Maternal Anthropometry and Weight Gain as Risk Factors for Poor Pregnancy Outcomes in a Rural Area of Southern Malawi

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Introduction

Poor pregnancy outcomes are frequent in developing countries. The commonly studied outcomes are low birth weight (LBW), preterm birth and intra-uterine growth retardation (IUGR), both of which are related to LBW. Pregnancy outcomes are influenced by several maternal factors including malaria nutrition, psychological stress and socio-demographic factors. Apart from nutritional and psycho-socio factors, pregnancy outcomes are also influenced by maternal anthropometric indices. In developing countries, low prepregnancy body mass indexes are on the other hand predictors of adverse pregnancy outcomes. Most important, poor pregnancy outcomes are not an end in themselves, but lead to increased neonatal morbidity and mortality, and must therefore be controlled.[1]

In pregnancy, weight gain is affected by prepregnancy weight, age, psychosocial stress and antenatal care advice. Weight gain in pregnancy is also known to influence pregnancy outcomes including LBW, preterm delivery, small for gestational age delivery (SGA) and cesarean delivery.[2] In Malawi, and generally in the developing world, factors affecting weight gain and the effect of weight gain on pregnancy outcomes have not been studied. The aim of this study was to determine the anthropometric risk factors for pregnancy outcomes, risk factors for pregnancy weight gain and effect of weight gain on pregnancy outcomes. These risk factors are of public health significance because they affect human health throughout life.

Methods

Study area

This study was undertaken between March 1993 and July 1995 in Chikwawa District, in the Lower Shire Walley, southern Malawi. This is a rural area where malaria is endemic. The estimated infant mortality rate in this District was 174 compared to a national average of 159 deaths per 1000 live births.[3] Chikwawa District comprises about 4,800 km^2 and is 10-300 meters above sea level. The average rainfall in the study period was 520mm/year of which 88% fell in the months of November – March. Mean temperature was 26.6°C, ranging from 22.3°C in June to 30.1°C in December.[4] Small-scale agriculture of maize, sorghum, cotton and sugar cane are the primary sources of food and income. The estimated population size in 1987 was 316,733 of which 68,998 were women of child bearing age.[3] The study was located in the two hospitals in the District, Chikwawa District Hospital (CDH), a government hospital with free services and Montfort Hospital (MH), 30 Km away, which is a fee-paying mission hospital.

Enrolment and Anthropometry

All women attending the antenatal facilities at CDH or MH between March 1993 and June 1994 were screened at their first antenatal visit after verbal consent was obtained. A questionnaire, completed by a project nurse, included information on age, obstetric history and antimalarial use in pregnancy. If age was uncertain, women were classified as either adolescent or adult. Literacy status was assessed by asking the participants to read a simple sentence in the local language (Chichewa). Gestational age at booking was assessed manually by a hospital midwife. Height, in bare feet and with no head cover, was measured to the nearest centimetre using a Minimeter.[5] Weight was estimated in bare feet to the nearest kilogram using a SECA scale, clothing was light. 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 only collected from women who attended the hospital facilities of CDH or MH for delivery. For logistic reasons, it was not possible to obtain this information from home or health centre deliveries. The baby was weighed immediately after birth on a Salter scale to the nearest 10 grams and was examined for gestational age between 6 and 24 hours later using a modified Ballard method.[6] Women stayed 48 hours post-partum in hospital for observation. 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.

Definitions

Low birth weight (LBW) was defined as less than 2500 grams. A cord haemoglobin of less than 12.5g/dl was used as the cut-off value for low cord haemoglobin. This value is 2 standard deviations below the mean cord haemoglobin for industrialised countries.[7] 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 using completed weeks of gestation, as recommended by WHO. Low maternal MUAC was defined as <23cm, low height <150 cm, low weight <50 Kgs[8] and low BMI <18.5 kgs/m^2.[9] Weight gain was calculated as weight soon after delivery less weight at recruitment if it was before 18 weeks gestation.

Sample size

To observe an increased risk of at least 2 of IUGR, LWB or pre-term delivery associated with low maternal height, with a 95% confidence interval and 80% power, 219 women with and 219 without low maternal height were required. We assumed a 10% prevalence of low maternal height and a 20% prevalence of LBW among mothers with low height.

Analysis

Data were analysed using SPSS for windows, version 11.0 (2001). The independent T-test was used to compare continuous variables. Logistic regression was used to analyse factors associated with IUGR, LBW, FA, pre-term delivery and still births. All significant factors in the univariate analysis were selected for the multivariate regression. For adjusted odds ratios (AORs,) a p value of not greater than 0.05 was taken as significant. 95% confidence intervals were estimated.

