Birthweights and growth of infants in five Aboriginal communities

Abstract

Objectives: To improve, by culturally appropriate means, birthweights and growth of children up to three years of age over 14 months in five Aboriginal communities in north-western Australia.
Methods: Frequent individual nutritional assessment of infants and children with counselling of mothers and carers and of pregnant women and the introduction of the Aboriginal-controlled Strong Women, Strong Babies, Strong Culture maternal support program. Outcomes compared with those in the same communities for the five years preceding intervention.
Results: By international standards, pre-intervention birthweights of full-term infants (37-42 weeks) were only moderately depressed and recovered to exceed standard weight-for-age within two weeks of birth. Growth of full-term infants slowed abruptly after six months. Prevalence and duration of breastfeeding were very high. Prevailing low average birthweight was chiefly attributable to a prevalence of pre-term birth approaching 20%. Intervention was not accompanied by any change in full-term birth weight but was associated with increased weight gain after six months. From 12 to 36 months growth rose by 30 g per month (p=0.001). Average birthweights of pre-term infants were <2,500 g and average weight-for-age did not improve during intervention.
Conclusions: Both low birthweight and a disproportionate part of intransigent failure to grow by Aboriginal infants were associated with pre-term birth. Depressed average growth of full-term infants appeared to respond to nutritional counselling accompanied by a community support program.
Implications: Investigation of the causes of the exceptionally high rate of Aboriginal pre-term birth in the region is urgently required.

(*Aust N Z J Public Health* 2000; 24: 124-35)

Richard M. Smith and Pamela A. Smith
Miln Walker and Associates Pty Ltd, Belair, South Australia

Moira McKinnon
Public Health Unit, Health Department of Western Australia

Michael Gracey
Curtin University, Western Australia, and Office of Aboriginal Health, Health Department of Western Australia

Birth statistics for the Northern Health Region of Western Australia (Kimberley and Pilbara) show the lowest average birthweight and the second highest proportion of low birthweight (<2,500 g) babies of all the State's administrative health regions.[1] Both effects were mainly attributable to Aboriginal births. The statistics, however, did not distinguish between low birthweights among full-term infants and low birthweights resulting from pre-term birth, although the aetiologies of these two conditions are very different.

In a review and meta-analysis of the causes of low birthweight (LBW), Kramer[2] demonstrated a sharp distinction between developed and developing countries in the aetiology of LBW. The principal cause of LBW in developing countries was intrauterine growth retardation (IUGR) of full-term infants attributable to malnutrition during pregnancy or to specific environmental factors such as malaria. In developed countries the principal cause of LBW was pre-term birth but at that time the underlying causes of pre-term birth were not well understood. There is now an emerging view that the principal immediate precursor of non-iatrogenic pre-term birth is intrauterine infection, generally of uro-genital tract origin.[3]

In attempting to deal with the persistent LBW problem in Aboriginal communities, it may be of considerable importance to establish whether LBW is mainly associated with full-term or with pre-term births.

A second long-term problem of Aboriginal child health in north-western Australia is the slow growth of infants and young children after six months of age. Reductions in Aboriginal infant mortality and infectious disease over the past 20 years have been accompanied by some improvement in birthweights but, compared with Caucasian standards,[4] mean birthweights remain depressed and the low rates of growth have not improved.[5]

The present work was undertaken as a nutritional intervention both to improve birthweights and to increase the growth rate of infants and children under three years of age in five Aboriginal communities in north-western Australia's Northern Health Region. The intervention was of two kinds: 1) periodic nutritional assessment and counselling of pregnant women and of the mothers of infants and young children was offered; 2) (at the same time) the introduction of the Strong Women, Strong Babies, Strong Culture (SWSBSC) program was facilitated. The latter is a community-based educational and support program from the Territory Health Services in Darwin. Both programs continued for 14 months before assessment of outcomes was made by comparison with

Submitted: April 1999
Revision requested: November 1999
Accepted: January 2000

Correspondence to:
Dr Richard Smith, Miln Walker & Associates Pty Ltd, PO Box 167, Belair, South Australia 5052. Fax: (08) 8278 8172; e-mail: smithric@tpgi.com.au

relevant outcomes from a five-year pre-intervention cohort from the same communities.

Methods

Communities

The intervention was carried out by invitation in five Aboriginal communities (three in the Kimberley and two in the Pilbara) between July 1996 and October 1997. The invitations followed an initial presentation of issues to community councils and consultations with community women. Communities ranged in size from 200 to 600 residents and were between 30 km and 160 km from towns with hospitals. Resident medical and/or nursing staff were present in the two largest communities and clinical records of infants and children were available in all of them. Four of the communities were serviced by community health staff from the Health Department of Western Australia and the fifth by a community-controlled health service.

Pre-intervention cohort (1991-96)

For comparison of birthweights and growth rates the potential control group comprised all singleton infants born in the five communities between 1 July 1991 and 30 June 1996. Infants were included for analysis only if birthweight, birth-length and gestational age at birth could be established. All retrievable records of weight and length were transcribed from clinic files from birth to 36 months of age. Of 240 singleton births established for the cohort, 204 (85.0%) had retrievable records and were included in the control group.

Intervention cohort (1996-97)

Qualification for this cohort was achieved by any infant or child under 36 months already living in any of the five communities on 1 July 1996 as well as by those born into the communities between 1 July 1996 and 3 September 1997. Enlistment in the project dated from the time informed consent was obtained from mother or carer and continued until 3 September 1997 or until age 36 months. New births made up 24.2% of the intervention cohort; the remainder were carried over from the first cohort. Because no infant was enlisted at birth (and only a few before two months) birthweights in the intervention cohort referred to a separate category comprising all enlisted infants born in the five communities during the intervention. Again infants and young children were accepted for analysis only if gestational age at birth, birthweight and birth length were established. Of 46 new singleton births, 43 were enlisted in the intervention.

Retrieval of birth data

Information about infants in both cohorts was obtained almost entirely from community clinic files with the help of clinic staff. Multiple births and two infants with serious congenital disease were excluded. Birthweight, birth length and gestational age (GA) at birth were extracted retrospectively from the mother's obstetric discharge sheet (ODS) for that birth issued by the hospital where the confinement took place. All infants enrolled or enlisted were born in one or other of the government hospitals that serviced their community. A copy of the ODS was generally present in the infant's clinic file or in the mother's file. In a few cases, the information on the ODS was obtained directly from the hospital but this was not generally possible.

The GA recorded on the ODS was based on the entire obstetric history of the pregnancy and was derived from a combination of last known menstrual period (LKMP), fetal ultrasound before 24 weeks gestation (if performed) and, occasionally, on some form of postnatal maturity scoring. Referred to as the 'best clinical estimate', the outcome is equivalent to the information supplied to State birth registers. Only rarely, however, could the actual basis of any given GA be established and attempts to estimate the proportion of pregnancies in which fetal ultrasound was performed were unsuccessful. The practice was said to be common and increasing but was not yet universal.

With the exception of two cases for whom informed consent was withheld, all exclusions of otherwise eligible infants for intervention arose from an inability to sight the ODS. The intervention cohort as a whole comprised 86.3% of eligible infants including 93.5% of new births during 1996-97.

Involvement of the Strong Women, Strong Babies, Strong Culture program

Initiated by the Territory Health Services in 1992, the Strong Women, Strong Babies, Strong Culture (SWSBSC) program is a predominantly Aboriginal initiative to address the problem of LBW among Aboriginal infants through interactive community activities. These activities stress traditional cultural values relating to pregnancy and child-birth as well as encouraging prudent and appropriate nutrition, hygiene and pre-natal care.[6] An assessment in 1996[7] indicated a substantial improvement in average birthweight in participating communities over four years, a conclusion confirmed in the evaluation of Mackerras in 1998.[8]

Following community agreement to the introduction of the SWSBSC program, suitably qualified Aboriginal women (one each from the Kimberley and Pilbara) were trained in Darwin by the SWSBSC program leader and visited and observed participating communities in the Northern Territory. After additional training in the nutritional principles relating to pregnancy and post-natal nurturing, these women acted as co-ordinators in the introduction and facilitation of the SWSBSC program in the five communities. The successful operation of these community groups was further promoted by a visit to each community by the SWSBSC program leader from Darwin and by means of two training workshops.

