European Journal of Clinical Nutrition (2001) 55, 682–689
 0954–3007/01 $15.00
www.nature.com/ejcn

Original Communication
An analysis of intra-uterine growth retardation in rural Malawi

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Objective: (1) To describe the sex-specific, birth weight distribution by gestational age of babies born in a malaria endemic, rural area with high maternal HIV prevalence; (2) to assess the contribution of maternal health, nutritional status and obstetric history on intra-uterine growth retardation (IUGR) and prematurity.
Methods: Information was collected on all women attending antenatal services in two hospitals in Chikwawa District, Malawi, and at delivery if at the hospital facilities. New-borns were weighed and gestational age was assessed through post-natal examination (modified Ballard). Sex-specific growth curves were calculated using the LMS method and compared with international reference curves.
Results: A total of 1423 live-born singleton babies were enrolled; 14.9% had a birth weight < 2500 g, 17.3% were premature (< 37 weeks) and 20.3% had IUGR. A fall-off in Malawian growth percentile values occurred between 34 and 37 weeks gestation. Significantly associated with increased IUGR risk were primiparity relative risk (RR) 1.9; 95% CI 1.4–2.6), short maternal stature (RR 1.6; 95% CI 1.0–2.4), anaemia (Hb < 8 g/dl) at first antenatal visit (RR 1.6; 95% CI 1.2–2.2) and malaria at delivery (RR 1.4; 95% CI 1.0–1.9). Prematurity risk was associated with primiparity (RR 1.7; 95% CI 1.3–2.4), number of antenatal visits (RR 2.2; 95% CI 1.6–2.9) and arm circumference < 23 cm (RR 1.9; 95% CI 1.4–2.5). HIV infection was not associated with IUGR or prematurity.
Conclusion: The birth-weight-for-gestational-age, sex-specific growth curves should facilitate improved growth monitoring of new-borns in African areas where low birth weight and IUGR are common. The prevention of IUGR requires improved malaria control, possibly until late in pregnancy, and reduction of anaemia.
Descriptors: reference curves; anaemia; intra-uterine growth; developing country; malaria
European Journal of Clinical Nutrition (2001) **55,** 682–689

Introduction

Low birth weight (LBW) is the most important risk factor for infant mortality and a significant determinant of childhood morbidity (McCormick, 1985; Ashworth, 1998). In developed countries LBW predominantly results from preterm delivery, whereas in developing countries, where LBW incidence is often greater than 10%, it is almost exclusively due to intra-uterine growth retardation (IUGR) (Villar & Belizan, 1982a).

In Kramer's (1987) extensive review on determinants of low birth weight, he reported several factors that have a causal effect on intra-uterine growth, such as socio-economic status, maternal height and low parity. Kramer (1987) did not assess the contribution of HIV to LBW and underestimated the effect of malaria on low birth weight risk (Brabin, 1991). Data from industrialised countries suggest that maternal anaemia and iron deficiency increase low birth weight and preterm birth risk (Klebanoff *et al*, 1991; Scholl & Hediger, 1994). In developing countries these effects may be compounded by chronic energy deficiency and poor maternal micronutrient status. Contributors to lower birth weights such as parity and infant sex are impossible to influence, but other factors are potentially modifiable. It is important to recognise these factors and their relative contribution to IUGR so that limited resources can be directed at those most at risk.

This paper describes the sex-specific, birth weight distribution by gestational age of a large group of hospital

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Contributors: The study was designed and planned by FV and BB, and they wrote the paper together. FV was responsible for data collection and analysis. SvB and JMW were involved in data analysis. PK and RB advised on the study at several stages and on interpretation of data.
Received 15 June 2000; revised 18 January 2001;
accepted 18 January 2001

births from a malaria endemic, rural area in Malawi with high maternal HIV prevalence. IUGR was defined using as birth weight below the 10th percentile of a birth weight-for-gestational age, sex-specific risk curve recommended by the WHO (1995). The contributions of maternal health, nutritional status and obstetric history on intra-uterine growth retardation and prematurity are assessed.

