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# A case-control study of singleton low birthweight babies at the Port Moresby General Hospital

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## SUMMARY

**A retrospective study of 432 consecutive singleton low birthweight babies and 432 unmatched controls was carried out at the Port Moresby General Hospital from January to December 1988. Of the 432 low birthweight babies 65% were preterm, 27% were light for gestational age, 6% were both preterm and light for gestational age and 2.5% could not be classified. The results of the analysis showed low birthweight to be significantly associated with the past delivery of a low birthweight infant, very young and elderly mothers, lack of antenatal care, poor family planning, hypertensive disease in pregnancy and intrauterine death. This study reveals that maternal education and improved antenatal care and family planning would ultimately reduce the incidence of low birthweight babies and perinatal mortality in Papua New Guinea.**

## Introduction

In Papua New Guinea low birthweight (lbw) is now defined as birthweight less than 2500 g. A decade ago the critical birthweight was 2200 g. The change came about mainly because of the need for international comparison. Low birthweight may be due to preterm delivery or an intrauterine growth retardation which produces a light for gestational age (lga) baby; occasionally, a baby may be both preterm and lga. The perinatal mortality rate (PNMR) among low birthweight infants is high. The Port Moresby General Hospital (PMGH) delivers around 8000 babies a year. The incidence of lbw at the hospital is 12%. The PNMR among the lbw babies is about 250/1000, compared with 30/1000 for all deliveries (1).

The objectives of the study were:

a) To identify any sociodemographic and obstetric factors which might have a significant association with singleton lbw.
b) To determine the proportions of preterm and lga infants in the lbw population at PMGH.
c) To compare the perinatal outcomes in the preterm and lga subgroups.

## Patients and Methods

This was a case-control study. All deliveries at the PMGH were entered in chronological order in a register in the labour ward. The study population consisted of singleton deliveries entered in the register during the study period. The register was used to identify the cases, ie, infants who weighed less than 2500 g at birth. The first baby with a birthweight of 2500 g or more to be delivered after a case was taken as a control. The subjects were sequentially enrolled and their case records retrieved for review. Data items of

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interest which were routinely recorded in the labour ward register were collected from the register. The patients' case notes were the source for data not routinely recorded in the register. Of the variables thought to be relevant to lbw, only those about which information was routinely and consistently recorded in the case notes were selected for study.

The independent variables investigated included: patient's age; Southern Region origin; parity before index pregnancy; last pregnancy interval; maternal height; previous perinatal death; past delivery of a lbw infant; antenatal care; complications during index pregnancy; maternal weight gain between first and last antenatal contacts; maternal weight gain/week during antenatal supervision; lowest mean antenatal haemoglobin level; history of malarial attack in this pregnancy; hypertensive disease in this pregnancy; urinary infection; fetal death in utero; sex of baby. The following outcome variables were compared in the preterm and lga subgroups: birthweight, sex, neonatal morbidity and mortality, the proportion of infants admitted to the special care nursery (SCN) and the duration of stay in the SCN. Perinatal mortality was defined as a stillbirth or a death within one week of birth and before discharge from hospital.

### Data limitations

Where the patient's case notes could not be found, data which could be obtained only from this source were treated as missing values in the analysis. Estimation of the gestational age (GA) was based on menstrual age, the fundal height at the first (booking) visit and ultrasound scan determination, if the patient was scanned. The GA was considered reliable if the menstrual age was in agreement with the booking visit fundal height, or if the sonographic scan was performed before 26 weeks. The last pregnancy interval (delivery-conception interval) was obtained by subtracting the gestational age at delivery from the number of months between the last delivery and this birth. Maternal age was as noted in the patient's hospital records.