During the intervention the educational and support roles of the SWSBSC groups relating to pregnant women were extended to include education and support of the mothers of infants and children under three years of age. Specific advice on the individual need for such education or support was provided by the co-ordinator after each visit to the community of the nutritional consultant.

Nutritional consultant assessments and counselling

During the intervention period the nutritional consultant (RMS) carried out seven 3-5 day visits to each community for nutritional assessment and anthropometry of children under three years. Access to these mostly remote communities was by motor vehicle and involved 35,000 km of road travel over the 14-month period. Body weights (unclad) and supine length were measured using standardised equipment and food intake other than breast milk for the preceding 24 hours was recorded from recall by the mother or carer.[9]

Measuring equipment (scales and supine length scale) used by clinics which gave values used in the study were standardised at each visit and any necessary corrections made to the clinic values. The current status of breastfeeding (breastfed every day or not breastfed now) was established at each interview and a record was made of how many breastfeeds a day were given.

The intervention as a whole consisted of the above input from the nutritional consultant plus the activities of the SWSBSC program in each of the five communities.

Growth standards

Standard growth percentiles in common use are those published by the US National Center for Health Statistics (NCHS).[4] This, in turn, derives from the US-based Fels Longitudinal Study (1928-75) which was limited predominantly to middle-class white families. Measurements were recorded only every three months and most infants were bottle-fed. Of those who were breastfed, very few were breastfed for more than three months. Despite these limitations, the NCHS values were adopted by the World Health Organization (WHO) in 1983 as the international standard for the growth of children.

Since 1990, WHO has formalised and rationalised its recommendation that infants should be exclusively breastfed for at least four months and that breastfeeding should then continue for up to two years or beyond with nutritionally adequate and safe supplementary foods.[10] Because uniform advice for prolonged breastfeeding was inconsistent with the continued use of growth standards derived mainly from bottle-fed infants, WHO in 1993 set up a working group to develop new internationally applicable standards based on the growth of infants who were breastfed according to the WHO protocol. The results of this study are due to be released in 2000 but an interim report based on seven of the contributing studies[11] gives provisional weight-for-age data on breastfed infants from birth to 12 months. Further information on the performance of some of these studies has appeared for ages up to 24 months.[12] Growth performance in the present work is referred to all of these figures, but because the commonly used *Z* scores refer ultimately to the NCHS standards and these are now considered inadequate for breastfed infants, the present report has avoided the use of *Z* scores; we have utilised the more clumsy but clinically better understood percentile ratings.

Statistical methods and management of data

In addition to birthweights, birth-lengths and gestational age at birth, the outcomes recorded were length-for-age and weight-for-age with age being calculated for each observation to 0.1 month. A normalising procedure was adopted for these data in which interpolated values replaced measured values in order to provide a limited number of observations for each child but at specified ages. The 32 specified ages were (in months): 0, 0.25, 0.75, 1.25, 1.75, 2.25, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13.38, 15, 16.5, 18, 19.5, 21, 22.5, 24, 25.5, 27, 28.5, 30, 31.5, 33, 34.5, 36. Each represents the mid-point of a range and the interpolated value at that point is derived as linear intercept from the two nearest flanking values. The flanking value on one side only may be distant. An interpolated value is accepted only if flanked by a measured value in the same or an adjacent range on at least one side. There is no extrapolation. This process was adopted both to maximise the input from under-recorded children and to minimise the over-representation of frequently measured children, the latter often because of ill-health. The normalisation was carried out by computer using software written for the purpose.[13]

Outputs were obtained in spreadsheet form and were examined statistically by standard programs (Microsoft Excel 5.0). Spreadsheet results are expressed in the paper as means and standard deviations (SD) and where means are compared the probability (p) of the difference being due to chance is stated. A value of $p<0.05$ is taken as significant.

In comparing the growth rates of groups of children where this has involved multiple sequential measurements on each of them, it is recognised that sequential estimates of mean body weights for age are not independent of one another. Statistical comparisons between mean growth rates of pre-intervention and intervention cohorts are therefore compromised. At the suggestion of Dr A.G. Constantine (see acknowledgements), linear regressions of weight-for-age were calculated for each infant over the near-linear ranges from 7-12 and 12-36 months in order to derive individual weight-for-age slopes for both ranges (if applicable) and individual weight intercepts at six, 12 and 36 months (if applicable). From these mutually independent estimates, mean slopes and estimates were calculated for the groups and comparisons were made of these. Again standard statistical programs from Microsoft Excel 5.0 were employed and means and standard errors (SE) were tested for significance of differences using the t test. Significance was assigned at $p<0.05$.

Results

Incidence of pre-term birth and of LBW in two cohorts in five Aboriginal communities

The numbers of births, the numbers of pre-term births and the numbers of LBW infants recorded for the study periods are shown in Table 1. The rate of pre-term birth (19.8% for the entire period) was higher than the 16% recorded in a study of Aboriginal births in Western Australia (WA) from 1980 to 1986.[14] It compares with a non-Aboriginal rate in WA then of 6.4%[14] and with rates of between 5% and 6% reported in affluent European countries and with rates approaching 10% in US.[15] It is also higher than values

Table 1: Prevalence of low birthweights and pre-term births in five Aboriginal communities.

Cohort	All births (no.)	Pre-term births (<37 weeks)	Term births (37-42 weeks)	All low birthweight (<2,500 g)	Pre-term and low birthweight (no.)	Term and low birthweight (no.)
1991-96	204	43 (21.1%)	161 (78.9%)	31 (15.2%)	28 (13.7%)	3 (1.5%)
1996-97	43	6 (14.0%)	37 (86.0%)	7 (16.3%)	4 (9.3%)	3 (7.0%)
1991-97	247	49 (19.8%)	198 (80.2%)	38 (15.4%)	32 (13.0%)	6 (2.4%)

around 11% pre-term births recorded in a prospective study of pregnancy outcomes in indigent black and white groups in the US.[16] A more recent (1991-94) Australia-wide survey published in 1999 showed pre-term births to average 11.6% of all Aboriginal live births as compared with 5.4% for non-Aboriginal births.[17]

Although the incidence of pre-term birth fell from 21% to 14% in the intervention period, the numbers of the latter were very small and the difference is not regarded as significant.

The overall level of 15.4% of births below 2,500 g is also very high. It exceeds the corresponding value of 12.5% LBW for Aboriginal births in WA (1980-1986) and may be compared with the value of 4.9% LBW for non-Aboriginal births in WA then.[14] Australia wide from 1991-94, 10.6% of Aboriginal births were LBW as compared with 4.4% of non-Aboriginal births.[17] The incidence of LBW in affluent European and North American countries has been reported as averaging 5.5% for the period 1980-1984.[11]

The apparent reduction in the incidence of pre-term LBW in the intervention period was accompanied by an increase in the incidence of full-term LBW. Although this might suggest a shift in diagnostic assignment of gestational age at birth, the constant proportion of pre-term births that were below 2,500gms (65.1% and 66.7% in the two cohorts respectively) does not support such a suggestion and the numbers of low birthweight infants were, in any case, very small.

Birthweights of full-term and pre-term infants

Birthweights and percentile distributions for full-term female and male infants in the two cohorts are shown in Table 2, which also shows means and percentile distributions for the NCHS reference values.[4] Also in Table 2 are the birthweight data for the two cohorts after removal of full-term LBW infants in order to compare the means with those of the interim WHO values.[11] It should be noted that the latter were not derived primarily as birthweight standards but are rather the birthweights of infants subsequently breastfed for at least 12 months and whose weight-for-age performance will be referred to later. Percentile distributions of the latter birthweights have not yet been published.

There were no significant differences between the two cohorts in the birthweights of either female or male infants and the data were combined. For females both the combined data and the 1991-96 values showed very close agreement with the NCHS reference values both for mean body weight and for percentile distribution. When compared with the WHO interim reference female mean birthweights, full-term Aboriginal females (after removal of LBW infants) showed a deficit of 156 g. For males, the overall mean birthweight was 138 g lower than the NCHS reference and (after removal of LBWs) was 211 g lower than the WHO interim reference. Notwithstanding the deficit in means, however, the percentile distribution of male full-term birthweights was again

Table 2: Birthweights of full-term infants in five Aboriginal communities compared with two international standards.