Ethical approval

The study was granted ethical approval by the Malawi National Health Sciences Research Committee.

Results

The study recruited 4,104 women of whom 38.3 % (1571) delivered in study hospitals. For logistic reasons, it was not possible to follow the women who delivered at home. Among the mothers who delivered in hospitals, their nutritional and anthropometric factors are summarised in Table 1.

Maternal anthropometric risk factors for poor pregnancy outcomes.

In a univariate analysis LWB was associated with low maternal height (OR=1.78, 95% C.I. 1.22, 2.60) and low MUAC (OR° 95% C.I. 1.72, 3.25). Preterm delivery was associated with low MUAC (OR=2.08, 95% C.I. 1.50, 2.89). IUGR was associated with low height (OR=1.67, 95% C.I. 1.14, 2.45) and low MUAC (OR=1.46, 95% C.I. 1.04, 2.04) (Table 2). In a multivariate analysis, LWB was independently associated with low height (AOR=1.53, 95% C.I. 1.03, 2.25) and low MUAC (AOR=2.25, 95% C.I. 1.63, 3.10). IUGR was independently associated with low height (AOR= 1.67, 95% C.I. 1.14, 2.45) (Table 3).

Maternal anthropometric risk factors for weight gain in pregnancy and effect of weight gain on pregnancy outcomes

There were 991 women recruited before or at 18 weeks gestation. Their mean height, MUAC, Fep and MCHC were not different at recruitment from those recruited after 18 weeks gestation ($p>0.05$). Their Hb and haemotocrit were significantly higher at recruitment ($p<0.05$). Of these 991 women, 335 delivered in study hospitals. The average weight gain was 685 grams (SD=3.8). Weight gain was independently associated with maternal weight, MUAC and age ($p<0.01$). Mothers with placental or peripheral malaria at delivery or HIV infection had lower mean weight gain in pregnancy. Mothers with low weight or height or were primigravidae had lower mean weight gain in pregnancy (Table 4). Mothers who delivered preterm or had LBW babies had lower mean weight gain in pregnancy (Table 4). LBW (OR=1.11, 95% C.I. 1.03, 1.19) and preterm delivery (OR=1.18, 95% C.I. 1.08, 1.28) were associated with weight gain (Table 5).

Table 1: Maternal and child characteristics and maternal.

Maternal Characteristics	n	%
Age		
Adolescents (<= 19 years)	1209	21.5
20 – 34 years	1209	70.4
35 years and above	1209	8.1
Primigravidae	1565	23.9
Illiterate	1565	73.4
Married	1565	96.5
1-4 ANC visits	1557	31.7
Anaemia at recruitment (Hb< 8g/dl)	1552	23.7
Anaemia at delivery (Hb< 8g/dl)	1533	12.5
Fe. deficiency anaemia at recruitment	1400	34.4
Fe. deficiency anaemia at delivery	1392	34.3
Malaria		
Recruitment	1505	20.5
Cord	1471	4.5
Delivery	1533	21.8
Placenta	1479	17.8
HIV positive	651	25.4
VDRL positive (MH)	952	4.8
MUAC < 22 cm	1563	6.0
Mean (SD)		25.07 (2.2)
Height < 150 cm	1561	9.9
Mean (SD)		156.35 (5.6)
BMI < 18.5 Kg/cm2	333	8.4
Mean (SD)		21.23 (2.2)
Weight (Kg) at recruitment <50 Kgs	335	34.6
Mean (SD)		52.08 (6.0)
Weight (Kg) at delivery <50 Kgs	1470	32.4
Mean (SD)		52.57 (6.7)
Infant characteristics		
Sex (males)	1560	50.3
Low birth weight	1560	19.4
Mean (SD) grams		2865.25 (543.8)
Multiple births	1568	5.7
Still births	1568	3.8
Fresh	59	1.3
Neonatal death	1536	2.3
Pre-term delivery (gestation <37 weeks)	1500	19.5
Mean (SD)		38.35 (2.3)
IUGR	1490	21.5
Fetal anaemia (Hbcord < 12.5 g/dl)	1421	23.8
Mean (SD)		13.59 (1.9)

Discussion

Maternal Anthropometry and Pregnancy Outcomes

Table 2: Odds ratio (95% C.I.) for pregnancy outcomes and maternal height, weight, BMI, MUAC.

