STUDY OF THE RELATIONSHIP OF LOW BIRTHWEIGHT WITH RACE AND SOCIOECONOMIC STATUS AT THE MATERNITY HOSPITAL KUALA LUMPUR MALAYSIA

A CASE-CONTROL STUDY

by

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ABSTRACT

Low birthweight of newborns is a major determinant of perinatal survival as well as postnatal morbidity. It represents major public health problem and is of great economic concern in developing countries.

There have been suggestions of several factors associated with low birthweight; these include Indian racial origin, low socioeconomic status, teenage pregnancy, poor maternal nutritional status, low maternal weight and height, inadequate antenatal care, close birth interval and prematurity.

This study investigated the impact of four groups of risk factors: genetic and constitutional factors, namely infant sex, ethnic origin, maternal height and maternal pre-pregnancy weight; demographic/psychosocial and nutritional factors related to the mother, namely maternal age prior to pregnancy, maternal education, occupation, total family income, total gestational weight gain, use of iron and/ or vitamin supplements and haemoglobin level; obstetric factors such as parity, interpregnancy interval, gestational age of previous birth, prior spontaneous abortion, prior stillbirth, prior child death and period of gestation at delivery; and antenatal care (i.e number of antenatal care visits).

To identify and quantify risk factors for low birthweight I conducted a hospital-based case-control study at the Kuala Lumpur Maternity Hospital, Malaysia.

The case-control study of 295 low birthweights and 590 controls showed that Indian ethnic origin, previous premature birth, low maternal pre-pregnancy weight (46-50 kg), brief use of iron and/cr vitamin supplements (2-4 weeks) and prematurity were significant independent risk factors for low birthweight.

The results of this study showed that low maternal pre-pregnancy weight, premature birth, poor quality of antenatal care are important and potentially modifiable risk factors. Hence the results suggest that nutritional and health intervention programmes (i.e improvement in nutritional status and antenatal care) can reduce the incidence of low birthweight. This study also can guide health care planners and providers in formulating preventive interventions in developing country settings where resources are scarce.

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1. INTRODUCTION

The birthweight of an infant, is highly significant in two important respects, firstly it is universally and in all population groups, the single most important determinant of the chances of the newborn to survive and to experience healthy growth and development[1,2]. Secondly it is strongly conditioned by the health and nutritional status of the mother, in the sense that maternal malnutrition, ill-health and other deprivation are the most common causes of low birthweight (LBW)[1], and therefore the proportion of infants born with a low birthweight closely reflects the health status of the communities into which they are born[2]. In both developed and developing countries birthweight is probably the single most important factor that affects neonatal mortality, in addition to being a significant determinant of post-neonatal infant mortality and of infant and childhood morbidity[3]. It has been shown that the LBW infant is at a much higher risk of mortality than the infant with normal weight at birth[3,4]. It has been found in a study in Saudi Arabia[4], that LBW is an independent risk factor associated with perinatal mortality. In the neonatal period, when most infant deaths occur, the proportion of LBW infants, especially those with very low birthweight (< 1500 g), is the major determinant of the magnitude of the mortality rates[3].

The global estimates of the prevalence of LBW as reported by the World Health Organisation (WHO)[1,2], was that, of the 127 million infants born in the world in 1982, some 20 million (16%) were estimated to weigh less than 2500g[1,2,5]. At the global level this means that about one in every 6 infants has a LBW, but the incidence is not evenly spread around the globe. For example in some parts of Asia the ratio is almost 1 in 2, while in parts of Europe it is only 1 in 17[1]. Between these two extremes, the incidence by geographic region, ranges from 31% in Middle South Asia and 20% for Asia as a whole, to only 4-8% for North America and Western Europe[1,5]. Of the 20 million LBW infants born in 1982, over 90% were born in developing countries[1,5]. The lowest birthweights were reported for Asia, with mean values ranging from about 2700-2800g in the Indian subcontinent, while the highest birthweights were reported for North America and Western Europe (mean birthweight, 3300-3500g).Therefore this presents major public health problems particularly in developing countries[1,2,5]. Birthweight has long been a subject of clinical and epidemiological investigations and a target for public health intervention. In particular considerable attention has been focused on the causal determinants of birthweight, and especially of LBW, in order to identify potentially modifiable factors[5]. For these reasons, increasing attention is now being given to the problem and has been universally recognised and targeted by the World Health Organisation at the Thirty-Fourth World Assembly as part of the global strategy for "Health for all by the year 2000". The proportion of infants born with a low birthweight will be monitored as one of a number of global indicators[2].