Methods

Study site

This study was undertaken between March 1993 and December 1994 in the two hospitals of Chikwawa District, Southern Malawi. In this rural area small-scale agriculture of maize, sorghum, cotton and sugar cane are the primary source of food and income. Malaria transmission is stable, and the adult prevalence of HIV-seropositivity is high (26.8%) (Verhoeff *et al*, 1999a). Chikwawa District Hospital, one of the two study hospitals, is a government hospital with free services, while Montfort Hospital is a fee-paying mission hospital located 30 km south of Chikwawa District Hospital.

Enrolment

All women attending the antenatal facilities of Chikwawa District Hospital or Montfort Hospital between March 1993 and June 1994 were screened at their first antenatal visit (booking) after verbal informed consent was obtained. A questionnaire was completed by a project nurse which included information on age and obstetric history. If age was uncertain the woman was classified as either adolescent (19 y of age and younger) or adult. Literacy status was assessed by asking the participants to read a simple sentence in the local language. Height, in bare feet and with no head cover, was measured to the nearest centimetre using a Minimeter (Child Growth Foundation, Chiswick, UK). Mid-upper-arm circumference (MUAC) was measured on the right arm, hanging loosely, with a tape measure and recorded to the nearest 0.1 cm. A blood sample was collected for laboratory investigation by venepuncture.

Delivery

Information on delivery was collected only from women who attended the hospital facilities for delivery; for logistical reasons it was not possible to obtain this information from home or health centre deliveries. Information on the number of antenatal visits and antimalarial drug use during pregnancy was taken from the antenatal card. At Chikwawa District Hospital women received one dose of sulphadoxine-pyrimethamine (SP) at the first antenatal visit occurring after 18 weeks gestation ('if quickening had occurred') and a second dose between 28 and 34 weeks gestation, according to Malawi government policy (Malaria Control Program, 1992). In Montfort Hospital malaria treatment was based on positive malaria slides collected at booking and subsequently with the occurrence of clinical symptoms.

A blood sample was collected from the women before delivery by venepuncture and from the cord and placenta for laboratory investigation. A malaria slide was made from blood collected deep between the placenta villi. The baby was weighed immediately after birth on a Salter scale to the nearest 10 g; scales were checked for accuracy on a weekly basis. Length was measured using a measure board. Gestational age was assessed between 6 and 24 h post-partum using a modified Ballard method, scoring for the six external criteria only (Ballard *et al*, 1979; Verhoeff *et al*, 1997).

Laboratory investigations

Haemoglobin level (Hb) was measured photometrically after conversion to cyanomethaemoglobin using a haemoglobinmeter (Biotron) within 6 h. Packed cell volume (PCV) was measured by microhaematocrit and erythrocyte protoporphyrin levels (EP) were assessed using an AVIV haematofluorometer, both within 24 h of collection. Hb, PCV and EP values were the means of duplicate measurements. Mean corpuscular haemoglobin concentration (MCHC) was calculated from the Hb and PCV.

Malaria slides were made from maternal blood at booking and at delivery, and from the placenta. The slides were Giemsa stained and read counting the number of asexual *Plasmodium falciparum* parasites per 200 white blood cells. Malaria slides read in Malawi were checked blindly by a microscopist at the Liverpool School of Tropical Medicine. The HIV seropositivity of women was determined using ICE*HIV-1.O.2 (Murex; Dartford, UK) with confirmation by VIDAS HIV 1/2 new (bioMérieux; Lyon, France). HIV testing was done, after counselling and obtaining informed consent, on sera collected in pregnancy from mothers whose babies were included in an infant follow-up study for which the criteria of enrolment were low birth weight (less than 2500 g), cord haemoglobin less than 12.5 g/dl or as control. An additional group of pregnancy sera were selected randomly from 15% of women whose babies were not enrolled in the infant follow-up study and these were tested anonymously.

Definitions

Low birth weight was defined as less than 2500 g. Babies were classified as premature if the gestational age was less than 37 weeks and as growth retarded if below the 10th percentile of the birth-weight-for-gestational-age, sex-specific risk curve (Williams *et al*, 1982) using completed weeks of gestation, as recommended by the WHO (1995). Rohrer's ponderal index was calculated as 100 times the birth weight (in grams) divided by the cube of birth length (cm^3). Asymmetric growth retardation was defined as a ponderal index $<10\%$ of reference value (Lubchenco *et al*,

1966). Adolescents were defined as aged 19 y or less. A MUAC <23 cm was used as indicator of poor maternal nutritional status (WHO, 1995). The cut-off level used for moderately severe anaemia was a haemoglobin less than 8 g/dl. Iron deficient erythropoiesis was defined as EP > 2.7 μgZP/gHb (International Nutritional Anaemia Consultative Group (INACG), 1985). Since the combination of abnormal values for two independent variables is a more sensitive indicator of iron deficiency (International Nutritional Anaemia Consultative GrouP (INACG), 1985), this was defined as EP >2.7 μgZP/gHb in combination with MCHC <32 g/dl (Letsky, 1991).