Class	Cohort	Females Mean ±SD (No.)	Females Percentiles 10	Females Percentiles 50	Females Percentiles 90	Males Mean ±SD (No.)	Males Percentiles 10	Males Percentiles 50	Males Percentiles 90
Singleton Full-term births	1991-96	3.279 ±0.420 (83)	2.77	3.27	3.83	3.248 ±0.447 (78)	2.67	3.23	3.81
	1996-97	3.190 ±0.430 (19)	2.66	3.24	3.71	3.270 ± 0.650 (18)	2.52	3.28	4.06
	1991-97	3.262 ±0.420 (102)	2.75	3.24	3.78	3.252 ±0.487 (96)	2.62	3.24	3.87
	NCHS[4]	3.250 ±0.530	2.58	3.23	3.64	3.400 ± 0.561	2.78	3.27	3.82
Singleton Full-term births 2,500 g or greater	1991-96	3.308 ±0.402 (80)	2.80	3.28	3.84	3.275 ± 0.428 (77)	2.76	3.24	3.82
	1996-97	3.230 ±0.390 (18)	2.74	3.32	3.71	3.410 ±0.520 (16)	2.86	3.32	4.16
	1991-97	3.29 ±0.40 (98)	2.78	3.28	3.79	3.30 ±0.45 (93)	2.77	3.26	3.90
	WHO[11]	3.450 ±0.405	–	–	–	3.509 ±0.419	–	–	–

Table 3: Birthweights of pre-term infants – means and percentiles.

Class	Cohort	Females Mean ±SD (No.)	Females Percentiles 10	50	90	Males Mean ±SD (No.)	Males Percentiles 10	50	90
Singleton Pre-term births	1991-96	2.214 ±0.743 (28)	1.16	2.22	3.11	2.500 ±0.573 (15)	2.10	2.46	3.01
	1996-97	2.210 – (2)	–	–	–	2.390 ±0.350 (4)	–	–	–
	1991-97	2.214 ±0.719 (30)	1.19	2.22	3.07	2.476 ±0.527 (19)	1.97	2.47	2.96

very close to those of the NCHS percentiles. In the Australia-wide survey from 1991 to 1994, the difference in median birthweights at 40 weeks' gestation between non-Aboriginal and Aboriginal females was 130 g and for males was 160 g.[17]

Birthweights and percentile distributions of pre-term female and male infants for the two cohorts and for the combined set are shown in Table 3. Mean birthweights of all categories were 2,500 g or less and there were no significant changes in birthweight between the two cohorts. Percentile distributions of both female and male pre-term birthweights show the 50th percentiles to lie below the NCHS 3rd percentiles for all births.

Weight-for-age performance of full-term infants and young children before and during intervention

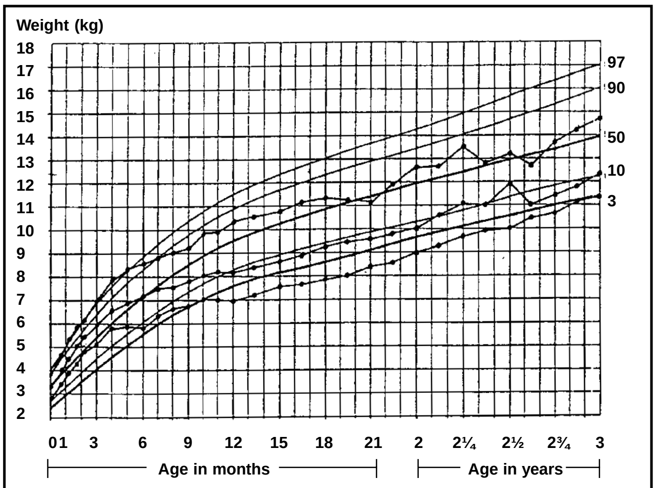
The percentile distributions of weight-for-age for all full-term infants in the 1991-96 cohort are shown for females in Figure 1 and for males in Figure 2 both in comparison with the standard NCHS percentiles.[4]

Compared with the widely used NCHS values, the weight-for-age (WFA) percentiles of Aboriginal females exceeded those standards up to six months of age (Figure 1) but then slowed abruptly to pursue approximately linear WFA profiles that were slower than the NCHS values. In the case of Aboriginal males (see Figure 2) the NCHS percentiles were exceeded only for the first four months before growth slowed abruptly and, as for females, followed linear WFA profiles up to three years at lower than NCHS values. Throughout the entire 36 months, the performance of females was slightly but noticeably superior to that of males.

Table 4 shows an abbreviated list (alternate ages only) of weight-for-age after removal of LBW infants (<2,500 g) in order to allow comparison with the new WHO reference values. Means and SD are given for females, males and combined sexes and *p* values are included to indicate any significant differences ($p<0.05$) between the cohorts. Significant differences for individual ages appeared for females between 10 and 18 months of age and between 10 and 21 months for combined sexes. No significant differences emerged for males alone at any age.

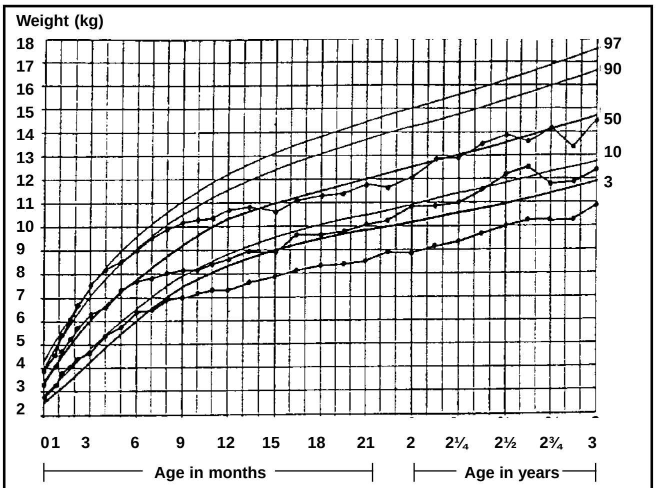
Using the data from an extended form of Table 4 (that is, including all calculated ages) the weight differences over three time intervals for females, for males and for combined sexes are shown in Table 5.

For reasons that are not apparent, the average body weight gain in the 1996-97 cohort was lower for the first six months than in the 1991-96 cohort and the average difference between body weights was negative. From six months onwards however, the average difference between body weights-for-age became positive. The improvement in growth during the intervention



(a) *The printed grid shows the NCHS 3rd, 10th, 50th, 90th and 97th percentiles marked on the right hand margin. The over drawn observations represent the 10th, 50th and 90th percentiles for the female full-term infants.*

Figure 1: Female full-term infants, 1991-1996 cohort.[a] Weight (kg) by age, girls 0-3 years.



(a) *The printed grid shows the NCHS 3rd, 10th, 50th, 90th and 97th percentiles marked on the right hand margin. The over drawn observations represent the 10th, 50th and 90th percentiles for the male full-term infants.*

Figure 2: Male full-term infants, 1991-1996 cohort.[a] Weight (kg) by age, boys 0-3 years.

was apparent in both females and males but was greater in females.

As stated earlier, in order to obtain a statistically valid comparison between cohorts, linear regressions of weight-for-age were calculated for each infant over the approximately linear range from seven to 36 months. The interpolated values of weight-for-age were used after elimination of infants with birth weights <2,500 g. The objective was to detect any significant differences in average rate of growth or in weight achieved and the values reported are the mean slopes of the individual regressions and the mean body weights yielded by the intercepts at six, 12 and 36 months. The results are shown in Table 6.

The intercepts representing weight-for-age at six, 12 and 36 months show that although there was no significant difference between cohorts at six months the difference of 0.50 kg at 12 months was significant (p=0.026) and the difference of 1.07 kg at 36 months was highly significant (p=0.001). The mean slopes representing rates of growth showed no difference between cohorts from six to 12 months and the small difference from 12 to 36 months was not significant. This difference, however, representing an improvement in growth of 30 g per month in the later cohort was sufficient to establish a substantial and significant difference in body weight by 36 months.

Prevalence of breastfeeding

The prevalence of breastfeeding over specified age ranges for full-term infants and for pre-term infants is shown in Figure 3.