Low birthweight has been defined by the World Health Organisation as a birthweight of less than 2500g (up to and including 2499g)[1], since below this value birthweight-specific infant mortality begins to rise rapidly[6]. Until 1976 the definition of low birthweight included birthweight of 2500g. This definition was altered by the Twenty-ninth World Health Assembly in 1976 to a birthweight of less than 2500g[7] (excluding 2500g).

Birthweight is controlled by two major processes: period of gestation and intrauterine growth rate. Therefore low birthweight can be caused either by premature delivery (short gestation period) or by fetal growth retardation ("small-for-gestational age" or "small-for-dates")[2,5]. Prematurity is usually defined as a gestational period of less than 37 weeks[5]. LBW infants have an increased risk of developing cerebral palsy, particularly premature ones which carry a greater risk[8]. On the other hand, small-for-gestational age infants are far more likely to exhibit growth deficiencies which appear to be permanent[9], and these infants do not recover from their intrauterine damage and have the lowest mental development score even up to school age[10]. It has been suggested that subtle neurocognitive deficiencies may also be more common in small-for-gestational age infants[9,11]. Because of the seriousness of problems associated with low birthweight, I have decided to carry out a study of its risk factors.

2. LITERATURE REVIEW

2.1 Previous work

The causes of low birthweight have been the focus of a vast number of investigations over the last few decades. Low birthweight can be caused either by prematurity (short gestation) or by fetal growth retardation[2,5]. Generally in countries where the proportion of low birthweight infants is low, most of them are pre-term, while in countries where the proportion of low birthweights is high, the majority are suffering from fetal growth retardation[2,5]. The causes of low birthweight are multiple and interrelated[2,5], for example poor maternal nutrition, hard physical work during pregnancy, illness, short maternal stature, young age prior to pregnancy, high parity and close birthspacing are all associated factors[2]. Kramer et al[12] reported that maternal prepregnancy weight, gestational weight gain (maternal dietary intake during pregnancy), maternal height and parity were all significantly associated with fetal growth. However it is important to know which factors have independent effects on low birthweight and their quantitative importance of those effect even though, it has been suggested, there is considerable confusion and controversy about the independent risk factors of low birthweight.

Ethnic group differences in low birthweight have been demonstrated in many parts of the world, and a common finding seems to be that Indian babies are smaller than other groups[1,13]. For example, the World Health Organisation reported that in Malaysia the proportion of low birthweight infant were 4.4%, 8.7%, and 14.3% for the Chinese, Malay and Indians respectively[1]. A study by Hughes et al[14] in Singapore reported a significantly increased risk of smaller babies among Indians (mean birthweight of 3020g) compared with the Malays (3080g) and the Chinese (3130g). The same study also showed that there was a higher proportion of low birthweight among Indians (11.5%) than the Malays (8.1%) and the Chinese (6.1%). This study concluded that lower birthweights in Indians to some extent represent factors of ethnic/genetic origin.

Several studies in Malaysia[15,16,17,18] also have found that Indian babies have mean birthweights less than those of Malay and Chinese babies. These studies and another study in Malaysia[19] also reported that Indians had the highest incidence of low birthweight compared with the Malays and Chinese. Yadav[15] in a hospital-based study found that the Indians had the lower mean birthweights (2830g) compared with the Malay (2970g) and the Chinese (3141g) newborns. Similarly Chong and Hanis[16] showed the Chinese (3100g) were significantly heavier than the Malays (3080g) and Indians (2930g)and the Malays were significantly heavier than the Indians. The Indians were observed to have the highest incidence of low birthweight babies (14.5%), followed by Malays (7.6%) and Chinese (5.6%). Similarly in the United States Eisner et al[20] found that non-white race was associated with increased risk of having an infant of low birthweight when other factors were held constant. Interestingly Mc Fayden et al[21] found that there were no significant differences between Asians and Europeans on birthweight and also between Moslems and the Europeans, but mean birthweight of the Hindus was about 190g lighter than that of the Europeans. Starfield et al[22] found that there was a similar risk of low birthweight among births to black women and white women (who were poor). Kramer[5] in his meta-analysis after reviewing 67 studies looking at ethnicity as a risk factor reported that the results were inconsistent. Several of these studies showed that racial/ethnic origin has direct causal effect on birthweights.