Analysis

Data were analysed using SPSS for Windows, version 6.1.2 (1995) and EPI-info version 6.02 (1994). The Pearson χ^2 test was used for comparison of discrete variables and Mantel–Haenszel χ^2 test for measuring linear association. In a forward stepwise logistic regression analysis candidates for entering the model were variables with $P < 0.10$ in the univariate analyses. A P-value of less than 0.05 was considered significant.

The LMS method (Cole & Green, 1992) was used to calculate point reference percentile-curves of birth weight by gestational age. For both boys and girls, optimal smoothing parameters of the model were edf (M) = 6, edf (S) = 3 and edf (L) = 0, which corresponds to a normal conditional reference distribution for all ages. The deviance of alternative candidate models, and the shape of the worm plot (Van Buuren & Fredriks, 2001) supported the choice of these parameters.

Ethical approval

The study was granted ethical approval by the Malawi Health Science and Research Committee.

Results

Study population

At first antenatal visit, 4104 women were enrolled in the study of whom 1523 delivered in the two study hospitals comprising 1480 singleton and 43 multiple births. Primigravidae, who attended for ANC, were more likely to have a hospital delivery than multigravidae (41.2 *vs* 36.0%; $P = 0.005$). Literate women and women attending antenatal services of Montfort Hospital were also significantly more likely to have a hospital delivery ($P < 0.001$). Women with an unknown outcome of pregnancy were not significantly different compared to women who delivered at one of the two hospitals in nutritional status, height, Hb level or malaria at first antenatal visit.

Stillbirth occurred in 57 cases (3.7%). Data are presented only for the 1423 live born singletons. For eight babies birth weight was not recorded and gestational age assessment was not performed for 18 cases. Mean birth weight was 2818 g (s.d. 481 g), and 211 babies (14.9%) had a birth weight of less than 2500 g (LBW). Mean gestational age was 38.6 weeks (s.d. 1.9 weeks) and 243 (17.3%) were premature. IUGR occurred in 285 (20.3%) babies, of these 109 (38.2%) were LBW and 26 (9.1%) were premature. Figure 1 shows the gestational age distribution of all live born singletons babies.

Figures 2 and 3 show the smoothed birth-weight-for-gestational-age, sex-specific curves with their 10th, 50th and 90th percentiles against the corresponding reference curves (Williams *et al*, 1982). The original data (Williams *et al*, 1982) was given in completed weeks gestation, therefore, to allow comparison, this data was adjusted with half a week (eg 37 weeks completed gestation is 37.5 weeks pregnancy). Note that the reference curves before 32 weeks gestation are based on few measurements, and thus have substantial variability. For boys and girls a deviation in Malawian percentile values commences between weeks 34 and 37 weeks gestation and the 90th percentile falls below the reference 90th percentile value from 31 weeks gestation. The Malawian 10th percentile values falls below the 10th percentile reference values at 35 weeks for boys and 37 weeks for girls. The smoothed Malawian reference data are presented in Table 1.

Of IUGR babies 14.0% were asymmetric (ponderal index <10%) compared to 1.4% of babies with no IUGR (RR 9.9; 95% CI 5.6–17.6). Multivariate analysis showed increased risk of disproportionate growth retardation in primigravidae (RR 1.8; 95% CI 1.0–3.1) and with poor maternal nutritional status (RR 1.9; 95% CI 1.0–3.7), but not with placental or maternal parasitaemia, antimalarial treatment or maternal anaemia.