### Statistical analysis

Univariate analysis was performed to examine independent variables suspected to have an association with lbw. Forward stepwise logistic regression analysis was performed to evaluate the impact of predictor covariates which univariate analysis showed to have a significant association with lbw. The Epi Info version 5 statistical package was used for the univariate analysis and the SPSS PC software for the logistic regression analysis (2,3). The chi squared, Fisher exact and Kruskal-Wallis H tests, as well as the odds ratios, were calculated as appropriate. Differences between the groups were considered significant if the p value was <0.05 or the 95% confidence interval of the odds ratio did not enclose 1.

## Results

From January to December 1988, 432 cases and 432 controls were studied. Of the 432 lbw infants, 279 (65%) were preterm, 117 (27%) were lga, 25 (6%) were both preterm and lga and 11 (2.5%) could not be classified.

### Sociodemographic characteristics and past obstetric history

When the suspected independent variables were examined by univariate analysis, the following were shown to have significant association with lbw: mean parity was lower - 1.5 (SD 1.9) vs 1.9 (SD 1.7); mean last pregnancy interval was shorter - 33.2 months (SD 22.1) vs 37.5 months (SD 18.3); mean age was lower - 24.0 years (SD 5.9) vs 25.1 years (SD 5.2); mean antenatal weight gain was less - 4.0 kg (SD 3.5) vs 5.3 kg (SD 4.0). The following were more frequent in the lbw group (Table 1): nulliparity (45% vs 26%); grandmultiparity (para >4) (11% vs 7%); last pregnancy interval <2 years (38% vs 9%); previous delivery of a low birthweight infant (6% vs 1%); age <18 years (9% vs 3%); age >35 years (7% vs 4%); Southern Region origin (76% vs 67%). The mean height - 157.7 cm (SD 6.4) - was not significantly different from that of the controls - 158.7 cm (SD 6.3). However, when the subjects were stratified by parity the grandmultiparous cases were significantly shorter than the grandmultiparous controls (155.8 ± 4.4 vs 159.6 ± 5.4), though in this case the numbers were small (35 cases and 23 controls).

**History of present pregnancy**

On univariate analysis, significantly more of the cases had had no antenatal care (22% vs 8%) (Table 2). Two antenatal complications were significantly more frequent in the lbw group: fetal death in utero (7.6% vs 0.2%) and hypertensive disease (6.5% vs 1.6%). Antenatal weight gain <10 kg was more frequent in the lbw group (93% vs 85%). However, when weight gain was converted to weight gained per week, there was no difference between the two groups, indicating that the cases had lower weight gains during antenatal observation because they had attended the clinic for a shorter time. Weight gain was not therefore included in the stepwise logistic regression model. Anaemia, defined in this study as a haemoglobin level <8 g/dl, was not significant on its own. Malaria could not be examined by itself because in this retrospective survey only two cases were identified. The sex ratio was not significantly different in the two groups.

When the significant categorical variables were subjected to forward stepwise logistic

**TABLE 1**

UNIVARIATE ANALYSIS OF LOW BIRTHWEIGHT BY DEMOGRAPHIC AND PAST OBSTETRIC HISTORY CHARACTERISTICS

| | Cases | Controls | OR (95% CI) | p value |
|---|---|---|---|---|
| Southern Region origin | | | | |
| | 75.7% (327/432) | 67.2% (289/430) | 1.52 (1.11-2.08) | <0.01 |
| Maternal age (years) | | | | |
| <18 | 9.1% (39/427) | 3.2% (14/432) | 3.00 (1.55-5.90) | <0.001 |
| >35 | 7.3% (31/427) | 3.7% (16/432) | 2.04 (1.05-3.98) | <0.03 |
| Last pregnancy interval <2 years | | | | |
| | 37.9% (77/203) | 9.4% (29/308) | 5.88 (3.55-9.79) | <0.0001 |
| Past delivery of a low birthweight infant | | | | |
| | 6.2% (14/227) | 1.3% (4/314) | 5.09 (1.54-18.58) | <0.002 |
| Parity before index delivery | | | | |
| P=O | 44.9% (194/432) | 26.2% (113/432) | 2.30 (1.71-3.11) | 0.000 |
| P>4 | 10.6% (46/432) | 6.7% (29/432) | 1.66 (1.02-2.70) | <0.04 |
| Previous perinatal death | | | | |
| | 4.6% (20/432) | 5.3% (23/432) | 0.86 (0.60-2.25) | 0.639 |