It could be postulated that genetic differences that exist between different racial or ethnic groups could lead to different average birthweights. However in view of the wide environmental differences between different ethnic groups, it is likely that the observed differences in weight could be potentially due to differences in maternal age, parity, maternal pre-pregnancy weight, maternal height, socioeconomic status (i.e education, occupation or income), maternal nutrition (i.e prepregnancy weight, gestational weight gain), interpregnancy interval, use of iron and/ or vitamin supplements and antenatal care visits. These are potential confounders, and should be controlled in order to assess the independent effect of ethnic origin.

Several studies have shown that socioeconomic status is an important factor on the outcome of pregnancy. Starfield et al[22] reported that low maternal education was associated with increased risk of low birthweight among black and white infants. Gould and LeRoy[23] showed that the deterioration of residential area socioeconomic status was associated with a significant increase in the percentage of low birthweight among black and white infants. Hughes et al[14] found that the proportion of low birthweight infants increases with a lowering of socioeconomic status. Several studies in Malaysia[17,24] reported similar findings. Da Vanzo et al[17] found that low birthweights particularly among the Indians were associated with falling family incomes. A similar finding has been reported by Prabha[24] in a study in a plantation sector in Malaysia, that parental low income generating occupations and low educational level were associated with high proportion (31.3%) of low birthweight infants. However interestingly in India Mavalankar et al[25] found that socioeconomic factors were not significantly associated with low birthweight. Eisner et al[20] similarly found that low maternal education was not a consistent risk factor for low birthweight, Kramer[5] in his meta-analysis after reviewing 113 studies looking at low maternal education as a risk factor reached a similar conclusion that socioeconomic status has no independent effect on birthweight. Nevertheless, he suggested that low socioeconomic status may be a social cause of other nutritional and anthropometric (maternal biological) factors that may themselves be causal determinants for low birthweights. Therefore, this can suggest that the effect of socioeconomic factors may be mediated through these factors and it may be possible to decrease the risk of low birthweight by improving these intermediate factors[25]. In order to see the direct effect of socioeconomic status, independent of others on low birthweight, several important variables need to be controlled, namely maternal age, parity, racial/ethnic origin, maternal height, prepregnancy weight, gestational weight gain, interpregnancy interval and antenatal care.

Several studies[25,26] showed that maternal height was one of the important risk factors for low birthweight. A study in India[25] showed that short maternal stature (< 156 cm) was significantly associated with increased risk of low birthweight. However maternal height did not remain significant after controlling for other factors. A study conducted by the World Health Organisation[26] in Brunei Darussalam in 1991, showed that short maternal stature of less than 150 cm was significantly associated with low birthweight. Kramer et al[12] found that fetal growth was significantly associated with maternal height. In his meta-analysis, Kramer[5] after reviewing 79 studies looking at maternal height as a risk factor found that 10 studies showed a statistically significant positive correlation with maternal height, while another 5 studies reported no significant effect. However these 5 studies were based on relatively small sample sizes.

Maternal height could affect intrauterine growth through either genetic or environmental (physical)[5,12] mechanisms. Kramer[5] suggested that diminished maternal height may well be one of the causes of the increased rate of low birthweight in many developing countries, whether caused by a true difference in genetic potential or prior stunting during the mother's childhood. Prepregnancy weight and gestational weight gain (nutritional status) may independently affect birthweight, these are potential confounders. In ethnically mixed populations, effects of height on birthweight may also be confounded by true genetic differences. He also suggested socioeconomic status is another potential confounder because women of lower socioeconomic status tend to be shorter than those of higher status. Finally another potential important confounder is age because adolescents who have not completed their growth will be shorter on average, than more physiologically mature women. So in order to assess the independent effect of maternal height on birthweight, these potential confounders (i.e prepregnancy weight, gestational weight gain, maternal age prior to pregnancy, race/ethnic origin and socioeconomic factors) should be controlled.