The sera of 600 women (42.1%) were tested for HIV, 437 women whose babies were in the infant follow-up

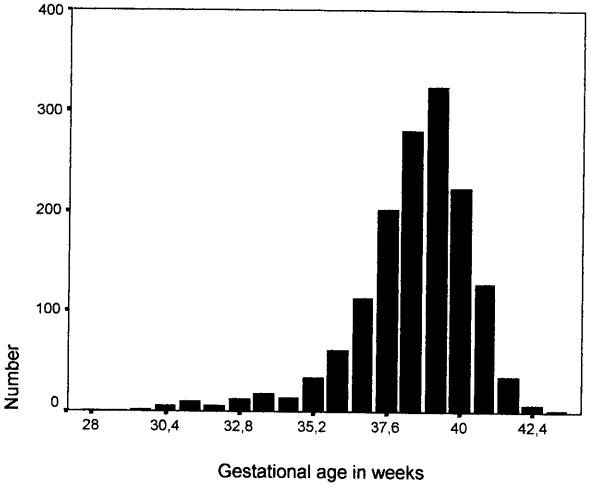

Figure 1 Gestational age distribution of 1423 singleton live-births.

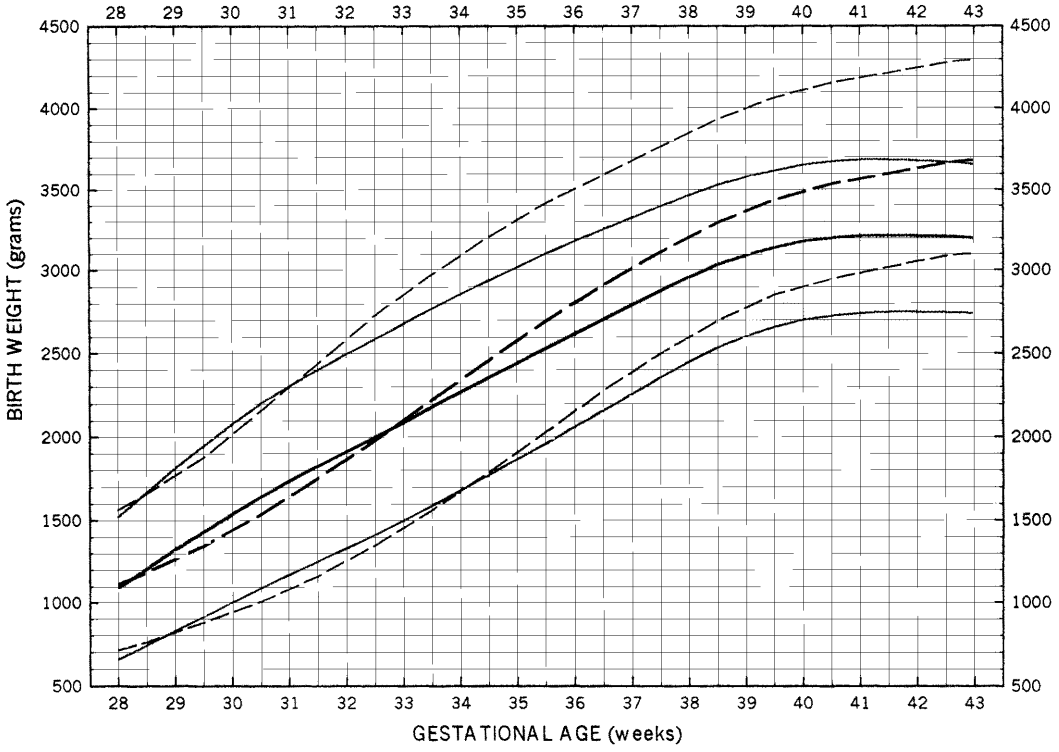

Figure 2 Birth-weight-for-gestational-age-curves for boys. The 10th, 50th and 90th percentiles are shown. Stippled line–Williams reference; continuous line–Malawian data.