More than 95% of full-term infants were breastfed for the first six months and 85% were still breastfed at 12-18 months. The prevalence of breastfeeding then declined, but at 30-36 months more than 20% of children were still receiving some breast milk each day. The corresponding figures for pre-term infants were lower, at least up to 30 months, and registered 91%, 67% and 27% for the three categories respectively.

The group of full-term infants and children who were not breastfed at any given age thus would have contained almost none who were not breastfed at all and very few who were not breastfed for at least 18 months.

Table 4: Mean weight for age in kg ± standard deviations (SD) of full-term females, males and combined sexes in both cohorts after removal of infants with birthweights <2,500 g. Differences between cohorts (Δ, kg) are shown with the probabilities (*p*) that the differences are due to chance.

	Females			Males			Both Sexes		
Age (months)	Intervention cohort 1996-97 ± SD (no.)	Pre-intervention cohort 1991-96 ± SD (no.)	Δ, kg (*p*)	Intervention cohort 1996-97 ± SD (no.)	Pre-intervention cohort 1991-96 ± SD (no.)	Δ, kg (*p*)	Intervention cohort 1996-97 ± SD (no.)	Pre-intervention cohort 1991-96 ± SD (no.)	Δ, kg (*p*)
0	–	3.31 ±0.40 (79)	–	–	3.27 ±0.43 (75)	–	–	3.29 ±0.41 (154)	–
0.75	3.93 ±0.75 (6)	4.04 ±0.49 (64)	-0.11 (p=0.74)	3.78 ±0.42 (2)	3.99 ±0.58 (59)	-0.22 (p=0.59)	3.89 ±0.66 (8)	4.02 ±0.53 (123)	-0.13 (p=0.61)
2.25	5.50 ±0.78 (10)	5.52 ±0.58 (66)	-0.03 (p= 0.92)	5.43 ±0.56 (7)	5.65 ±0.92 (62)	-0.22 (p=0.39)	5.47 ±0.68 (17)	5.58 ±0.76 (128)	-0.11 (p=0.53)
4	6.42 ±0.75 (16)	6.62 ±0.83 (59)	-0.20 (p=0.35)	6.33 ±0.89 (6)	6.71 ±1.09 (61)	-0.37 (p=0.37)	6.40 ±0.77 (22)	6.67 ±0.97 (120)	-0.27 (p=0.16)
6	7.44 ±1.03 (17)	7.22 ±1.07 (56)	0.21 (p=0.47)	7.87 ±1.05 (9)	7.61 ±1.16 (61)	0.25 (p=0.52)	7.59 ±1.04 (26)	7.43 ±1.13 (117)	0.16 (p=0.49)
8	8.18 ±1.15 (18)	7.72 ±1.05 (50)	0.46 (p=0.15)	8.02 ±0.83 (9)	8.12 ±1.22 (56)	-0.10 (p=0.76)	8.13 ±1.04 (27)	7.93 ±1.16 (106)	0.20 (p=0.40)
10	8.77 ±0.87 (15)	8.08 ±1.08 (48)	0.69 (p=0.02)	8.55 ±0.90 (11)	8.39 ±1.24 (52)	0.16 (p=0.62)	8.68 ±0.87 (26)	8.24 ±1.17 (100)	0.44 (p=0.04)
12	9.10 ±1.07 (17)	8.39 ±1.30 (49)	0.71 (p=0.03)	8.64 ±0.87 (17)	8.78 ±1.29 (52)	-0.13 (p=0.63)	8.87 ±0.99 (34)	8.59 ±1.30 (101)	0.28 (p=0.19)
15	9.72 ±1.41 (16)	8.79 ±1.29 (46)	0.93 (p=0.03)	9.28 ±0.85 (14)	9.13 ±1.20 (39)	0.15 (p=0.62)	9.51 ±1.18 (30)	8.94 ±1.25 (85)	0.57 (p=0.03)
18	10.05 ±0.80 (15)	9.20 ±1.35 (43)	0.84 (p=0.01)	9.83 ±0.82 (18)	9.82 ±1.32 (41)	0.01 (p=0.98)	9.93 ±0.80 (33)	9.50 ±1.36 (84)	0.42 (p=0.04)
21	10.23 ±0.84 (10)	9.73 ±1.15 (40)	0.50 (p=0.14)	10.44 ±0.72 (17)	10.17 ±1.39 (34)	0.27 (p=0.37)	10.36 ±0.76 (27)	9.94 ±1.28 (74)	0.43 (p=0.04)
24	10.74 ±1.39 (11)	10.33 ±1.28 (28)	0.41 (p=0.40)	10.97 ±1.05 (13)	10.53 ±1.21 (27)	0.43 (p=0.22)	10.87 ±1.18 (24)	10.43 ±1.24 (55)	0.45 (p=0.12)
27	11.25 ±1.22 (12)	11.32 ±1.52 (28)	-0.06 (p=0.89)	11.72 ±0.94 (13)	11.24 ±1.57 (23)	0.48 (p=0.26)	11.49 ±1.08 (25)	11.28 ±1.53 (51)	0.21 (p=0.49)
30	11.38 ±0.93 (10)	11.25 ±1.40 (19)	0.13 (p=0.77)	12.01 ±1.19 (13)	11.92 ±1.71 (19)	0.09 (p=0.86)	11.73 ±1.11 (23)	11.58 ±1.58 (38)	0.15 (p=0.66)
33	12.15 ±0.95 (10)	11.85 ±1.28 (20)	0.30 (p=0.48)	12.29 ±1.12 (14)	12.17 ±1.94 (16)	0.12 (p=0.83)	12.23 ±1.04 (24)	11.99 ±1.59 (36)	0.24 (p=0.48)
36	12.64 ±1.10 (12)	12.59 ±1.32 (20)	0.06 (p=0.90)	12.54 ±1.23 (13)	12.70 ±1.86 (15)	-0.16 (p=0.79)	12.59 ±1.14 (25)	12.64 ±1.55 (35)	-0.05 (p=0.89)

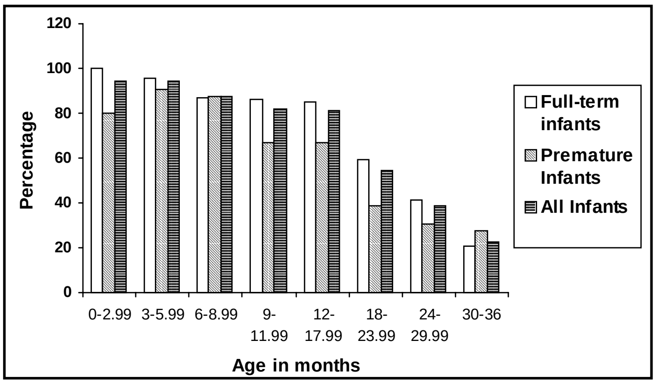


Figure 3: Proportions of full-term and pre-term infants breastfed by age ranges.

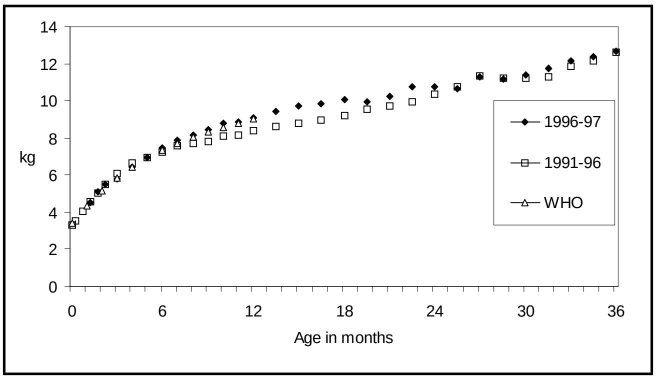


Figure 4. Mean weights of full-term female infants in two cohorts compared with WHO interim reference, the latter available only for 0-12 months.

Comparison of growth rates with interim WHO reference values for breastfed infants and children

Because of the very high rate of breastfeeding it is relevant and appropriate to compare the growth of the entire group of singleton full-term infants and young children with that of the interim WHO reference for breastfed children. These interim values apply to singleton full-term births of not less than 2,500 g birthweight and they extend only from 0-12 months. As was the case for Tables 4, 5 and 6, infants with birthweights <2,500 g have been removed from the data for the Aboriginal children in Figure 4.