Several studies[17,25] reported that prepregnancy maternal weight was independently associated with low birthweight. Kramer et al[12] found that it was also significantly associated with fetal growth. In his meta-analysis[5], after reviewing 74 studies looking at maternal pre-pregnancy weight as a risk factor found that prepregnancy weight was positively correlated with gestational age and birthweight. However most prepregnancy weight used in those studies were based on mothers' self-reports, usually obtained by interview during the course of antenatal care. Therefore to some extent the validity of the findings might be affected due to recall bias. Since heavier women are generally taller and have greater caloric intake (gestational weight gain), separating the effect of maternal prepregnancy weight should be controlled for the confounding effects of maternal height and gestational weight gain.

Another potential confounder is racial/ethnic origin since maternal weight is likely to co-vary with it as well as secioeconomic status. These factors may be linked to intrauterine growth independent of their relationship to weight. Therefore all these factors should be controlled.

Several studies[17,20,25,26] reported that maternal age was significantly associated with low birthweight. Eisner et al[20] showed that maternal age under 18 years or over 35 years each increase the risk of having an infant of low birthweight. Mavalankar et al[25] reported that maternal age less than 20 years was significantly associated with (pre-term) low birthweight. The World Health Organisation in a study in Brunei[26] also reported similar finding (i.e young maternal age of less than 25 years). A study in Singapore[14] showed that the highest proportion (10.7%) of low birthweight was in the youngest age group (less than 20 years), declining to the lowest level (5.9%) in the age group 25-29 years, and then steadily rising (except that for the Malays, the lowest proportion was in the 30-34 age group). However Kramer et al[12] reported that maternal age had no significant independent effects on birthweight.

Kramer[5] in his meta-analysis after reviewing 144 studies reported most of these studies showed no independent effect of maternal age on birthweight. However, age is closely associated with parity and furthermore majority of the young adolescents often are late in seeking antenatal care. Therefore these two factors (i.e parity and antenatal care) should be controlled in assessing the effect of maternal age on birthweight.

It has been shown in several studies[12,26], that parity was significantly associated with birthweight. In a study in Brunei[26], the World Health Organisation reported a significant association between incidence of low birthweight and low parity. The young mother who is a primigravida or who has a low parity and who is still maturing figures out as the most potentially at risk of giving birth to a low birthweight baby. Hughes et al[14] showed the proportion of low birthweight babies declined from 7.6% in first births to a low of 5.1% in third births. The proportion of low birthweight then increased with increasing parity. Kramer et al[12] showed parity was significantly associated with fetal growth. However studies by Eisner et al[20] and Mavalankar et al[25] reported that there was no significant association between parity and birthweight when other factors were controlled for.

Several studies[17,20,25,27] reported that there was a significant association between pregnancy interval and birthweight.

Mavalankar et al[25] in a study in India showed that short inter-pregnancy interval of less than or equal to 6 months was significantly associated with (preterm) low birthweight. Similar finding was observed by Eisner et al[20] where a short inter-pregnancy interval (< 6 months) was associated with an increased percent of low birthweight babies. Da Vanzo et al[17] found that after considering other factors, a short inter-pregnancy interval of less than 15 months significantly reduces birthweight.

Kramer[5] reported in his meta-analysis that prior spontaneous abortion and stillbirth/neonatal death were not consistent risk factors for low birthweight. Mavalankar et al[25] reported that clinical anaemia was significantly associated with increased risks of low birthweight. The same study also showed that no or brief use of iron/vitamin supplements significantly increased the risk of low birthweight. However Kramer[5] in his meta-analysis after reviewing 42 relevant studies looking at haematological status and iron intake as risk factors found that the association between low birthweight and haematological status/iron intake were not consistent.