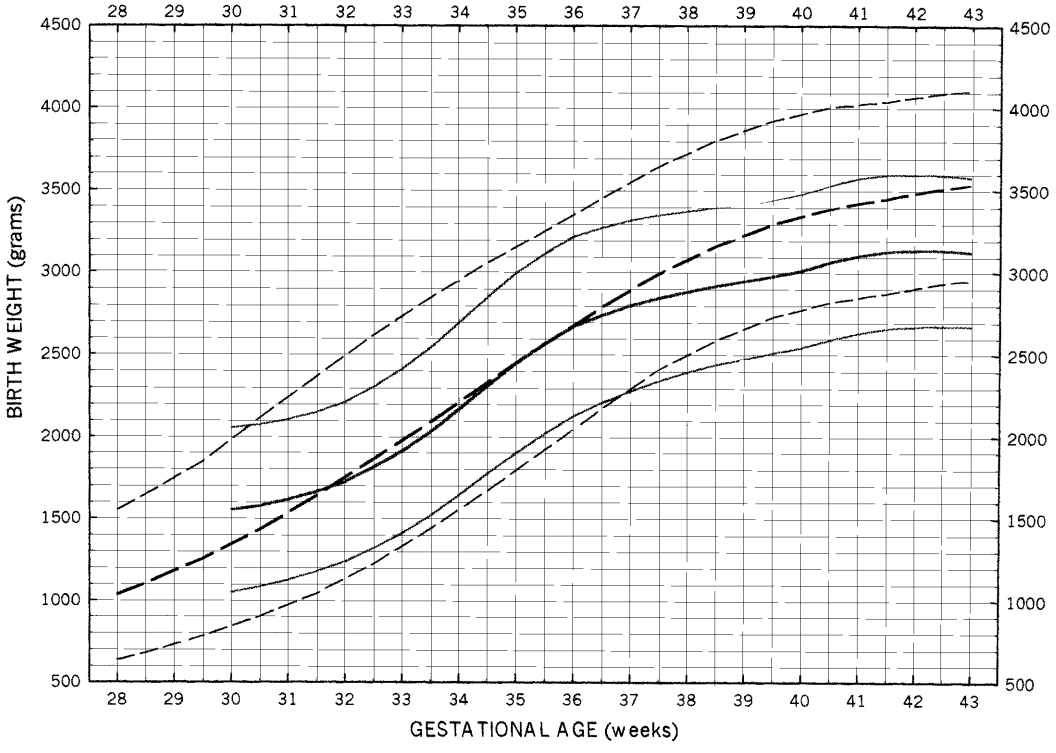

Figure 3 Birth-weight-for-gestational-age curves for girls. The 10th, 50th and 90th percentile values are shown. Stippled line–Williams reference; continuous line–Malawian data.

Table 1 Smoothed curve data for singleton Malawian boys and girls

		Boys				*Girls*		
GA[a]	n	*P10*	*P50*	*P90*	n	*P10*	*P50*	*P90*
28	2	661	1092	1523				
29		830	1323	1816	1			
30	3	1002	1541	2081	1	1050	1552	2054
31	3	1170	1739	2307	4	1126	1615	2104
32	9	1332	1915	2497	5	1237	1724	2211
33	5	1501	2090	2679	5	1411	1913	2414
34	7	1681	2268	2856	6	1644	2170	2697
35	16	1867	2445	3022	16	1902	2449	2995
36	79	2063	2623	3183	78	2129	2674	3220
37	115	2259	2792	3326	71	2281	2800	3319
38	125	2451	2958	3466	144	2393	2883	3374
39	167	2605	3092	3578	143	2475	2946	3417
40	147	2704	3181	3657	202	2547	3013	3479
41	12	2743	3215	3688	21	2635	3104	3573
42	4	2750	3216	3682	4	2676	3138	3600
43	2	2742	3201	3659	1	2679	3129	3579

[a]Gestational age.

study and 163 anonymous women. HIV was present in 25.7%. None of the HIV-infected women fulfilled the clinical case-definition of AIDS. The HIV-tested group is comparable to those not tested except for birth weight and parity which relates to the recruitment criteria for the infants in the follow-up study (Verhoeff *et al*, 1999a).

Factors associated with intra-uterine growth retardation and prematurity

Table 2 shows the association of IUGR and prematurity with maternal and infant characteristics. Significantly associated with both IUGR and prematurity were adolescence, primiparity, low mid-upper-arm circumference, short stature and placental malaria. Increased IUGR, but not prematurity, was observed with illiteracy, anaemia at booking or delivery and malaria parasitaemia at delivery. Women with preterm delivery made significantly fewer antenatal visits.