**Continuous variables**

| | Cases Mean (SD) | Controls Mean (SD) | K-W p value |
|---|---|---|---|
| Maternal height (cm) | 157.7 (6.4) | 158.7 (6.3) | >0.05 |
| Maternal age (years) | 24.0 (5.9) | 25.1 (5.2) | <0.0002 |

OR = odds ratio
CI = confidence interval
SD = standard deviation
K-W = Kruskal-Wallis H test

regression analysis (Table 3), the following continued to be significantly associated with lbw: previous delivery of a lbw infant, last pregnancy interval <2 years, maternal age <18 years, maternal age >35 years, lack of antenatal care in this pregnancy, fetal death in utero, and hypertensive disease.

**Preterm babies compared with controls**

When the preterm subgroup was compared with the controls, the following variables were found to have significantly higher frequencies in the preterm subgroup (Table 4): Southern Region origin, age <18 years, last pregnancy interval <2 years, nulliparity, fetal death in utero, previous delivery of a lbw baby, and lack of antenatal care in the index pregnancy. The mean age was lower (23.7 years vs 25.1 years) and the mean last pregnancy interval in months was shorter (32.9 vs 37.5) - in the preterm subgroup. Hypertensive disease occurred in 4% of the preterm mothers compared with 2% of the control; even though the p value was 0.048 the 95% confidence interval for the odds ratio enclosed 1 and this difference was therefore not considered to be significant.

**Light for gestational age (lga) babies compared with controls**

When the lga subgroup was separately compared with the controls, the following variables were found to have significantly higher frequencies in the lga subgroup (Table

**TABLE 2**

UNIVARIATE ANALYSIS OF LOW BIRTHWEIGHT BY COMPLICATIONS IN INDEX PREGNANCY

| Cases | Controls | OR (95% CI) | p value |
|---|---|---|---|
| Weight gain <10 kg during antenatal supervision | | | |
| 92.6% (261/282) | 85.4% (328/384) | 2.12 (1.21-3.74) | <0.005 |
| Lack of antenatal care | | | |
| 22.2% (96/432) | 7.9% (34/432) | 3.34 (2.15-5.21) | <0.0001 |
| Fetal death in utero | | | |
| 7.6% (33/432) | 0.2% (1/432) | 35.65 (5.14-716.41) | <0.00001 |
| Hypertensive disease in pregnancy | | | |
| 6.5% (28/432) | 1.6% (7/432) | 4.21 (1.72-10.78) | <0.0006 |

**Continuous variables**

| | Cases Mean (SD) | Controls Mean (SD) | K-W p value |
|---|---|---|---|
| Weight gain (kg) | 4.01 (3.52) | 5.34 (3.95) | <0.0001 |
| Weight gain/week (kg) | 0.44 (0.37) | 0.44 (0.30) | 0.253 |
| Lowest Hb (g/dl) | 9.3 (1.7) | 9.3 (1.5) | 0.925 |

OR = odds ratio
CI = confidence interval
SD = standard deviation
K-W = Kruskal-Wallis H test
Hb = haemoglobin level

5): Southern Region origin, last pregnancy interval <2 years, nulliparity, hypertensive disease in the index pregnancy, and lack of antenatal care in the index pregnancy. Fetal death in utero (2.6% vs 0.2%), previous delivery of a lbw baby (6% vs 1%) and maternal age <18 years (8% vs 3%) were more frequent among the cases, but the 95% confidence intervals for their odds ratios enclosed 1 and the differences were therefore taken as not statistically significant.

