Study', *American Journal Clinical Nutrition,* vol. 57, pp. 140-145.

Dewey, K. G., Peerson, J. M., Brown, K. H., Krebs, N. F. & W.H.O. Working Group on Infant Growth 1995, 'Growth of Breast-Fed Infants Deviates from Current Reference Data:A Pooled Analysis of U.S., Canadian and European Data Sets', *Pediatrics: American Academy,* vol. 96, pp. 495-503.

Diaz, S., Herreros, C., Aravena, R., Casado, M., Reyes, M. & Schiappacasse, V. 1995, 'Breast-feeding duration and growth of fully breast-fed infants in a poor urban Chilean population', *American Journal Clinical Nutrition,* vol. 62, pp. 371-6.

Earle, S. 2002, 'Factors affecting the initiation of breastfeeding: implications for breastfeeding promotion', *Health Promotion International,* vol. 17 (3), pp. 205-214.

Fein, S. B. & Falci, C. D. 1999, 'Infant formula preparation, handling and related practices in the United States', *Journal of the American Dietetic Association,* vol. 99 (10), pp. 1234-40.

Freeman, J. V., Cole, T. J., Chinn, S., Jones, P. R. M., White, E. M. & Preece, M. A. 1995, 'Cross sectional stature and weight reference curves for the UK, 1990', *Archives of Disease in Childhood,* vol. 73, pp. 17-24.

Graham, V. A., Gibbons, K., Marraffa, C., Henry, L. & Myers, J. 1998, 'Filling the gap: Weaning practices of children aged 0-2 years in western metropolitan Melbourne', *Journal of Paediatrics and Child Health,* vol. 34 (6), pp. 513-517.

Griffiths, D., Stirling, D. W. & Weldon, L. K. 1998, *Understanding Data: Principles & Practice of Statistics,* Jacaranda Wiley Ltd, Brisbane, Qld.

Hamill, P. V. V., Drizd, T. A., Johnson, C. L., Reed, R. B. & Roche, A. F. 1977, *NCHS Growth Curves for Children Birth - 18 years,* U.S. Dept. of Health, Education, and Welfare, Public Health Service, National Center for Health Statistics, Hyattsville,Md. USA.

Hamill, P. V. V., Drizd, T. A., Johnson, C. L., Reed, R. B., Roche, A. F. & Moore, W. M. 1979, 'Physical growth: National Center for Health Statistics percentiles', *American Journal of Clinical Nutrition,* vol. 32, pp. 607-629.

Hediger, M. L., Overpeck, M. D., Ruan, W. J. & Troendle, J. F. 2000, 'Early infant feeding and growth status of US-born infants and children aged 4-71 mo: analyses from the third National Health and Nutrition Examination Survey, 1988-1994,' *American Journal of Clinical Nutrition,* vol. 72, pp. 159-167.

Hibbert, C. & Crookes, P. A. 1998, 'Accessing sources of knowledge' in *Research into Practice: Essential skills for reading and applying research in nursing and health care,* Eds. P. A. Crookes and S. Davies, Baillierre Tindall, London.

Hitchcock, N. E. & Coy, J. F. 1988, 'Infant-feeding practices in Western Australia and Tasmania: a joint survey, 1984-1985', *The Medical Journal of Australia,* vol. 148, Feb 1, pp. 114 -117.

Hitchcock, N. E. & Coy, J. F. 1989, 'The growth of healthy Australian infants in relation to infant feeding and social group', *The Medical Journal of Australia,* vol. 150 (March 20), pp. 306-311.

Hitchcock, N. E., Gracey, M. & Gilmour, A. I. 1985, 'The Growth of Breast Fed and Artificially Fed Infants from Birth to Twelve Months', *Acta Paediatrica Scandinavica,* vol. 74 (2), pp. 240 - 245.

Hitchcock, N. E., Owles, E. N. & Gracey, M. 1981, 'Breastfeeding and growth of healthy infants', *The Medical Journal of Australia,* vol. 2 (November 14), pp. 536-537.