Risk Factor	n	Prevalence (%)	Height (<150cm) (n=1571)	Weight (<50 Kgs) (n=333)	BMI (<18.5Kgs/cm2) (n=333)	MUAC (<23cm) n= 1571
Sex (male)	1560	50.3	1.33	1.12	0.57	1.10
			(0.95, 1.86)	(0.71, 1.76)	(0.26, 1.27)	(0.82, 1.46)
Low birth weight	1560	19.4	1.78	1.25	1.04	2.37
			(1.22, 2.60)*	(0.74, 2.11)	(0.43, 2.55)	(1.72, 3.25)*
Pre-term delivery	1500	19.5	1.37	1.16	1.33	2.08
			(0.91, 2.06)	(0.61, 2.18)	(0.48, 3.70)	(1.50, 2.89)*
IUGR	1490	21.5	1.67	1.13	0.82	1.46
			(1.14, 2.45)*	(0.67, 1.91)	(0.32, 2.12)	(1.04, 2.04)*
Fetal anemia (Hbcord < 12g/dl)	1421	23.8	0.72	0.91	0.59	1.04
			(0.45, 1.12)	(0.53, 1.56)	(0.22, 1.62)	(0.73, 1.48)
Still birth	1658	3.8	1.70	1.15	2.59	1.79
			(0.82, 3.52)	(0.41, 3.25)	(0.69, 9.68)	(0.95, 3.370)

*Significant.

Table 3: Significant risk factors for pregnancy outcomes (LBW and IUGR) on logistic regression.

Pregnancy outcome	Adjusted Odds Ratio (95% C.I.)	P_value
LBW		
Maternal short stature (Height <150 cm)	1.53 (1.03, 2.25)	0.034
Low maternal MUAC (<23 cm)	2.25 (1.63, 3.10)	<0.001
IUGR		
Maternal short stature (Height < 150 cm)	1.67 (1.14, 2.45)	0.008

In our study poor pregnancy outcomes were associated with low maternal height and low MUAC (Tables 2 & 3). LBW and its constituents of IUGR and preterm delivery have been associated with maternal short stature and low maternal MUAC. The association of LBW and maternal short stature has been reported in several studies especially in middle income and developing countries. Studies in Saudi Arabia, Papua New Guinea and India have all reported an association of maternal short stature and LBW. Maternal short stature has also been shown to be related to poor pregnancy outcomes even in very rich countries.

Maternal short stature and low MUAC could indicate intergenerational poor anthropometry[10] and intergenerational poor social economic status, hindering the mothers from obtaining nutritious foods. In our study, the poor maternal nutrition, other than the height, could result in LBW through inability of the mother to transfer enough nutrients to the fetus caused by malnutrition related chronic infections. This could also be through competition between the mother and the fetus especially in adolescent pregnancies. Much more likely is that mothers with low height or MUAC could be suffering from some chronic infections which result into LBW.[11] In this area, total fertility rate (TFR) is high at 6.3, average interpregnancy interval is short at 33.8 months with close to 70% of the mothers with an interpregnancy interval of less than 39 months.[12] In a study in Karachi, Pakistan found an association between birth interval and maternal weight (p=0.001), BMI (P=0.002) and change in birth weight (p=0.048).[13] Khan et al[13] concluded that short birth interval and its resultant reproduction stress results in maternal nutritional stress which affects maternal and fetal outcomes. A large study of 173, 205 singletons carried out in Utah, USA sheds light on this intermediary causal pathway by looking at the effects of birth interval lengths on LBW, preterm and SGA.[14] Pregnancies before folate restoration have a raised risk of folate insufficiency and their offspring have increased risks of neural tube defects, IUGR and preterm birth.[15]

Maternal Anthropometry and Weight Gain

Weight gain was associated with maternal weight, age and MUAC. Women with higher weights gained less (regression coefficient, -0.29). Similarly a study in Ilula, Tanzania showed that women weighing more than 60 kgs gained less than those weighing less than 50 kgs.[16] Studies from developed countries however are inconsistent with some showing no association between pregravid weight to weight gain[17] and others showing higher pregravid weight being associated with higher weight gain[18]. It is not clear why results from developing and developed countries are different. One possible explanation could be the higher representation of low and high weight women in study samples of developing and developed countries respectively.

Age was also associated with weight gain. This was also reported by Caulfield et al. where younger women had lower weight gains.[18] Contrary to these results, other studies have reported that young adolescent women not only gained more weight but had also a higher weight gain velocity from the beginning of pregnancy. Finding similar results, Garn et al., concluded that this represents a tendency to increased edema among young adolescent gravidas.[19] This could be caused by an increased abnormal fetal-placental vascular resistance in adolescents.[20] The influence of age, especially adolescence, on weight gain could be because of nutrient partitioning which is altered to promote growth of the maternal body at the expense of the gradually evolving nutrient requirements of the gravid uterus and mammary gland.