**Perinatal outcome of this pregnancy**

As was to be expected, the cases had worse outcomes than the controls (Table 6). Both perinatal morbidity, measured as number of infants admitted to the special care nursery (43% vs 3%) and the duration of stay in the SCN (4.9 days vs 0.1 days), as well as perinatal deaths (20% vs 2%), were significantly higher in the cases. When the preterm and lga subgroups were compared (Table 7), the preterm babies had significantly lower birthweight and worse outcomes than the lga babies. The sex ratio was not significantly different in the two subgroups.

## Discussion

Low birthweight is perhaps the single most important determinant of the survival chances of a newborn; it is a good predictor of the infant's prospects for healthy growth and development (4). Babies born alive but weighing less than 1500 g are very likely to die, regardless of gestational age (5). At the Port Moresby General Hospital (PMGH) the crude death rate is around 20% for babies weighing 1000 - 1499 g at birth; and 8% for those weighing 1500-1999 g. The perinatal mortality (stillbirths + first week deaths) rate is 250/1000 deliveries for babies weighing less than 2500 g, compared with 30/1000 for all babies (1). Strategies to reduce perinatal mortality must therefore give a prominent place to the prevention of lbw. This in turn requires knowledge of the causal or risk factors for lbw, especially knowledge of the factors which are preventable. Unfortunately, it is not easy to define the causes. This is because lbw is determined by the interaction of a multitude of genetic, behavioural, environmental and medical factors. Some of these factors are associated. To disaggregate and isolate the impact of each of these characteristics is a daunting task. Nonetheless, through the application of multivariate and multiple logistic regression analyses, the independent impacts of some of these factors have been confirmed. The present study indicates that some of these correlations hold true for our population.

**TABLE 3**

FORWARD STEPWISE LOGISTIC REGRESSION SHOWING THE EFFECTS OF THE EXPLANATORY VARIABLES ON LOW BIRTHWEIGHT

| Variable | -2 Log likelihood | p value |
|---|---|---|
| Constant | 1197.758 | 0.0000 |
| Last pregnancy interval <2 years | 1084.241 | 0.0000 |
| Fetal death in utero | 999.518 | 0.0006 |
| Lack of antenatal care | 982.220 | 0.0020 |
| Hypertensive disease of pregnancy | 966.345 | 0.0053 |
| Maternal age >35 years | 952.379 | 0.0111 |
| Previous delivery of a lbw infant | 943.797 | 0.0161 |
| Maternal age <18 years | 939.276 | 0.0196 |

It is universally known that first babies, ie, babies of nulliparae, are generally lighter at birth than subsequent babies, ie, babies of parous mothers, at least through para 2-3 (6-8). The incidence of lbw therefore decreases with parity. In this study, both nulliparity and grandmultiparity (para >4) had significant association with lbw on univariate analysis. But the association disappeared when stepwise logistic regression analysis was performed.

In many studies of lbw, mothers younger than 18 years and mothers over 35 years of age had been found to be at greatest risk of lbw (5,7-14). In the very young, ie, under 15 years, the impact of age may be partly due to inadequate physical maturity, a higher incidence of preeclampsia, malaria and anaemia, low socioeconomic status and lack of antenatal care. LeGrand and Mbacke showed that the negative effect of teenage motherhood on children's birthweight was for the most part not due to differences in health behaviour, and that the association remained after controlling