Karr, M. A., Mira, M., Alperstein, G., Labib, S., Webster, B. H., Lammi, A. T. & Beal, P. 2001, 'Iron deficiency in Australian-born children of Arabic background in central Sydney', *Medical Journal of Australia,* vol. 174, Feb (4), pp. 165-168.

Kuczmarski, R. J., Kuczmarski, M. F. & Roche, A. F. 2002, '2000 CDC Growth Charts:background for clinical application.(Centers for Disease Control and Prevention)', *Topics in Clinical Nutrition,* vol. 17, March (i2), pp. 15-27.

Labbok, M. & Krasovec, K. 1991, 'Toward Consistency in Breastfeeding Definitions', *Breastfeeding Review,* vol. July, pp. 121-124.

Lilburne, A. M., Oates, R. K., Thompson, S. & Tong, L. 1988, 'Infant feeding in Sydney: A survey of mothers who bottle feed', *Australian Paediatric Journal,* vol. 24, pp. 49-54.

Lindeke, L. L., Rogers, S. & Finley, L. 2002, 'An update on growth charts, old and new. (Primary Care Approaches)', *Pediatric Nursing,* vol. 28 March-April, (i2), pp. 138-141.

Loesch, D. Z., Stokes, K. & Huggins, R. M. 2000, 'Secular Trend in Body Height and Weight of Australian Children and Adolescents', *American Journal of Physical Anthropology,* vol. 111, pp. 545-556.

Male, C., Persson, L. A., Freeman, V., Guerra, A., van't Hof, M. A., Haschke, F. & Euro-Growth Iron Study Group 2001, 'Prevalence of iron deficiency in 12-mo-old infants from 11 European areas and influence of dietary factors on iron status (Euro-Growth study).' *Acta Paediatrica,* vol. 90, May (5), pp. 492 - 498.

McKenna, J. J., Mosko, S. & Richard, C. 1997, 'Bedsharing Promotes Breast Feeding', *Pediatrics,* vol. 100 (2), pp. 214 - 219.

Mehta, K. C., Specker, B. L., Bartholmey, S., Giddens, J. & Ho, M. L. 1998, 'Trial on Timing of Introduction to Solids and Food Type on Infant Growth', *American Academy of Pediatrics,* vol. 102 (3), pp. 569-573.

NHMRC 1989, *Nutrition policy statements,* Australian Government Publishing Service, National Health and Medical Research Council, Canberra, ACT.

NHMRC 1996, *Infant feeding guidelines for health workers,* Australian Government Publishing Service, National Health and Medical Research Council, Canberra, ACT.

NHMRC 2003, *Dietary Guidelines for Children and Adolescents in Australia incorporating the Infant Feeding Guidelines for Health Workers,* National Health and Medical Research Council, Australian Government Printing Office, Canberra, ACT.

Norberg, M., Amantidis, S. & Holliday, K. Eds., 1995, *Early Childhood Nutrition News,* 'Product Information', Nutrition information service for staff of the Early Childhood Centres, November, No. 10, Central Sydney Community Health Services, Sydney.

NSW Department of Health 1989, *Use of cows milk for the introduction of solids in infancy*, Circular number 89/168, NSW Department of Health, Sydney.

NSW Government 2003, "Families First Initiative", New South Wales www.familiesfirst.nsw.gov.au, accessed on 21-05-03.

Palmer, G. 1993, *The politics of Breastfeeding,* Pandora Press, Division of Harper Collins, London.

Paneth, N. 1980, 'Hypernatremic dehydration of infancy: an epidemiologic review', *American Journal of Diseases of Children,* vol. 134 (8), pp. 785-792.

Patwardhan, A., Norberg, M., Samman, S. & Lilburne, A. M. 1994, 'An investigation of the nutrition information provided at early childhood centres in Central Sydney', *Australian Journal of Nutrition and Dietetics,* vol. 51 (4), pp. 180-185.

Paul, A. A., Black, A. E., Evans, J., Cole, T. J. & Whitehead, R. G. 1988, 'Breastmilk intake and growth in infants from two to ten months', *Journal of Human Nutrition and Dietetics,* vol. 1, pp. 437-450.