In our study, MUAC was associated with weight gain. Its association with weight gain is expected since any weight gain is dependent on nutrition. In an urban area of Lima,

Table 4 Mean weight gain/loss (grams) in pregnancy by risk factor.

Factor	n	Present	Absent	P_value
SP (1x vs. 2x)	125	-0.38	0.62	0.16 *
Placental malaria	307	-0.66	0.87	0.005
Malaria at delivery	326	-0.44	0.96	0.004
Malaria at recruitment	321	0.97	0.57	0.45 *
Cord malaria	309	-0.77	0.61	0.52 *
Season of delivery (rainy)	314	1.08	0.34	0.85 *
Maternal anaemia (<8 g/dl)	329	0.21	0.84	0.24*
Maternal HIV (+)	119	-0.20	1.23	0.031
Literacy (illiterate)	314	0.86	0.62	0.62*
Weight at recruitment (< 50 Kgs)	335	1.62	0.19	0.001
Height (<150 cm)	314	2.52	0.50	0.009
MUAC (<23 cm)	314	0.62	0.69	0.91*
Age (adolescent)	248	0.04	1.07	0.09*
Parity (primigravidae)	335	-0.47	1.2	<0.001
Pre-term delivery	300	-1.27	1.08	<0.001
IUGR	299	0.06	0.94	0.08*
LBW infant	330	-0.49	1.05	0.002
Fetal anaemia	300	-0.17	0.84	0.049
Sex of infant	333	0.43	0.91	0.27*
Multiple births	334	-0.70	0.78	0.09*
Still births	334	1.15	0.67	0.65*

Table 5 Relationship between pregnancy outcome and weight gain on logistic regression.*

Pregnancy outcome	n	Prevalence (%)	OR (95% C.I.)	P-value
Low birth weight (< 2500g)	333	23.4	1.11 (1.03, 1.19)	0.003
Pre-term delivery (< 37 wks)	315	15.6	1.18 (1.08, 1.28)	<0.001
IUGR	314	26.4	NS	
Fetal anaemia (Hbcord < 12g/dl)	300	26.0	NS	
Still birth	334	4.8	NS	
Multiple-birth	334	6.0	NS	
Sex of infant (male)	333	46.8	NS	

Peru, an association was found between infant birth weight and increased maternal calories and protein reserves.[21] This association is attributable to the calorie and protein reserves increasing weight gain in pregnancy and then subsequently increased birth weight. In an assessment of nutritional status in a communities of developing regions, Jelliffe contends that nutrition plays a part in weight gain and concluded that well nourished women add 15 to 25% of their pregravid weight in pregnancy.[22] Studies in the developed world consistently indicate higher average weight gains than those in developing countries.

Mean maternal weight gains were lower in women with placental or peripheral malaria or HIV infection (Table 4). This relationship is more likely nutritional in nature since malaria and HIV[23] are both known to cause malnutrition through several mechanisms including down-regulation of whole-body protein in the case of HIV. A study in Dar-es Salaam, Tanzania found that wasting was 34% (95% C.I. 3% - 73%) more prevalent among HIV infected than uninfected mothers, after adjusting for week of gestation, height and sociodemographic indicators.[24] In our study primiparaous women had also lower mean weight gains. This could be related to malaria which is more prevalent in primiparae.[25] It could also be related to competition for nutrients between young gravida and/or to the higher nutritional needs of growing adolescent women who are more likely primiparae.

Weight Gain and Pregnancy Outcomes

LBW and preterm delivery were associated with weight gain. In a review on weight gain and pregnancy outcomes, Abrams et al. showed that pregnancy weight gain within the North American Institute of Medicine's (IOM) recommended ranges was associated with the best outcomes for both mothers and infants.[26]

The association of LBW and weight gain has been widely reported by several studies. In this study, women with placental or peripheral malaria had a lower average weight gain. It is known that malaria, through causing placental malfunctioning causes LBW in malarious areas. LBW was also associated with MUAC in this study. Low weight gain could be related to malaria and malnutrition leading into LBW.

Conclusions

Maternal nutrition should be improved to reduce adverse pregnancy outcomes. Interventions to improve maternal nutrition should be both long and short term ones. On a long term basis interventions should aim at improving maternal heights so that birth outcomes in subsequent generations should not be affected by maternal short stature. On a short-term basis, interventions should improve pre-pregnancy weights and MUAC (maternal nutrition) and malaria in pregnancy, which in turn affect maternal weight gain and then pregnancy outcomes.

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