Figure 4, which refers to females, shows the WFA profiles of the two Aboriginal cohorts compared with the interim WHO values.

Comparison of the two Aboriginal profiles for females shows that the intervention cohort grew slightly slower than the pre-intervention group prior to six months but both cohorts over that age range were similar to the WHO figures. Between six and 12 months, growth of the intervention cohort was clearly quicker than that of the pre-intervention group and was, in fact, slightly faster than that of the WHO figures for breastfed female-infants. Prior to six months, both Aboriginal cohorts as well as the WHO profile exceeded by up to 500 g the NCHS 50th percentile (not shown) but both fell increasingly short of the 50th percentile after six months. By 12 months, both the intervention cohort and WHO standard fell towards the NCHS 25th percentile.

The WHO profile is available only up to 12 months but the intervention profile continued to fall below the NCHS 50th percentile and crossed below the NCHS 25th percentile at 18 months. Thereafter, the intervention profile tracked at around 400 g below the NCHS 25th percentile.

The results for males were similar in some respects but were less favourable (see Figure 5). As with females, the pre-intervention cohort and the WHO interim figures for males below six months of age exceeded the NCHS 50th percentile (not shown) but both did so to a smaller extent than females. The pre-intervention cohort exceeded the NCHS 50th percentile by up to 300 g during that period and the WHO reference values exceeded the NCHS 50th percentile by up to 400 g. The intervention cohort for males crossed below the NCHS 50th percentile at five months; the WHO profile crossed at seven months. The male intervention cohort, which at the first observation at 0.75 months had been a mean 210 g lighter than the pre-intervention group, continued to track below the pre-intervention group until the age of five months but from then on was heavier than the pre-intervention group by

Table 5: Mean differences in weight between full-term pre-intervention and intervention cohorts over three time intervals.

Time interval (no. of age groups)	Female (kg)	Male (kg)	Both sexes (kg)
0.75-6 months (8)	-0.05	-0.16	-0.11
7-12 months (6)	+0.57	+0.02	+0.30
13-36 months (16)	+0.41	+0.09	+0.32

Table 6: Regressional analysis of growth of combined sexes from six to 12 months and from 12 to 36 months in two cohorts of full-term infants after removal of low birthweight infants.

	Regression parameters	1996-97 cohort (no of obs)	1991-96 cohort (no of obs)	*p*
Mean intercept at given age	6 months (kg ± SE)	7.82 ± 1.28 (39)	7.55 ± 1.27 (118)	0.253
	12 months (kg ± SE)	9.11 ± 1.54 (72)	8.61 ± 1.33 (104)	0.026
	36 months (kg ± SE)	13.87 ± 2.14 (72)	12.80 ± 1.96 (104)	0.001
Mean slope for given age range	6-12 months (kg/mth ± SE)	0.18 ± 0.18 (39)	0.18 ± 0.17 (118)	0.978
	12-36 months (kg/mth ± SE)	0.20 ± 0.11 (72)	0.17 ± 0.08 (104)	0.130

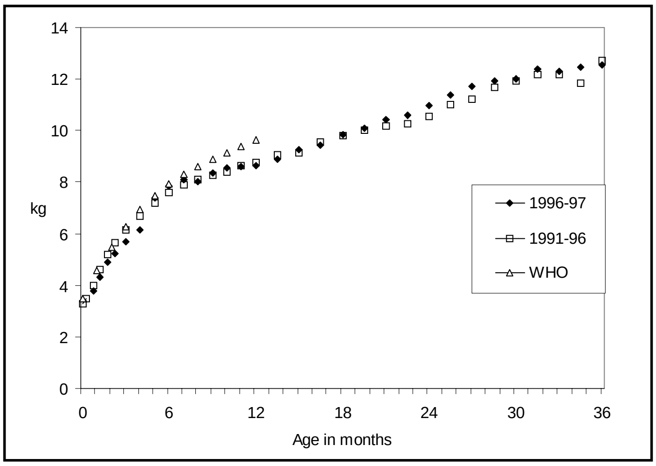


Figure 5: Mean weights of full-term male infants in two cohorts compared with WHO interim reference, the latter available only for 0-12 months.

an average 150 g. Both groups, however, fell short of the WHO male interim values and both fell below the NCHS 25th percentile from about eight months of age.

Weight-for-age performance of pre-term infants and young children before and during intervention

The weight-for-age percentiles for pre-term female infants and young children in the 1991-96 cohort are shown in Figure 6 in comparison with NCHS percentiles. Although an initial surge in growth from 0-6 months was present, comparison with Figure 1 shows a consistent depression below full-term infants from the same cohort and a consistent and larger depression below the NCHS percentiles. The latter is particularly striking and from nine months of age shows a displacement of 2-3 kg below the NCHS values.

The results for pre-term males in the 1991-96 cohort are shown in Figure 7.

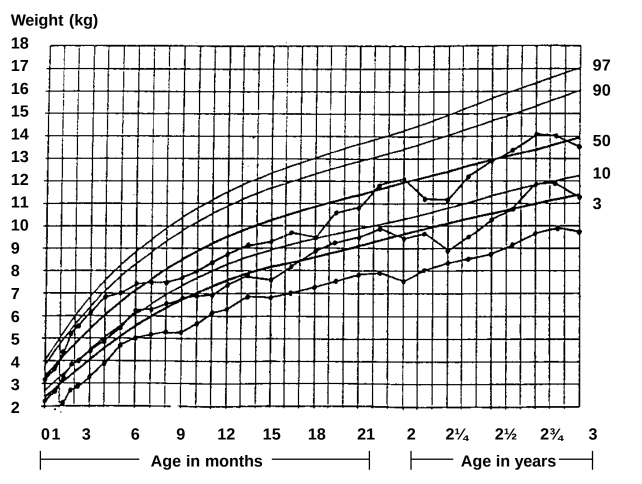
The numbers of pre-term males were generally smaller than the number of females (see Tables 7 and 8) and, presumably by chance the scatter of values was smaller at later ages. The results up to 12 months were not dissimilar to those of females but from 12 months to 28.5 months (when numbers became too small to report) the narrow band of male percentiles was associated with an improving performance with the Aboriginal 50th percentile moving from below the NCHS 3rd percentile to above the NCHS 10th percentile, a feature that was entirely absent in females.

The difference in mean weight performance of pre-term infants between the 1991-1996 cohort and the intervention cohort is shown for females in Table 7 and for males in Table 8.

The numbers in the latter cohort were small and the composition of the age groups in terms of gestational age at birth was heterogeneous so that statistical comparison of the groups was impractical. The small between-cohort mean difference for females (+0.069 kg) does not support an increased rate of growth during the intervention and the negative difference for males (-0.703 kg) suggests particular reasons for the much poorer performance of those infants. One such reason may have been the particularly high incidence of clinically diagnosed failure-to-thrive (FTT) among the male pre-term infants in the 1996-97 cohort (see following section). Another may have been the unusually favourable growth performance between 12 and 28.5 months in the 1991-96 cohort of pre-term male infants mentioned above (see Figure 7).

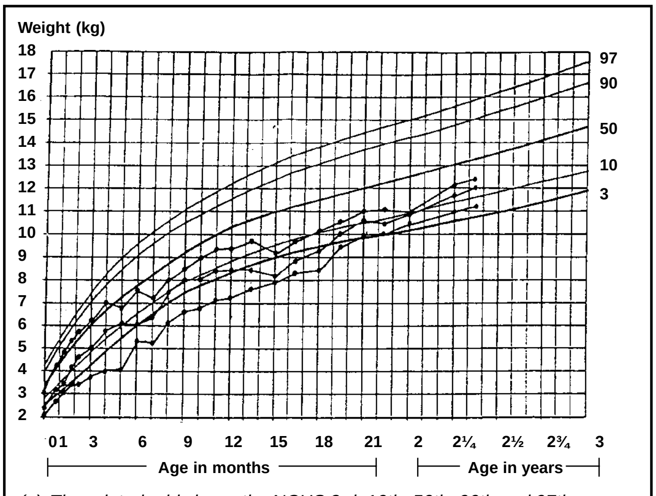
Failure-to-thrive

FTT indicates that an infant or child is failing to achieve its growth potential. This can be due to a range of underlying organic diseases, such as malabsorption, or sometimes due to non-organic causes including emotional disorders or to neglect.[18,19] In tropical, developing countries FTT is very common, often endemic, and is usually associated with gastrointestinal and respiratory infections, other infections, intestinal parasites, nutritional



(a) The printed grid shows the NCHS 3rd, 10th, 50th, 90th and 97th percentiles marked on the right hand margin. The over drawn observations represent the 10th, 50th and 90th percentiles for the female pre-term infants.