Peerson, J. M., Heinig, M. J., Nommsen, L. A., Lonnerdal, B. & Dewey, K. G. 1993, 'Use of Growth Models to describe patterns of Length, Weight, and Head Circumference among Breast-Fed and Formula-Fed Infants: The DARLING (Davis Area Research on Lactation, Infant Nutrition and Growth) Study', *Human Biology,* vol. 65 (4), pp. 611-626.

Perez-Escamilla, R., Segura-Millan, S., Canahuati, J. & Allen, H. 1996, 'Prelacteal Feeds are Negatively Associated with Breast-Feeding Outcomes in Honduras', *American Journal of Nutrition,* vol. 126, pp. 2765-2773.

Public Health Division 2003, *The health of the people of New South Wales - Report of the Chief Health Officer*, Sydney: NSW Department of Health. Available at:http://www.health.nsw.gov.au/public-health/chorep/beh/beh_brstfeed.htm., accessed on 23-02-2003.

Retallack, S. J., Simmer, K., Makrides, M. & Gibson, R. A. 1994, 'Infant weaning practices in Adelaide: The results of a shopping complex survey', *Journal of Paediatrics and Child Health,* vol. 30 (1), pp. 28-32.

Riordan, J. & Auerbach, K. G. 1993, *Breastfeeding and Human Lactation,* Jones and Bartlett Publishers, Boston.

Royal College of Midwives 1991, *Successful Breastfeeding,* Second edition, Churchill Livingstone, Edinburgh.

Schon, D. A. 1987, *Educating the Reflective Practitioner,* Jossey-Bass Publications, California.

Shepherd, R. W., Oxborough, D. B., Holt, T. L., Thomas, B. J. & Thong, Y. H. 1988, 'Longitudinal Study of the Body Composition of Weight Gain in Exclusively Breast-Fed and Intake-Measured Whey-Based Formula-Fed Infants to Age 3 Months', *Journal of Pediatric Gastroenterology and Nurtition,* vol. 7 (5), pp. 732-739.

Smith, R. M., Smith, P. A., McKinnon, M. & Gracey, M. 2000, 'Birthweights and growth of infants in five Aboriginal communities', *Aust. N. Z. Journal of Public Health,* vol. 24 (2), pp. 124-135.

South Australian Health Commission 1990, *A Social Health Atlas of South Australia,* cited in Retallack, S.J., Simmer, K., Makrides, M. & Gibson, R.A. 1994, 'Infant weaning practices in Adelaide: The results of a shopping complex survey', *Journal of Paediatrics and Child Health,* vol. 30 (1), pp. 28-32.

Stuff, J. E. & Nichols, B. L. 1989, 'Nutrient intake and growth performance of older infants fed human milk', *The Journal of Pediatrics,* vol. 115 (6), pp. 959-968.

W.H.O. 1994, *An Evaluation of Infant Growth: WHO Working Group on Infant Growth,* Nutrition Unit, World Health Organization, Geneva, Switzerland.

W.H.O. 2002, *Report of the Expert Consultation on the optimal duration of exclusive breastfeeding,* 28-30 March 2001, World Health Organization, Geneva, Switzerland.