**TABLE 4**

PREDICTOR VARIABLES WHICH IN UNIVARIATE ANALYSIS WERE SIGNIFICANTLY DIFFERENT IN PRETERM AND CONTROL GROUPS

| | Cases | Controls | OR (95% CI) | p value |
|---|---|---|---|---|
| Southern Region origin | | | | |
| | 74.6% (208/279) | 67.2% (289/430) | 1.43 (1.00-2.04) | <0.04 |
| Maternal age <18 years | | | | |
| | 9.5% (26/275) | 3.2% (14/432) | 3.12 (1.52-6.46) | <0.0005 |
| Last pregnancy interval <2 years | | | | |
| | 42.4% (53/125) | 9.4% (29/308) | 7.08 (4.05-12.42) | <0.0001 |
| Past delivery of a low birthweight infant | | | | |
| | 7.0% (10/143) | 1.3% (4/314) | 5.83 (1.64-25.80) | <0.003 |
| Parity before index delivery | | | | |
| P=O | 47.0% (131/279) | 26.2% (113/432) | 2.50 (1.79-3.49) | <0.001 |
| P>4 | 11.1% (31/279) | 6.7% (29/432) | 1.74 (0.98-3.07) | <0.04 |
| No antenatal care in this pregnancy | | | | |
| | 23.9% (50/209) | 8.5% (34/398) | 3.37 (2.04-5.58) | 0.0000 |
| Fetal death in utero | | | | |
| | 9.3% (26/279) | 0.2% (1/432) | 44.29 (6.30-897.76) | <0.00001 |

**Continuous variable**

| | Cases Mean (SD) | Control Mean (SD) | K-W p value |
|---|---|---|---|
| Mean age (years) | 23.7 (5.8) | 25.1 (5.2) | <0.00002 |

OR = odds ratio
CI = confidence interval
SD = standard deviation
K-W = Kruskal-Wallis H test

## TABLE 5

PREDICTOR VARIABLES WHICH WERE SIGNIFICANTLY DIFFERENT IN LIGHT FOR GESTATIONAL AGE AND CONTROL GROUPS

| Cases | Controls | OR (95% CI) | p value |
|---|---|---|---|
| Southern Region origin | | | |
| 76.9% (90/117) | 67.2% (289/430) | 1.63 (0.98-2.70) | <0.05 |
| Last pregnancy interval <2 years | | | |
| 27.9% (17/61) | 9.4% (29/308) | 3.72 (1.77-7.76) | <0.0001 |
| Para 0 before index delivery | | | |
| 41.0% (48/117) | 26.2% (113/432) | 1.96 (1.25-3.09) | <0.002 |
| Hypertensive disease in index pregnancy | | | |
| 10.3% (12/117) | 1.6% (7/432) | 6.94 (2.45-20.23) | <0.0001 |
| No antenatal care in index pregnancy | | | |
| 16.5% (17/103) | 8.5% (34/398) | 2.12 (1.05-4.10) | <0.02 |

OR = odds ratio
CI = confidence interval

## TABLE 6

COMPARISON OF PERINATAL OUTCOME OF THIS PREGNANCY IN LOW BIRTHWEIGHT AND CONTROL GROUPS

| Cases | Controls | OR (95% CI) | p value |
|---|---|---|---|
| Admission to special care nursery (SCN) | | | |
| 43.1% (186/432) | 2.8% (12/432) | 26.46 (14.05-50.96) | <0.0001 |
| Perinatal death | | | |
| 19.9% (86/432) | 1.6% (7/432) | 15.09 (6.59-36.36) | <0.00001 |
| Congenital anomaly | | | |
| 1.2% (5/432) | 0.9% (4/432) | 1.25 (0.29-5.58) | >0.70 |

**Continuous variable**

| | Cases Mean (SD) | Controls Mean (SD) | K-W p value |
|---|---|---|---|
| Number of days in SCN | 4.9 (8.8) | 0.1 (0.8) | <0.00001 |

OR = odds ratio
CI = confidence interval
SD = standard deviation
K-W = Kruskal-Wallis H test

for other explanatory variables as well (14). In the elderly, the ageing process and its attendant medical conditions, such as essential hypertension and a less pliant cardiovascular system, may be contributary. High parity, short birth intervals, low socioeconomic status and the maternal depletion syndrome may also be important. In this study, age >35 years had a significant association with lbw.

It is well known that maternal height has a positive correlation with birthweight (5,15); the incidence of lbw in term infants has been found to decrease significantly with increasing maternal height (15). In this study, although the mean height of the cases was lower than that of the controls, the difference did not reach significance (p=0.0514). However, when the analysis was performed within parity categories, the grandmultiparous cases were found to be significantly shorter than their controls, even though the numbers available for analysis were small.