Figure 6: Female pre-term infants, 1991-1996 cohort.[a] Weight (kg) by age, girls 0-3 years.



(a) The printed grid shows the NCHS 3rd, 10th, 50th, 90th and 97th percentiles marked on the right hand margin. The over drawn observations represent the 10th, 50th and 90th percentiles for the female pre-term infants.

Figure 7: Male pre-term infants, 1991-1996 cohort.[a] Weight (kg) by age, boys 0-3 years.

anaemias and other nutritional deficiencies. This is very often associated with high levels of microbiological contamination of living conditions and transmission of infections from infected humans, animals, water or food.

In the present work, the frequency at which infants and young children had been categorised as FTT varied widely between community health clinics depending, in part, on whether or not a FTT program was in place. For the purposes of this study, acceptance of a FTT assignment was limited to those cases noted as medically diagnosed or admitted to hospital specifically as FTT, for example gastroenteritis, intestinal parasites, nutritional anaemias, skin sores, eye infections and infections of the respiratory and gastrointestinal tracts accompanying failure to grow. Such admissions were often followed by a rapid gain in weight but return to the home environment did not always sustain this gain.

The entire cohort (1991-97) yielded 63 infants or children under three years who had been diagnosed with one or more episodes of FTT. The distribution in terms of birthweight range and pre-term or full-term birth is shown in Figure 8.

Although FTT occurred mostly in full-term infants, a significant contribution to the birthweight profile came from infants born pre-term and particularly from those with low birthweight. A rather unexpected contribution to FTT came from six infants whose birthweights exceeded 4.0 kg, but it was not possible to establish any association with maternal diabetes.

Overall and including those over 4.0 kg, 70% of FTT came from full-term births in which birthweights were appropriate for gestational age, 27% came from pre-term births and 3% came from full-term infants assessed as intra-uterine growth retarded (IUGR). Since the overall prevalence of pre-term birth in the 1991-97 cohort was 19.8%, there was an apparent excess of 36% of FTT associated with pre-term birth over what would be expected from the prevalence of pre-term birth. An association of FTT with low birthweight has been reported.[20]

Females and males in the 1996-97 cohort contained a high proportion of infants diagnosed at some time as FTT. Only two of the 1996-97 pre-term males were born during the intervention, the remainder being carried over from the previous cohort. Most

Table 7: Mean weight for age of pre-term female infants in 1996-97 and 1991-96 cohorts.[a]

	Females				
	1996-97		1991-96		
Age (months)	No.	Mean±SD (kg)	No. (kg)	Mean±SD (kg)	Diff.
2.25	4	3.44±0.12	17	4.10±1.06	-0.66
3	8	4.18±0.63	18	4.67±1.07	-0.49
4	8	4.82±0.57	18	5.08±1.17	-0.26
5	9	5.51±0.67	16	5.86±1.05	-0.35
6	9	5.94±0.71	17	6.06±1.00	-0.12
7	9	6.23±0.66	15	6.44±1.06	-0.21
8	9	6.50±0.68	16	6.64±1.18	-0.14
9	7	6.72±0.51	16	6.73±1.21	-0.01
10	9	7.10±0.70	16	6.93±1.06	+0.17
11	9	7.49±0.79	17	7.16±1.02	+0.33
12	9	7.74±0.91	17	7.42±1.06	+0.32
13.38	9	7.98±0.90	14	7.77±1.0	+0.21
15	5	8.47±1.29	10	6 7.75±1.21	+0.72
16.5	3	8.24±0.53	9	8.14±1.30	+0.10
18	4	8.90±0.70	9	8.55±1.20	+0.35
19.5	6	9.00±0.65	11	9.19±1.43	-0.19
21	6	9.25±0.79	9	9.52±1.49	-0.27
22.5	5	9.57±0.72	8	9.84±1.78	-0.27
24	6	10.20±0.84	6	9.71±2.19	+0.49
25.5	5	10.40±1.34	6	9.64±1.62	+0.76
27	4	10.97±0.93	6	9.48±1.59	+1.49
28.5	3	11.03±0.94	7	10.08±1.74	-0.05
30	4	10.69±0.87	5	10.66±2.11	+0.03
31.5	3	11.30±1.27	4	11.14±2.35	+0.16
33	3	11.32±1.27	4	11.88±2.38	-0.56
34.5	4	11.64±1.33	4	11.91±2.29	-0.27
36	5	12.13±1.35	4	11.54±2.09	+0.59

Note:
(a) Mean difference +0.069 kg.

Table 8. Mean weight for age of pre-term male infants in 1996-97 and 1991-96 cohorts.[a]

	Males				
	1996-97		1991-96		
Age (months)	No.	Mean±SD (kg)	No. (kg)	Mean±SD (kg)	Diff.
2.25	3	4.95±0.18	12	4.61±0.92	+0.34
3		–	14	5.11±0.92	
4		–	13	5.69±1.13	
5		–	11	5.95±1.10	
6	3	6.87±0.03	7	6.42±1.15	+0.45
7	4	7.02±0.20	6	6.26±0.97	+0.75
8	4	7.21±0.26	5	7.14±0.95	+0.07
9	4	7.38±0.27	6	7.71±0.89	-0.33
10	4	7.10±0.60	6	7.96±0.98	-0.86
11	4	7.26±0.66	7	8.16±1.00	-0.90
12	4	7.26±0.49	7	8.30±0.99	-1.04
13.38	4	7.14±0.40	7	8.49±0.90	-1.35
15	3	7.37±0.36	5	8.43±0.64	-1.06
16.5	3	8.07±0.79	5	8.94±0.67	-0.87
18	3	8.06±0.89	7	9.31±0.73	-1.25
19.5	4	8.86±0.98	5	10.03±0.50	-1.17
21	4	8.73±0.89	5	10.41±0.55	-1.68
22.5	4	9.16±0.99	4	10.50±0.55	-1.34
24	4	9.97±0.75	3	10.70±0.29	-0.73
25.5	4	10.4±10.83		–	
27	4	10.67±0.68	5	11.61±0.55	-0.94
28.5	3	11.11±0.48	5	11.85±0.57	-0.74
30	3	11.43±0.54		–	
31.5	5	12.10±0.61		–	
–		–		–	
–		–		–	
–		–		–	

Note:
(a) Mean difference -0.703 kg.

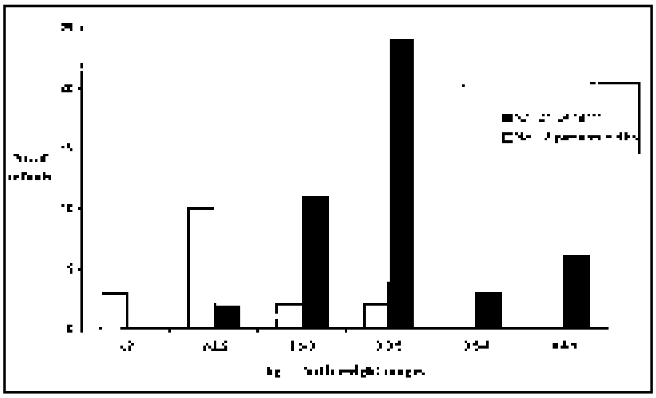


Figure 8: Birthweight precursors of failure-to-thrive infants.

of the episodes of FTT had occurred prior to the intervention. Of the 13 infants included in the 1996-97 pre-term male cohort, six (46%) were or had been FTT and of the females seven of 21 (33%) were or had been FTT infants or children. In addition to the crises leading to diagnosis, many FTT children were left with a persistent weight deficit. The negative difference between the pre-term male cohorts in Table 8 is partly due to this effect and reflects a continuing impaired growth of a substantial part of the later cohort, much of it associated with specifically diagnosed FTT.