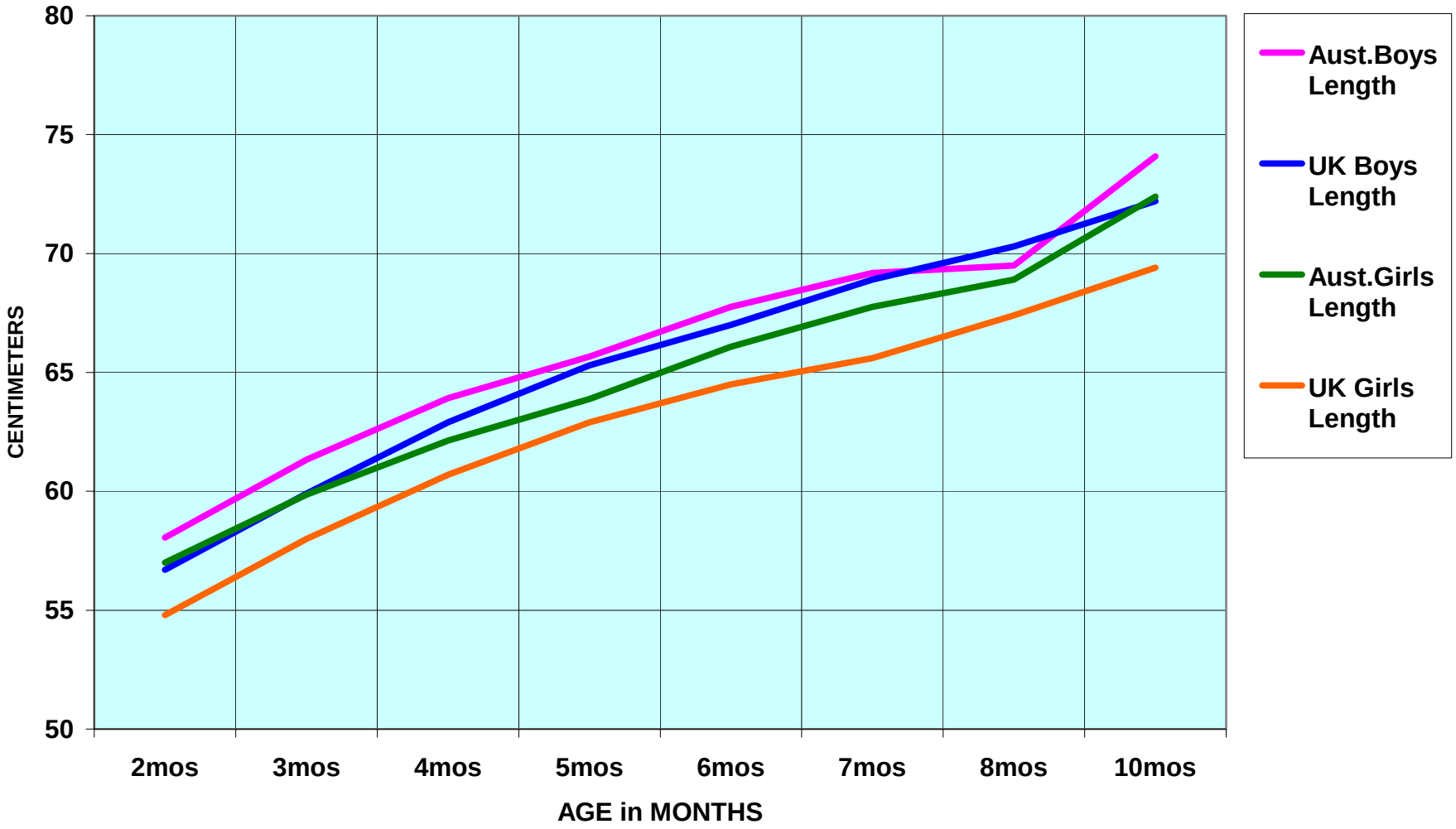
Whitehead, R. G. 1995, 'For How Long is Exclusive Breast-feeding Adequate to Satisfy the Dietary Energy Needs of the Average Young Baby?' *Pediatric Research,* vol. 37 (2), pp. 239-243.

WHO / UNICEF Statement 1989, *Protecting, promoting and supporting Breast-Feeding: the special role of maternity services,* World Health Organization, Geneva.

Woolridge, M. W. 1995, 'Baby-Controlled Breastfeeding: Biocultural Implications,' in *Breastfeeding: Biocultural Perspectives,* Eds. Patricia Stuart-Macadam and Katherine A. Dettwyler, Aldine De Gruyter, New York.