Many studies have shown that ethnic origin and birthweight are associated (5,6,8,16). The mean birthweight has been found to be higher in whites than in blacks. In the same country, birthweight may differ between ethnic groups. The explanation may not be entirely genetic. Socioeconomic status, nutritional status, general health, and in some cases altitude and climate, may partly account for these differences. This study showed Southern Region origin to be a risk factor in the univariate but not in the logistic regression analysis.

Other workers had found previous perinatal death and previous delivery of a lbw infant to be independent predictors of lbw in the index pregnancy (5,8,15). The explanation for these associations is not clear. It could be due to a persisting effect of the detrimental factor which contributed to the previous poor perinatal outcome. The association with a previous lbw infant, but not that with a perinatal death, was confirmed in the present study. When examined as a continuous as well as a categorical variable, the interval between the

**TABLE 7**

COMPARISON OF PERINATAL OUTCOMES IN PRETERM AND LIGHT FOR GESTATIONAL AGE SUBGROUPS

| Preterm | Lga | OR (95% CI) | p value |
|---|---|---|---|
| Admission to special care nursery (SCN) | | | |
| 57.3% (160/279) | 13.7% (16/117) | 8.49 (4.58-15.91) | <0.000001 |
| Perinatal death | | | |
| 26.9% (75/279) | 6.0% (7/117) | 5.78 (2.54-15.33)* | <0.000003 |

**Continuous variables**

| | Preterm Mean (SD) | Lga Mean (SD) | K-W p value |
|---|---|---|---|
| Number of days in SCN | 6.7 (10.1) | 0.9 (2.9) | <0.0000001 |
| Birthweight (g) | 1791.6 (510.8) | 2270.6 (192.4) | <0.0000001 |

Lga = light for gestational age
OR = odds ratio
CI = confidence interval
* Exact confidence limits
SD = standard deviation
K-W = Kruskal-Wallis H test

last delivery and the index conception, ie, the interpregnancy interval, was found to be significant. This is in agreement with the findings of numerous previous studies which showed a short pregnancy interval to be an independent risk factor of lbw. Elegant studies which simultaneously controlled for confounders such as previous pregnancy outcome, parity and maternal age have confirmed the conclusions of earlier less robust methodologies which found short pregnancy interval to be a risk factor for lbw (7,8,17-19).

Malaria could not be examined by itself because of small numbers (only two subjects). It is, however, well known that chronic anaemia and malaria are associated with lbw. In a study in Madang, Brabin et al. found a significantly increased risk of lbw for primigravidae with haemoglobin levels below 8 g/dl (20).

The risk factors identified in this retrospective survey had been found in many previous studies. The same risk factors were found to be associated with perinatal mortality, as well as with infant and child mortality. Many epidemiological studies which controlled for other factors found the mean birthweight of babies of mothers who smoked to be 170-200 g below that of women who did not smoke; the smoking mothers had significantly higher rates of both preterm and lga babies (21-24). Because information on smoking was not routinely recorded in the patients' hospital notes, the association between lbw and smoking could not be investigated in this retrospective study. However, a study of our postpartum population in 1990 which used an interviewer-administered questionnaire found that fewer than 5% of the mothers smoked. A future longitudinal sociodemographic study would reveal more data on the effect of maternal smoking and low birthweight. In spite of the limitations of this study, its message is clear: we can reduce the incidence of lbw babies and perinatal mortality by educating and persuading our mothers to attend for antenatal care, and by promoting and providing family planning to prevent short birth intervals and pregnancies in the elderly and very young.

## REFERENCES


1 **Division of Obstetrics and Gynaecology.** Port Moresby General Hospital, Division of Obstetrics and Gynaecology Annual Report for 1987. Port Moresby: Port Moresby General Hospital, 1988.

2 **Dean AD, Dean JA, Burton AH, Dicker RC.** Epi Info version 5: a Word-Processing, Database and Statistics Program for Epidemiology on Microcomputers. Stone Mountain, Georgia: USD, Incorporated, 1990.