A significant reduction in IUGR and prematurity was observed with increasing parity (χ^2 for linear trend; $P < 0.0001$ for both). IUGR prevalence in primiparae was 31.3%, 17.4% in parae 2–4 and 12.9% in grandemultiparae (parity ≥ 5). The corresponding percentages for prematurity were 24.1, 16.7 and 12.9%, respectively. Maternal HIV seropositivity was not associated with IUGR or prematurity for either the 437 HIV-tested women whose baby was enrolled in the follow-up study or the 163 anonymously tested women. IUGR prevalence was 26.4% with maternal parasitaemia at delivery and/or placental malaria *vs* 18.0% if aparasitaemic ($P = 0.001$). For prematurity these rates were 21.4 and 15.4%, respectively ($P = 0.009$).

At Chikwawa District Hospital, 252 women received only one SP treatment dose at their first antenatal visit, 232 women received also the second SP dose, according to Malawi government guidelines. IUGR prevalence in

Table 2 Risk factors for IUGR, univariate analyses

		IUGR		*Prematurity*	
Characteristic	*Prevalence %*	*OR*[a]	*95% CI*	*OR*	*95% CI*
Adolescence	18.2	1.1	1.4–2.2	1.7	1.3–2.1
Primiparae	24.0	1.7	1.5–2.3	1.6	1.3–2.1
Booking in first trimester	22.9	0.8	0.7–1.1	1.3	1.0–1.7
Less than four ANC[b] visits	30.4	0.9	0.7–1.2	2.0	1.6–2.5
Not literate	27.1	1.3	1.0–1.6	1.0	0.7–1.3
MUAC[c] < 23 cm	13.4	1.5	1.1–1.9	1.8	1.3–2.3
Height < 150 cm	9.9	1.5	1.2–2.0	1.5	1.1–2.0
HIV	25.7	1.2	0.9–1.6	1.3	0.9–1.8
Moderately severe anaemia					
at booking	23.6	1.6	1.2–2.0	1.2	0.9–1.6
at delivery	11.4	1.4	1.0–1.8	1.2	0.9–1.7
Hb cord < 12.5 g/dl	23.1	0.8	0.6–1.1	1.3	1.0–1.6
Iron deficiency					
at booking	41.7	1.2	1.0–1.5	1.4	1.1–1.7
at delivery	37.3	0.9	0.7–1.2	1.1	0.8–1.4
Malaria					
at booking	20.2	1.2	1.0–1.6	1.0	0.7–1.4
at delivery	21.5	1.4	1.1–1.8	1.3	1.0–1.6
of the placenta	17.4	1.4	1.1–1.8	1.4	1.1–1.9
Placental or peripheral malaria at delivery	26.1	1.6	1.2–2.2	1.5	1.1–2.0
SP (one *vs* two doses)[d]	51.6	1.4	0.9–2.2	1.4	1.0–2.0
Iron-folate (< 5 *vs* ≥ 5 suppl.)[e]	48.3	0.9	0.5–1.5	1.8	1.2–2.8
Male infant	49.8	1.0	0.8–1.2	1.1	0.7–1.4

[a]Odds ratio.
[b]Antenatal care.
[c]Mid upper arm circumference.
[d]Single *vs* two treatment doses of sulphadoxine-pyrimethamine, Chikwawa District Hospital only ($n = 484$).
[e]Less than 5 *vs* 5 or more supplementations of iron-folate, Chikwawa District Hospital only ($n = 484$).

women who received two SP treatment doses was 11.7% compared with 16.3% in women who received SP once in pregnancy ($P = 0.15$). Excluding 40 very preterm births (< 34 weeks gestation), therefore excluding those who may have delivered before a second SP dose could be given, showed 17.3% IUGR with one SP treatment dose and 12.0% with two doses ($P = 0.11$). SP use was significantly associated with prematurity risk with a reduction from 26.6 to 17.7% with a second SP dose ($P = 0.048$). After excluding the 40 very premature babies the observed prevalence was 20.8 and 16.0%, respectively ($P = 0.19$). Frequency of iron-folate supplementation did not affect IUGR risk but was associated with a significant reduction in prematurity. Smoking was reported by 1.6% of women and less than 0.5% had hypertension (diastolic blood pressure > 90 mmHg and/or systolic blood pressure > 140 mmHg) at any time during pregnancy. These variables were omitted from the analyses due to their low prevalence.