APPENDIX I

Comparison between Cambridge infants and Australian-European infants
BOYS & GIRLS LENGTH using the arithmetic mean values



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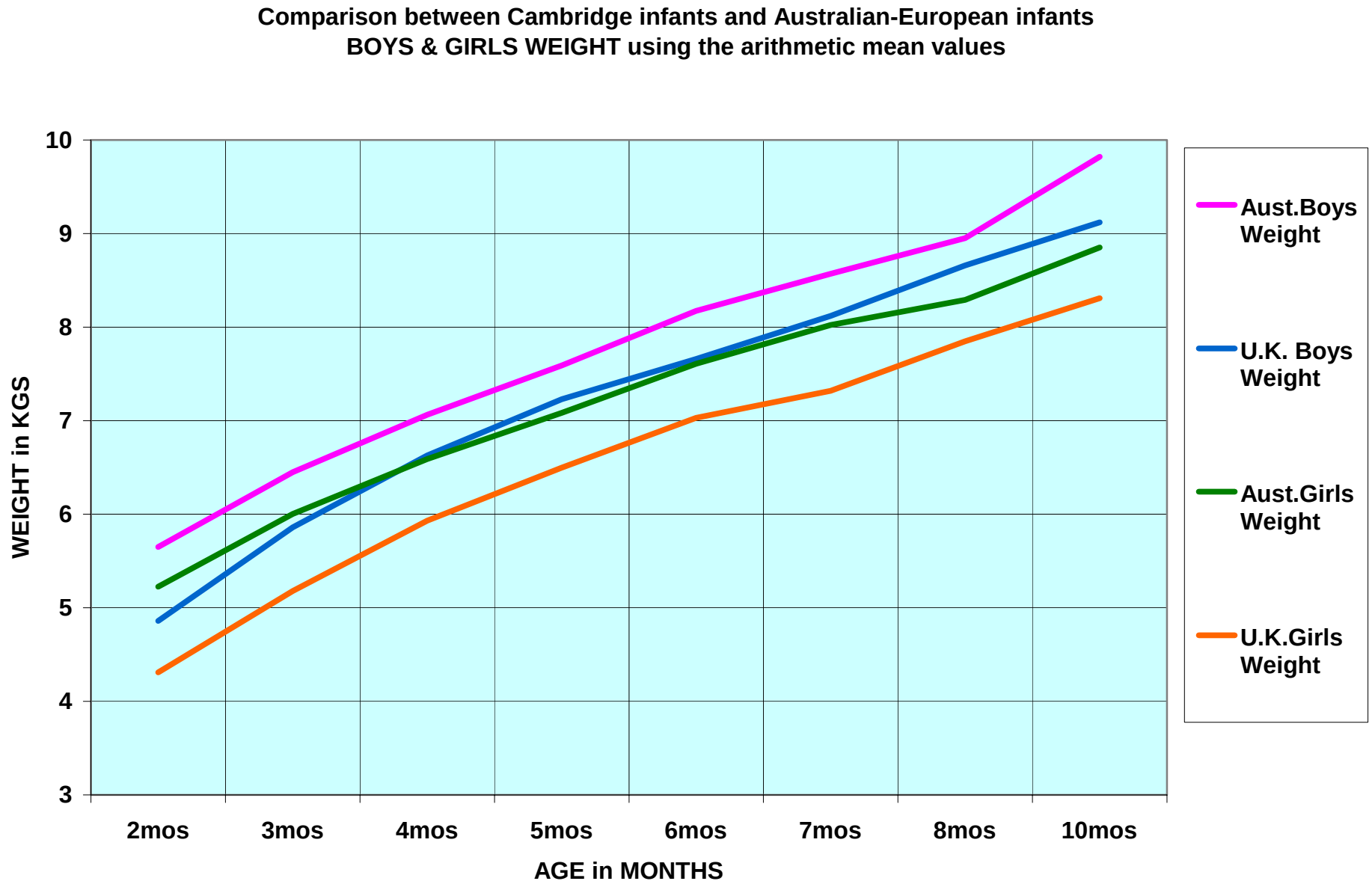
Comparison between Cambridge infants and Australian-European infants
BOYS & GIRLS WEIGHT using the arithmetic mean values
WEIGHT in KGS
10
9
8
7
6
5
4
3
2mos
3mos
4mos
5mos
6mos
7mos
8mos
10mos
AGE in MONTHS
Aust.Boys Weight
U.K. Boys Weight
Aust.Girls Weight
U.K.Girls Weight