3 **SPSS Inc.** SPSS PC+ Statistical Package for the Social Sciences. Chicago: SPSS Inc., 1990.

4 **Kane TT, Smith JB.** Maternal smoking and birthweight: an international perspective. In: Rosenberg MJ, ed. Smoking and Reproductive Health. Littleton, Massachusetts: PSG Publishing, 1987:19-117.

5 **Thomson AM.** Fetal growth and size at birth. In: Barron SL, Thomson AM, eds. Obstetrical Epidemiology. London: Academic Press, 1983:89-142.

6 **Cunningham FG, MacDonald PC, Gant NF.** Williams Obstetrics, 18th edition. Connecticut: Appleton and Lange, 1989:744.

7 **Fortney JA, Higgins JE.** The effect of birth interval on perinatal survival and birth weight. *Public Health* 1984;98:73-83.

8 **Eisner V, Brazie JV, Pratt MW, Hexter AC.** The risk of low birthweight. *Am J Public Health* 1979;69:887-893.

9 **Goldstein H.** Factors related to birth weight and perinatal mortality. *Br Med Bull* 1981;37:259-264.

10 **Selvin S, Garfinkel J.** The relationship between parental age and birth order with the percentage of low birth-weight infants. *Hum Biol* 1972;44:501-509.

11 **Arkutu AA.** Pregnancy and labour in Tanzanian primigravidae aged 15 years and under. *Int J Gynaecol Obstet* 1978;16:128-131.

12 **Jones EF, Forrest JD, Goldman N, Henshaw SK, Lincoln R, Rosoff JI, Westoff CF, Wulf D.** Teenage pregnancy in developed countries: determinants and policy implications. *Fam Plann Perspect* 1985;17:53-63.

13 **Elster AB.** The effect of maternal age, parity and prenatal care on perinatal outcome in adolescent mothers. *Am J Obstet Gynecol* 1984;149:845-846.

14 **LeGrand TK, Mbacke CSM.** Teenage pregnancy and child health in the urban Sahel. *Stud Fam Plann* 1993;24:137-149.

15 **Fedrick J, Adelstein P.** Factors associated with low birth weight of infants delivered at term. *Br J Obstet Gynaecol* 1978;85:1-7.

16 **Hytten FE, Leitch I.** The Physiology of Human Pregnancy, 2nd edition. Oxford: Blackwell, 1971.

17 **Spiers PS, Wang L.** Short pregnancy interval, low birthweight and the sudden infant death syndrome. *Am J Epidemiol* 1976;104:15-21.

18 **Lieberman E, Lang JM, Ryan KJ, Monson RR, Schoenbaum SC.** The association of inter-pregnancy interval with small for gestational age births. *Obstet Gynecol* 1989;74:1-5.

19 **Erickson JD, Bjerkedal T.** Interval between pregnancies. *Lancet* 1979;1:52.

20 **Brabin BJ, Ginny M, Sapau J, Galme K, Paino J.** Consequences of maternal anaemia on outcome of pregnancy in a malaria endemic area in Papua New Guinea. *Ann Trop Med Parasitol* 1990;84:11-24.

21 **US Department of Health and Human Services.** The health benefits of smoking cessation: a report of the Surgeon General. Department of Health and Human Services Publication No (CDC) 90-8416. Atlanta: Centers for Disease Control, 1990:371-423.

22 **Haworth JC, Ellestad-Sayed JJ, King J, Dilling LA.** Fetal growth retardation in cigarette-smoking mothers is not due to decreased maternal food intake. *Am J Obstet Gynecol* 1980;137:719-723.

23 **Ounsted M, Moar VA, Scott A.** Risk factors associated with small-for-dates and large-for-dates infants. *Br J Obstet Gynaecol* 1985;92:226-232.

24 **Shiono PH, Klebanoff MA, Rhoads GG.** Smoking and drinking during pregnancy. Their effects on preterm birth. *JAMA* 1986;255:82-84.