Table 3 shows the result of a multivariate regression analysis for risk factors associated with IUGR and prematurity. Significantly associated with increased risk of IUGR were primiparity, short maternal stature, moderately

Table 3 Multivariate risk analysis of categorical variables of IUGR and prematurity

	IUGR			*Prematurity*		
Characteristic	*OR*[a]	*95% CI*	P-*value*	*OR*	*95% CI*	P-*value*
Primiparae[b]	1.9	1.4–2.6	<0.001	1.7	1.3–2.4	<0.001
Less than four ANC visits				2.2	1.6–2.9	<0.001
Height <150 cm	1.6	1.0–2.4	0.003			
MUAC <23 cm				1.8	1.2–2.5	0.003
Hb <8 g/dl at booking	1.6	1.2–2.2	0.047			
Malaria at delivery[c]	1.4	1.0–1.9	0.048			

[a]Odds ratio.
[b]The reference group for primiparae is multiparae.
[c]Peripheral or placental parasitaemia.

severe anaemia at booking and malaria at delivery (placental or peripheral). Analyses for continuous variables showed that parity, maternal height, haemoglobin level at delivery and malaria at delivery (placental or peripheral) were significantly associated with IUGR risk. Prematurity risk was associated with primiparity, number of antenatal visits and MUAC < 23 cm (Table 3). Risk factors for premature delivery were not different for continuous or categorical variables.

A separate multivariate analysis was performed for the 484 women who delivered at Chikwawa District Hospital to investigate the association of SP treatment and iron folate supplementation with IUGR and prematurity. No independent effect of the second SP treatment dose or frequency of iron-folate supplementation was observed on IUGR or prematurity.

Discussion

To our knowledge this is the first analysis to present birthweight-for-gestational-age, sex-specific, data of full and pre-term babies from a malaria endemic area. Data were displayed against cross-sectional reference curves, as recommended by WHO (1995). The reference curves were from a survey of two million births, in a multiracial Californian population, where neonatal care and outcomes were 'reasonably good' (Williams *et al*, 1982). Children of socio-economic advantaged classes in developing countries, follow intra-uterine growth curves similar to healthy, well-nourished children in developed countries, suggesting that babies of all races have the same intra-uterine growth potential. Therefore, population- or race-specific reference curves should not be used (Bakketeig *et al*, 1998). However, the sex-specific reference curves presented in this paper will allow comparisons to be made in developing countries where, due to insufficient nutrition and disease burdens, intra-uterine growth conditions are far from optimal. Furthermore, we expect that when used in conjunction with the international reference curves these curves should improve understanding of intra-uterine growth retardation in sub-Saharan Africa.

The effect of including only hospital-based deliveries on these curves is difficult to assess. In Malawi it is estimated that 90% of women use antenatal care services but only 55% will have a delivery assisted by a nurse/midwife or doctor (Malawi Demographic and Health Survey, 1992). Assisted deliveries can be at a hospital or health centre, which explains why only 37.1% of women who attended for antenatal care at one of the two study hospitals also delivered at these facilities. In our study primigravidae and literate women were more likely to attend the hospital facilities for delivery, a finding comparable to results from the Malawi Demographic and Health Survey (1992). Primigravidae are more likely to have an IUGR baby, literate women less likely.

In this population IUGR was common: 20.3% of babies born with a weight below 10th percentile of a birth weight-for-gestational age, sex-specific reference curve. Due to the availability of reliable gestational age estimates (Verhoeff *et al*, 1997), it was possible to define IUGR according these criteria, as is recommended by WHO (Williams *et al*, 1982). Using LBW as a proxy for IUGR would have misclassified almost half of LBW babies, mainly prematures, as growth retarded. In addition, one in six babies born at term with a birth weight over 2.5 kg were IUGR. This shows the limitations of using the term-LBW as a proxy for growth retardation.

Low weight for gestation is not necessarily the result of exposure to growth-inhibiting factors. Low birth weight babies may represent the lower tail of a 'normal' foetal growth distribution, eg those born to short mothers, rather than true *in utero* growth restriction (de Onis *et al*, 1998). The mean height of the Malawian mothers was 156.4 cm (s.d. 5.7), approximately 7 cm lower than the 50th percentile of NCHS reference data (Hamill *et al*, 1979).