It has been shown by several studies[17,20,25,26] that lack of antenatal care significantly increased the risk of low birthweight. Mavalankar et al[25] also showed that there was a significant trend of increasing risk of low birthweight associated with decreasing number of antenatal visits. The World Health Organisation reported from a case-control study in Brunei[26] , that inadequate antenatal care attendence was significantly associated with incidence of low birthweight. Eisner et al[20] also showed that no antenatal care increases the risk of having an infant of low birthweight. Kramer[5] in his meta-analysis after reviewing 27 relevat studies looking at antenatal care visit reported significant association between low birthweight and lack of antenatal care (i.e < 6 visits). This can be explained by the fact that since the greater number of contact with health professionals who attempt to reduce or eliminate risk factors and treat pregnancy complications, the better the outcome should be (i.e normal birthweight babies).

2.2 Bias and Confounding

Bias can be defined as deviation of results or inferences from the truth, or processes leading to such deviation[28]. Since most of the above studies conducted were hospital-based case-control studies, bias might potentially be introduced into the study, which can seriously affect the validity of the findings. In the hospital-based studies, selection bias (particularly due to admission rate bias, where the admission rates of exposed and unexposed cases and controls may differ), is a problem and the relative odds of exposure to the putative cause will be distorted[29]. However, even though our study is also a hospital-based study, we feel less bias here because the sample size is drawn from a big and central hospital which is fairly representative of the structure of the population in the country.

Another potential bias that can be introduced in these studies is ascertainment or information bias. This bias can lead to a distortion in the estimate of effect due to measurement error or misclassification of subjects on one or more variables. It can be either through diagnostic or recall bias. Diagnostic bias can be due to a flaw in measuring exposure or outcome that results in differential quality (accuracy) of information between compared groups[28]. Low birthweights (i.e cases) may be missed in the control group if they are not accurately weighed prior to inclusion in the study. Therefore, inaccuracy in measuring birthweight may lead to misclassification of study subjects into either case or control groups. Since informations gathered in several studies (for example prepregnancy weight and family income) are usually obtained by interview (mothers' self-reports), recall bias might also be potentially introduced. The recall of cases and controls may differ both in amount and in accuracy[29]. As a result, these biases can alter the odds ratio and thus potentially lead to an invalid conclusion.

Since it is clear from the multiplicity of causes of low birthweight, that interventions have to be cause-specific, determination of significant independent risk factors is very important. All potential confounders should be considered in statistical analysis (such as by multivariate analysis). For example in order to assess the independent effect of racial/ethnic origin on low birthweight, potential confounders such as maternal age, parity, maternal height, prepregnancy weight, socioeconomic status, maternal nutrition, interpregnancy interval and antenatal care should be controlled, because these factors may explain a large part of the observed differences in birthweight.

2.3 Summary

It has been universally agreed that the birthweight of an infant is the single most important determinant of its chances of survival and healthy growth and development. As shown by the World Health Organisation, the problem of low birthweight is being recognised and targeted as part of the global strategy for health for all by the year 2000. It is acknowledged that many factors can influence the length of gestation or the rate of intrauterine growth, i.e that the causality of low birthweight is "multifactorial". However there is considerable argument about the factors that have independent effects on low birthweight as well as the quantitative importance of those effects.

Past works have shown that several risk factors namely ethnic origin, low socioeconomic status, young maternal age, short maternal stature, low maternal weight, poor obstetric history, short inter-pregnancy interval, anaemia and lack of antenatal care were significant independent risk factors for low birthweight. However most of this studies were based on small samples and were hospital-based. Considering all the above factors, a study of these potential risk factors, avoiding potential bias and adjusting for suspected confounders, could be timely. I hope the results from this study can suggest that improvement in risk factors of low birthweight could result in substantial reduction in low birthweight and hence decrease the infant mortality rate. Therefore, hopefully the findings can serve as an important tool for guiding preventive interventions for policy makers and health planners particularly in developing countries.

3. AIMS OF THE STUDY

The aims of this study were to determine the impact of maternal biological factors including ethnicity, socioeconomic, antenatal and intrapartum factors on risk of low birthweight. The study investigated the relationship of low birthweight with all the above risk factors at the Federal Territory Maternity Hospital, Kuala Lumpur, Malaysia.

Although one of the problems with prior studies was potential bias due to the studies being hospital based, we had to restrict our study to the Maternity Hospital, Kuala Lumpur, due to practical considerations. However, as explained earlier, we feel the potential for bias is minimised since Maternity Hospital captures more than 90% of births in the Kuala Lumpur area (based on the 1991 National Census released by the Statistics Department, Malaysia, 1992).