Discussion

Published data from two large retrospective surveys (WA 1980-86[14] and Queensland 1988-92[21]) permit calculation of the distribution of Aboriginal live births below 2,500 g into full-term and pre-term categories. Both made comparison with concurrent non-Aboriginal births and both used centralised data collections to assign birthweights and gestational ages at birth. The distributions derived from both surveys are summarised in Table 9 and they are almost identical. Furthermore, and despite the much lower incidence of LBW in the non-Aboriginal populations, the proportion of LBW attributable to pre-term birth was approximately two-thirds in both ethnic groups in both surveys. The more recent Australia-wide survey[17] does not permit such an assignment but is in general agreement with Table 9 in the proportion of LBW (10.6%) and in the prevalence of pre-term birth (11.6% cf. 16.0%).[14]

The basis of the assignment of gestational age in all of these studies represented the best clinical estimate based on last known menstrual period, on ultrasound fetometry before 24 weeks (if performed) or on some form of neonatal maturity scoring in the absence of other indicators. The assessment was recorded by the hospital or the mid-wife at the time of birth and was entered routinely with birthweight on a State-based central register. The preponderance of pre-term LBW found is characteristic of births in developed countries[2,22] even where the overall rate is high as it is in sub-groups in extreme poverty.[16]

In the present small study of 247 births, LBW represented 15.4% of live births of which full-term LBW accounted for 2.4 % of live births. Pre-term LBW accounted for 84.2% of all LBW. Again the assignment of gestational age represents the best clinical estimate at the time of birth as registered in hospital records.

A quite different outcome appears to have been reached in a Darwin-based study of 503 Aboriginal births in which gestational ages were assigned exclusively by neonatal Dubowitz scores of developmental maturity.[23,24] The data as published showed rates of 14% LBW babies but only 7.4% of all births were pre-term. Assignment of LBW shows that (by coincidence) 7.4% of all births were full-term LBW babies and that only 47.1% of all LBW babies were pre-term.[24] The latter value compares with over 65% in either Aboriginal or non-Aboriginal LBW babies elsewhere (see Table 9). Unless the circumstances of the Darwin Aboriginal population were radically different from those elsewhere, use of the Dubowitz score to establish gestational age would appear to have been accompanied by a reduction of about half in the estimated prevalence of pre-term birth.[14] This, in turn, has resulted in the lower proportion of pre-term LBW noted and in almost a doubling of the prevalence of full-term LBW in Aborigines (7.4%[23]) from that found elsewhere (see Table 9). Anomalously advanced neonatal Dubowitz scores are recognised to occur with LBW infants[22,25] and had previously been shown in Aboriginal infants with LBW.[26] The same tendency was confirmed in the Darwin study.[23]

The possibility that misclassification of gestational age may have been responsible for the calculated distribution of LBW was addressed in the Queensland study by means of sensitivity analysis.[21] It was found that implausibly large misclassification proportions would have been required to upset the conclusion of a preponderance of pre-term LBW.[21] This result, together with the impressive consistency of the two large studies (see Table 9) supports the acceptability of the documented evidence used here showing a predominance of pre-term LBW among Aboriginal births in north-western Australia.

The excess prevalence of LBW in the pre-intervention cohort was almost entirely attributable to the very high prevalence of pre-term birth. When full-term birth outcomes are examined, there

Table 9: Low birthweights among full-term and pre-term births in Western Australia and Queensland.

		Total Births	All LBW as proportion of all births (%)	Full-term LBW as proportion of all births (%)	Pre-term LBW as proportion of all LBW (%)
Aboriginal	WA[14] 1980-1986	7,208	12.6	4.1	67.4
	Qld[21] 1988-1992	7,452	11.7	3.7	68.2
Non-Aboriginal	WA[14] 1980-1986	135,363	4.9	1.7	66.3
	Qld[21] 1988-1992	179,899	4.7	1.6	66.4

is little evidence of a serious weight deficit of the kind that might be attributed to maternal malnutrition. Although showing deficits in mean birthweight compared with either NCHS or WHO interim reference values, those deficits were not apparent in relation to NCHS weight-for-age (WFA) percentile distributions at birth, and when short-term postnatal performance is taken into account any deficits in mean body WFA at full-term birth were quickly made good and the NCHS percentiles exceeded. It must be concluded that any shortfall in the birthweight of full-term infants did not reflect a serious nutritional problem and responded quickly to the universal practice at that age of generous breastfeeding. Both birthweights and immediate post-natal growth indicate a generally adequate state of maternal pre-natal and immediate post-natal nutrition in the five communities concerned.

During the pre-intervention period, adequate post-natal growth of both males and females was maintained for 4-6 months, but then fell away progressively in NCHS percentile terms until 9-12 months. From 12 to 36 months, the growth pattern of both males and females maintained the lower NCHS percentile status achieved by 12 months. In simple WFA terms, mean and percentile growth profiles in the pre-intervention cohort were roughly linear from six months onward. A comparable linear form is not achieved in NCHS data until after 12 months of age.

The improvement in WFA during the intervention was highly significant and may have been an outcome of the intervention process. It demonstrates that, under the conditions prevailing in the five communities in 1996-1997, the growth of full-term females closely matched the interim WHO reference values for breastfed females for the first year of life and the growth of full-term males made an incremental improvement. It would appear that there is no serious impediment to the achievement of adequate growth rates of full-term Aboriginal infants. All that may be required is periodic individual and detailed nutritional advice accompanied by culturally appropriate community support. From 12 months onward there is not yet an international standard for the growth of breastfed infants but our results up to 12 months and the demonstrated improvement beyond 12 months encourage an expectation that accepted international rates of growth should be fairly readily achieved.

The very high prevalence and long duration of breastfeeding in the five communities is characteristic of the practice in Aboriginal communities in the region, but it is in sharp contrast to the brief duration of breastfeeding reported in the Melbourne Aboriginal community and in Perth.[27,28] In the former report, only 50% of Aboriginal babies were breastfed at three months and only 32% were still breastfed at six months of age. These values were said to be similar to those for the general population of Victoria.[27] Breastfeeding practices in the five communities were closely in accord with the recommendations of WHO/UNICEF.[10] This circumstance points up the need for ongoing advice in communities on the timely introduction of appropriate supplementary foods as well as the need for health advisers there to help achieve new growth patterns that reflect the WHO recommendations. The level of breastfeeding found also justifies the expectation that such growth standards should be achievable. According to WHO sources, comprehensive growth references for breastfed infants should become available in 2000.[11]

The greatly depressed WFA performance for pre-term infants in the 1991-96 cohort persisted up to three years of age and showed no demonstrable improvement during the intervention period. This suggests that much of the chronicity of impaired growth as well as most of the birthweight problem in the region is attributable to pre-term birth. The special problem of FTT among the infants and children in this study was also partly and disproportionately associated with pre-term birth.

The present work has identified two contributors to persistent failure to grow of Aboriginal children in the region. One of these is the diagnosed FTT of full-term infants whose birthweights were appropriate for gestational age and the other is the low birthweight pre-term infant whether or not diagnosed as FTT. Numerically, the latter is the predominant component.

The depressed growth of pre-term infants and children did not respond (on average) to the intervention process and this may reflect a permanent consequence of pre-term birth – an organic cause of FTT. The public health objective here, as in low birthweight, must be the prevention of pre-term birth.

The contribution of full-term FTT children to the overall depressed growth of the 1991-96 cohort was not assessed because of inconsistencies in diagnosis of FTT between communities. It was observed, however, that many FTT infants who recovered rapidly in hospital later relapsed, sometimes repeatedly. Although the treatment given in hospital often involved the resolution of gastroenterological or other disorders, the underlying problem was seen at community level as social rather than either medical or nutritional. It is, in any case, intransigent and significant and requires individual and special attention, possibly involving support from a community group.

The present work strongly supports previous indications that pre-term birth rather than maternal under-nutrition is the primary cause of the persistently low average birthweight of Aborigines born in the remoter areas of Western Australia and Queensland. No evidence has been advanced as to the causes of so high a rate of pre-term birth but recent evidence that intrauterine infection may be one of the primary causes of pre-term birth deserves to be explored in this context.[3,29]

Conclusion

The main findings and implications of this work depend on the general validity of the estimates of gestational age that were entered on obstetric discharge forms by midwives or physicians. Although referred to as 'best clinical estimate', some of the methods used are recognised to be inaccurate and because the study in this respect was retrospective and the values extracted could not be individually validated the conclusions must be regarded as suggestive.