Our data confirms previous findings that parity and maternal height are important contributors to IUGR (Kramer, 1987). Kramer estimated the relative risk of IUGR associated with primiparity to be 1.2, which is significantly lower than the relative risk of 1.9 (95% CI 1.5–2.3) observed in these Malawian babies. He further reported a difference in mean birth weight between primiparous and multiparous of 83 g, which again is considerably lower than the 282 g difference observed in this study. Carr-Hill and Pritchard (1985) suggested that increased birth weight with increasing parity may be related more to an increase in maternal weight with successive pregnancies than to parity *per se*. Pre-pregnancy weights were not available for these Malawian women to test this hypothesis but the increase in MUAC observed with increasing parity suggests that this may play a role (Verhoeff *et al*, 1996). Primiparae were also more likely to be shorter: 30.7% had a height of less than 150 cm compared to 23.6% of multiparae ($P = 0.06$). Other important risk factors associated with IUGR were anaemia and malaria (Table 3), both of which were significantly more common in primigravidae in this area (Verhoeff *et al*, 1999b).

The weight curves shown in Figures 2 and 3 indicate that intra-uterine growth deceleration occurs in both sexes

late in pregnancy. This decline coincides with the lack of protection from malaria infection during the last 4–5 weeks of pregnancy, as no sulphadoxine-pyrimethamine was prescribed after 34 weeks gestation. During this time re-infection with *P. falciparum* malaria is common (Verhoeff *et al*, 1997). Our data also showed a reduction in IUGR risk by about one-third following a second SP treatment dose given before 34 weeks gestation, but this difference did not reach statistical significance. Reduction in foetal weight gain late in pregnancy would lead to asymmetric (disproportionate) growth retardation (Villar & Belizan, 1982b) and 14% of growth-retarded babies in this sample were in this category. There is also evidence from Zaire that malaria in pregnancy leads to asymmetric growth (Meuris *et al*, 1993). However, the exact cause of this later deceleration in growth is unknown and could be associated with adverse placental changes which have occurred earlier in pregnancy. Requirements for foetal growth late in pregnancy may be limited by these changes in the placenta resulting from earlier malaria infection (Battaglia, 1997).

The commonest causes of anaemia in pregnant women in Africa are iron and folate deficiency, malaria, and AIDS (WHO, 1993). Other nutritional deficiencies (eg vitamin A) may also be important contributors. In this population, in primigravidae iron deficiency and malaria were identified as the most important causes of anaemia and in multigravidae iron deficiency. No significant association between HIV seropositivity and anaemia was observed (Verhoeff *et al*, 1999b). The extent to which malaria control can improve birth weight through anaemia reduction will therefore vary in relation to the prevalence of malaria and causes of anaemia in these women.

Increased prematurity risk was associated with primiparity and poor maternal nutritional status. Less frequent antenatal attendance was also associated with prematurity (Table 3), which could reflect fewer SP treatments and less iron-folate supplementation, but also that mothers with preterm deliveries have less available time for antenatal attendance.

In conclusion, the observed pattern of deceleration of foetal growth in the last trimester indicates that interventions late in pregnancy are likely to improve foetal growth. Achieving a higher uptake of the second SP treatment dose between 28 and 34 weeks gestation is a priority, especially in primigravidae. The use of an alternative antimalarial regimen for late pregnancy coverage should be considered in view of the recommendation not to use SP after 34 weeks gestation. Furthermore, the prevention of IUGR requires efforts to reduce anaemia prevalence prior to pregnancy considering the high prevalence of anaemia at first antenatal visit and late attendance in pregnancy to antenatal clinics of many women. This means targeting adolescents, as young primigravidae are most at risk of anaemia (Verhoeff *et al*, 1999b). The higher risk of IUGR for smaller women also prioritises the need to delay first pregnancies until optimum maternal height is reached. This may not be achieved in these young women until 20–21 y of age (Verhoeff *et al*, 1996). Longer term strategies than pregnancy interventions alone are required to improve the nutritional status of these young women and the health of their babies.

Acknowledgements—We would like to thank Ms Makwiza, Ms Mlanga, Ms Nakoma, Ms Gwaza and Mr Banda for their dedication to this project. We are most grateful for the support received from the staff of Chikwawa District Hospital and Montfort Hospital, Nchalo, Malawi. We also thank the laboratory technicians from the Department of Paediatrics, College of Medicine, Blantyre, for technical support and the Health Science Research Committee, Malawi, for allowing us to conduct this study. Financial support for this study was through the European Commission, Program for Life Sciences and Technologies for Developing Countries and Ter Meulen Foundation, Amsterdam (for FV).

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