4. OBJECTIVES OF THE STUDY

4.1 To review the available information on low birthweight babies and the factors associated with low birthweight at the Maternity Hospital Kuala Lumpur.

4.2 To estimate the prevalence of low birthweight at the Maternity Hospital.

4.3 To investigate the association of low birthweight and risk factors.

4.4 To identify independent risk factor(s) for low birthweight.

5. METHODS

5.1 Study design

A hospital-based case-control study was used to identify risk factors for low birtrhweight. The Kuala Lumpur Maternity Hospital was chosen because it is the largest maternity hospital in the country.It has a large number of births and mothers come from a large socioeconomic diversity. It has an annual delivery between 24000 to 26000 babies[30]. The population is made up of approximately equal numbers of Malays and Chinese and a smaller proportion of Indians, similar to the population of Malaysia[31,32].

Recently, there has been an influx of Indonesians into the territory, primarily in the construction industry. This has resulted in 10 - 15% of deliveries in Maternity Hospital to be of Indonesian origin. Further to discussions with heads of both Obstetrics and Gynaecology Departments General Hospital and Faculty of Medicine University Kebangsaan Malaysia, I decided to include infants born to Indonesian mothers in the study.

5.2 Study Location: Background

Malaysia is a federation of 13 states with a population of

17.5 million. It is populated by three main ethnic communities, Malays, Chinese and Indians with annual population growth rate of 2.3%[33]. The proportion of low birthweight infants for Malaysia was 10.6% in 1982[2] and 8.3% in 1989[33].

The General Hospital Kuala Lumpur is located in the capital of Malaysia. It is the largest and central referral hospital serving the whole of Malaysia. It is a service as well as teaching hospital and serves the Faculty of Medicine of the University Kebangsaan Malaysia (UKM) for the latter purpose. The hospital also provides training for doctors at all levels of education and also medical auxilliary personnel. The Department of Obstetrics and Gynaecology of UKM forms a major clinical department in the Faculty of Medicine at UKM. It provides service to patients at the Maternity Hospital and General Hospital Kuala Lumpur, sharing the workload with the government Obstetrics and Gynaecology unit. The General Hospital serves patients mainly within the city of Kuala Lumpur and the suburbs. However patients from many parts of the country are frequently referred and treated in the hospital for varying conditions. The entire General Hospital complex can accomodate 1500 in-patients and handles about 2000 out-patients daily in all its units. The Maternity Hospital Kuala Lumpur is a separate building by itself, still within the General Hospital complex and administration. It houses the antenatal, postnatal and family planning clinics on the ground floor and the obstetric and labour wards on the floors above. Activities carried out by both General Hospital and UKM obstetrics units include antenatal clinics, ultrasound services, care of in-patients deliveries and obstetric procedures. The labour wards are shared together.

5.3 Antenatal Clinic

Patients are referred from general practitioners, Maternal and Child Health clinics (City Hall Kuala Lumpur) and District Hospitals to the antenatal clinic for booking. On the first visit, a detailed history is taken from the patient pertaining to the present and the past obstetric history, medical and surgical history and family history. A note is made of social and menstrual history. This is followed by a complete physical examination, including height and weight. Several important investigations are carried out including the haemoglobin (Hb) level. Ultrasound scan is also carried out whenever possible to confirm period of gestation or to predict maturity in those patients who were unsure of their last normal menstrual period.

5.4 Subsequent Antenatal Visits

Over 90% of the patients are on a shared care basis, i.e the patient returning to the care of the General Practitioner or Maternal and Child Health clinics until between 28-32 weeks. The later part of the pregnancy for 36 weeks onwards is wholly under the care of the Antenatal Clinic, Maternity Hospital, Kuala Lumpur. At each visit mother's weight is taken. At appropriate times, ultrasound examination is also carried out whenever necessary to monitor fetal well being and fetal growth. Prophylactic supplement of iron and/ or vitamin are given. However some mothers refuse to take these because of various reasons (such as unable to tolerate their smell and taste). Some refuse to take them in order to produce smaller babies for easier delivery. Therefore the actual duration mothers were on iron/vitamin supplements is better represented by the history taken from them rather than what is reported in their antenatal cards.