The nature and quality of the data, however, is equivalent (perhaps in the hospital context identical) with that recorded in those State or Commonwealth birth registers used in the three large studies.[14,17,21] The basis of the present conclusions about pre-term birth is thus comparable with those of the three studies cited and confirms the general conclusion of a very high rate of pre-term birth in Aboriginal pregnancies.

In Western Australia, ultrasound dating of pregnancies had become routine by 1985, but between 1985 and 1987 a survey of non-metropolitan Aboriginal births showed only 40% of such pregnancies to have presented for scanning before 24 weeks gestation.[30] A policy to make the practice universal in the State has been pursued, however, and it will have resulted in a progressive increase in the accuracy of estimated dates of confinement and hence in the validity of the gestational age recorded at birth. When the 1980-86 Western Australian study[14] was published in 1989 it was accompanied by a leading article criticising the adequacy of gestational age data for Aboriginal births.[31] In 1999, the author of that criticism published, with a colleague, Australia-wide values for Aboriginal birthweights and gestational ages for 1991-94 that were also based on data from centralised birth registers.[17] The authors concluded, with suitable reservations, that the incidence of pre-term birth among Aboriginal women was, indeed, very high, being more than double that of the non-Indigenous rate. The acceptability of the later values presumably reflected the authors' conviction that the more recent data were sufficiently reliable to warrant such a conclusion.

The present evidence of extremely high rates of pre-term birth in five communities in north-western Australia is suggestive and not conclusive but, even if only partly true, the public health implications are very serious. It would seem to be of far greater importance and urgency to investigate directly the extent and causes of pre-term birth in remote Aboriginal communities than to continue to debate the adequacy of what is certainly a changing methodology for estimating gestational age. That debate has continued for more than a decade and it appears to have prevented any such direct approach.

Acknowledgements

This work was supported by a contract grant from the Operations Branch of the Health Department of Western Australia. We thank the chairpersons and councils of the five Aboriginal communities for inviting us to carry out the work and for their continuing support during its tenure. The generous support of the community health and public health staff of the Health Department of Western Australia is acknowledged. Major contributions came from those Aboriginal Health Workers employed on the project as co-ordinators of the Strong Women, Strong Babies, Strong Culture program in the communities. The contribution of Lorna Fejo, leader of SWSBSC program, in training both the co-ordinators and the women's groups in the communities was a major one and is gratefully acknowledged. Dr A.G. Constantine, formerly of CSIRO, Division of Mathematical Statistics, Adelaide, suggested and supervised the analysis of growth data by regressional methods, which were carried out by C. Creswick, IT TAFE, Broome. We thank the Commissioner, WA Health Department for permission to publish this work.

References

1. Somerford PJ, FitzGerald P, Gattorna L, et al. *Our state of health, 1995: An overview of the health of the Western Australian population.* Perth: Health Department of Western Australia, 1995.
2. Kramer MS. Determinants of low birthweight: Methodological assessment and meta-analysis. *Bull World Health Organ* 1987; 65: 663-737.
3. Martius J, Roos T. The role of urogenital tract infections in the etiology of preterm birth: A review. *Arch Gynecol Obstet* 1996; 258: 1-19.
4. Hamill PVV, Drizd TA, Johnson CL, et al. Physical growth: National Center for Health Statistics percentiles. *Am J Clin Nutr* 1979; 32: 607-29.
5. Rousham EK, Gracey M. Persistent growth faltering among Aboriginal infants and young children in north-west Australia: A retrospective study from 1969 to 1993. *Acta Paediatr* 1997; 86: 46-50.
6. Fejo L. Northern Territory: Strong women, strong babies, strong culture program. In: Bear-Wingfield R, editor. *Sharing good tucker stories: A guide for Aboriginal and Torres Strait Islander Communities*. Canberra: Department of Health and Family Services, 1996.
7. Fejo L, Rae C. *Report: Strong women, strong babies, strong culture project, 1992-1996.* Darwin: Territory Health Services, 1996.
8. Mackerras D. *Evaluation of the strong women, strong babies, strong culture program*. Darwin: Menzies School of Health Research, 1998. Menzies Occasional Papers No.: 2/98.
9. Beaton GH, Milner J, Corey P, et al. Sources of variance in 24-hour dietary recall data: Implications for nutrition study design and interpretation. *Am J Clin Nutr* 1979; 32:2546-59.
10. WHO/UNICEF. *Innocenti Declaration of the protection, promotion and support of breast feeding*. Florence: WHO/UNICEF, 1990.
11. WHO. *An evaluation of infant growth: WHO working group on infant growth*. Geneva: WHO Nutrition Unit, 1994.
12. Dewey KG, Peerson JM, Brown KH, et al. Growth of breast-fed infants deviates from current reference data: A pooled analysis of US, Canadian and European data sets. *Pediatrics* 1995; 96: 495-503.
13. Beaumont-Smith AJ. *Program for interpolated values.* Adelaide: Department of Electronic Engineering, University of Adelaide, 1997.
14. Kliewer EV, Stanley FJ. Aboriginal and non-Aboriginal births in Western Australia, 1980-86, Part 1: Birthweight and gestational age. *Med J Aust* 1989; 151: 493-502.
15. Berkowitz GB, Papiernik E. Epidemiology of pre-term birth. *Epidemiol Rev* 1993; 15: 414-43.
16. Tucker JM, Goldenberg RL, Davis RO, et al. Etiologies of pre-term birth in an indigent population: Is prevention a logical expectation? *Obstet Gynecol* 1991; 77: 343-7.
17. Roberts CL, Lancaster PAL. Australian national birthweight percentiles by gestational age. *Med J Aust* 1999; 170:114-8.
18. Egan J, Chartoor I, Rosen G. Non-organic failure to thrive: Pathogenesis and classification. *Clin Proc Child Hosp Natl Med Cent* 1980; 36(4): 173-82.
19. Gottlieb MI, Williams JE. *Textbook of developmental pediatrics*. New York: Plenum, 1987: 260.
20. Hardy JB, Drage JS, Jackson EC. *The first year of life*. Baltimore: Johns Hopkins University Press, 1979: 214-51.
21. Coory M. Effect of gestational age misclassification on the pattern of low birthweight in Aborigines. *Aust N Z J Public Health* 1997; 21: 84-8.
22. Crouse DT, Cassady G. The small for gestational-age infant. In: Avery GB, Fletcher MA, Mcdonald MG, editors. *Neonatology* 4th ed. Philadelphia: Lippincott, 1994: 369-98.
23. Sayers SM, Powers JR. Birth size of Australian Aboriginal babies. *Med J Aust* 1993; 159: 586-91.
24. Sayers SM, Powers JR. Risk factors for Aboriginal low birthweight, intrauterine growth retardation and preterm birth in the Darwin health region. *Aust N Z J Public Health* 1997; 21: 524-30.
25. Hall MH. Definitions used in relation to gestational age. *Paediatr Perinat Epidemiol* 1990; 4: 123-8.
26. Watson DS. Obstetrics at Galiwin'ku. *Br J Obstet Gynaecol* 1984; 91: 791-6.
27. Holmes W, Phillips J, Thorpe L. Initiation rate and duration of breast-feeding in the Melbourne Aboriginal community. *Aust N Z J Public Health* 1997; 21: 500-3.
28. Phillips FE, Dibley MJ. A longitudinal study of feeding patterns of Aboriginal infants living in Perth, 1980-82. *Proc Nutr Soc Aust* 1983; 8: 130-3.
29. McGregor JA, French JI. Prevention of preterm birth (letter). *N Engl J Med* 1998; 339: 1858-9.
30. Blair E, Morich P, Stanley F. Why do Aboriginal newborns weigh less? Gestational age at delivery; estimation, distribution and determinants. *Aust N Z J Obstet Gynaecol* 1994; 34: 158-63.
31. Lancaster PAL. Birthweight percentiles for Aborigines? *Med J Aust* 1989; 151: 489-90.