APPENDIX II

Table 2

European means of weight (kgs), std dev. & n

F	Rows	Birth	1mo	2mo	3mo	4mo	5mo	6mo	7mo	8mo	9mo	10m	11m	12m
Weight kgs	149	3.483 446	4.470 333	5.225 659	6.003 333	6.591 535	7.085	7.607 456	8.021 97	8.291 327	8.433 904	8.851 351	8.999 138	9.392 647
Std dev	149	0.434 184	0.506 785	0.590 858	0.669 26	0.724 774	0.815 389	0.809 812	0.940 954	0.758 452	0.862 846	0.953 392	1.046 902	1.614 422
n	149	148	135	129	120	114	95	114	66	49	73	37	29	51
M														
Weight kgs	151	3.518 813	4.608 212	5.648 885	6.450 225	7.064 05	7.591 848	8.174 202	8.571 311	8.950 833	9.443 333	9.821 429	9.956 452	10.27 841
Std dev	151	0.400 462	0.537 817	0.653 478	0.702 645	0.804 654	0.913 378	0.850 667	0.973 202	0.956 888	0.894 911	0.801 128	1.059 539	0.967 459
n	151	150	137	139	111	121	92	119	61	60	60	35	31	44

Table 2a. The means of weight (kgs), std. dev. and n of the male and female Australian breastfed infants group.

APPENDIX II

European means of length (cms), std dev. & n

F	Rows	Birth	1mo	2mo	3mo	4mo	5mo	6mo	7mo	8mo	9mo	10m	11m	12m
Length cms	149	50.81622	53.73125	57.00902	59.85463	62.13495	63.88193	66.08393	67.756	68.90233	69.89265	72.39032	73.21786	74.296
Std dev	149	2.415991	2.10679	2.12599	2.415425	2.405374	2.301492	2.373751	2.394666	2.235694	2.920862	2.558561	2.844625	2.601723
n	149	148	112	122	108	103	83	112	53	43	68	31	29	50
M														
Length cms	151	51.27517	54.1381	58.05597	61.33511	63.92243	65.66538	67.75045	69.18163	69.49149	72.20741	74.09091	74.5069	75.86136
Std dev	151	1.949044	2.21177	2.352842	2.208182	2.110857	2.381194	2.072762	1.846695	2.280399	2.270055	2.059485	2.333289	2.203403
n	151	149	105	134	94	107	78	111	49	47	54	33	29	44

Table 2b. The means of length (cms), std. dev. and n of the male and female Australian breastfed infants group.

APPENDIX III

Table 1. A comparison between the breastfed group means and data available from the NCHS/WHO data (Hamill et al 1977) and CDC 2000 growth charts data available online (www.cdc.gov/nchs 2002). Figures were worked out from tables available from the NCHS and CDC 2000.

	Males			Females		
Weight	Slope1: 1 - 3 months	Slope2: 3 - 6 months	Slope3: 6 - 12 months	Slope1: 1 - 3 months	Slope2: 3 - 6 months	Slope3: 6 - 12 months
Mean	0.9274 kg/mth	0.5794 kg/mth	0.3506 kg/mth	0.7896 kg/mth	0.5414 kg/mth	0.3494 kg/mth
95% CI	0.8762 - 0.9786	0.5405 - 0.6184	0.3148 - 0.3865	0.7454 - 0.8338	0.5131 - 0.5696	0.3154 - 0.3835
N	103	89	41	108	99	40
NCHS /WHO **Feeding method not noted**	0.845 kg/mth (p<0.05)	0.623 kg/mth (p<0.05)	0.383 kg/mth (p>0.05)	0.710 kg/mth (p<0.05)	0.603 kg/mth (p<0.05)	0.386 kg/mth (p<0.05)
CDC 2000	*0.8349 kg/mth p<0.05*	*0.6525 kg/mth p<0.05*	*0.4219 kg/mth p<0.05*	*0.7165 kg/mth p<0.05*	*0.5791 kg/mth p<0.05*	*0.3998 kg/mth p<0.05*
Length						
Mean	3.5344 cms/mth	2.2600 cms/mth	1.3816 cms/mth	3.0878 cms/mth	2.0651 cms/mth	1.3987 cms/mth
95% CI	3.2629 - 3.8059	2.1082 - 2.4118	1.2894 -1.4738	2.8623 - 3.3134	1.9305 - 2.1998	1.3126 - 1.4849
N	64	70	39	82	87	39
NCHS /WHO **Feeding method not noted**	3.25 cms/mth (p<0.05)	2.23 cms/mth (p>0.05)	1.38 cms/mth (p>0.05)	3.0 cms/mth (p>0.05)	2.13 cms/mth (p>0.05)	1.4 cms/mth (p>0.05)
CDC 2000	*3.4565 cms/mth p>0.05*	*2.1721 cms/mth p>0.05*	*1.466 cms/mth p>0.05*	*3.2052 cms/mth p>0.05*	*2.1042 cms/mth p>0.05*	*1.4631 cms/mth p>0.05*

To calculate the interval of slope 1, the mean at 1 month was subtracted from the mean at 3 months and divided by 2.
To calculate the interval of slope 2, the mean at 3 months was subtracted from the mean at 6 months and divided by 3.
To calculate the interval of slope 3, the mean at 6 months was subtracted from the mean at 12 months and divided by 6.

APPENDIX IV

Acronyms List and Definitions

BFHI	Baby Friendly Hospital Initiative is a joint World Health Organisation and United Nations Children's Fund quality improvement program designed to accomplish hospital accreditation for supporting breastfeeding women.
BMI	Body Mass Index is an indicator of overweight in adults more recently adopted for use in child health after the age of two years. This is the weight /height^2. For hand calculation the formula used to calculate the Body Mass Index = weight (kg)/ stature (cm)/ stature (cm) X 10,000. It is used to predict body fatness in children.
Box-Cox	This is a mathematical power transformation used to normalise data for distribution when creating centile curves for clinical percentile charts.
CAFN	Child and Family Nurses are the health professionals who work in Early Childhood Health centres in New South Wales.
CDC	Center for Disease Control in the United States.
CI	Confidence intervals are used to give clear explanations of the comparison between two sets of data. Confidence intervals are frequently reported at the 95% level of confidence. If the confidence interval is sufficiently wide we may be very confident that the comparison between the two sets of data is reliable.
CSAHS	Central Sydney Area Health Service in New South Wales.
DARLING	Davis Area Research on Lactation, Infant Nutrition and Growth is a research centre in the Department of Nutrition in the University of California, Davis, United States.

APPENDIX IV

IAHS	Illawarra Area Health Service in New South Wales.
LMS	Age appropriate percentiles are expressed using the Box-Cox power "L" required to normalise the distribution of the data. "M" represents the median and "S" the coefficient of variation within the distribution. To create a 'goodness of fit', the values of L, M and S need to change smoothly with each age group so that the representation of the data is in smooth curves.
NCHS	National Center for Health Statistics, which is now incorporated with the Center for Disease Control and Prevention in the United States, Department of Health and Human Services, Hyattsville, MD.
NHMRC	National Health and Medical Research Council, Canberra, ACT.
Serendipitous	To make a fortunate discovery by accident.
SES	Socio-economic status is a term used to describe the rating order of occupations in the workforce.
Spline	Methods for smoothing the curves on the NCHS 1977 chart. This was a computerised curve-smoothing procedure called "spline polynomial smoothing of observed percentiles".
TBK	Total Body Potassium is a substance that can be measured in lean tissue, which contains 99% of TBK. Measuring the TBK makes it possible to detect a difference in the quality of weight gain between fat tissue and lean tissue.
UNICEF	United Nations Infant and Children's Fund, Palais des Nations, CH 1211 Geneva 10, Switzerland
WHO	World Health Organisation, 1211 Geneva 27, Switzerland.