5.5 Labour Ward

Patients are admitted directly to the labour ward from the antenatal ward or through the admission centre. History taking and complete physical examination is carried out.

5.6 Postnatal Ward

Primigravidae are discharged after at least 12 hours of observation and multigravidae after 6 hours unless any complications arise which require the patient to be warded for a longer period of time. Normal babies are nursed in cots beside their mother. All babies are screened and examined for any congenital abnormalities by the paediatricians. Babies with low birthweight (< 2500g) and ill babies are nursed in the Special Care Nursery which is also located within the Maternity Hospital.

5.7 Sampling

The study was conducted from April 1 to June 13, 1993 covering both units; General Hospital and University Kebangsaan Malaysia. For every case (i.e low birthweight baby) selected into the study, the immediately next available two normal babies were identified as controls until the required sample size (see below) was met. The eligible study subjects were identified from the Master Birth Register which was maintained and kept in the labour room (both labour room and the Master Birth Register are shared together by the General Hospital and UKM units and all deliveries are recorded in sequence according to time of delivery regardless of the unit). Cases of low birthweight were selected based on the international definition adopted by the 29th World Health Assembly 1976 and recommended by the Ninth Revision of The International Classification of Diseases (ICD 9) 1979[2], namely a birthweight of less than 2500g from among live singletons. Babies with birthweights equal to or more than 2500g were classified as controls.

Multiple births, infants with multiple congenital abnormalities obvious at birth, mothers with history of eclampsia, pre-eclampsia and hypertension, diabetes mellitus, complicated pregnancy including abruptio placenta and placenta praevia major, stillbirth and ethnic origins other than Malays, Chinese, Indians and Indonesians were excluded from the study. Exclusions were made before controls were selected. Whenever a case was excluded the next available case was selected. Similarly whenever a control was excluded the next available control was recruited.

5.8 Sample size

In order to test the difference in proportions of low birthweight, the following formula (as used by Kelsey et al)[34] was used:

$$n = \frac{(Z_{a/2} + Z_b)^2 \; p \; (1-p) \; (r+1)}{(d)^2 \; r}$$

$$\text{where} \; : \; p = \frac{p_1 + r \, p_0}{1 + r}$$

The required sample size was calculated based on the following definitions:

alpha level of 0.05

beta level of 0.20 (i.e statistical power of 80%)

p_0 =the proportion of low birthweight infants among Malays (used as the standard) = 0.08

p_1 =proportion of low birthweight infants among Indians = 0.14

Both proportions were based on the report by WHO in 1980[1] d =nonnull value of the difference in proportions = 0.06

n =the number of cases (low birthweight)

r =the ratio of the number of controls studied (2 controls) to the numbber of cases (1 case) studied =2

p =weighted average of p_1 and p_0

As a result, 295 low birthweight infants were recruited. With the selection of two controls for every case, 590 controls were selected for the study.

5.9 Questionnaire and Data Collection

The standard questionnaire (appendix 1) included relevant personal particulars, baby's birthweight and risk factors of low birthweight. Once an eligible infant was selected, his parents who agreed to participate in the study were asked to sign the consent form (appendix 2).

Risk factors were classified into 4 groups:

1. genetic and constitutional
2. demographic, psychosocial and nutritional
3. obstetric care
4. antenatal care

Infant sex, ethnic origin, maternal height and maternal prepregnancy weight were grouped under genetic and constitutional factors. Under demographic, psychosocial and nutritional factors were maternal age prior to pregnancy, socioeconomic status (i.e occupation, maternal educational attainment and total family income), mother's haemoglobin level, use of iron and/ or vitamin supplements and total gestational weight gain. Among the obstetric factors included were parity, interpregnancy interval, gestational age of previous birth, prior spontaneous abortion, prior stillbirth and prior child (infant) death and under antenatal care was the number of antenatal care visits.

For maternal age prior to pregnancy there were three categories for coding : Group I (< 20 yr), Group II (20-34 yr) and Group III (>35 yr). For occupation of mother and father there were 8 groups based on the classification used by the Malaysian Department of Statistics (1990)[32]. However for the purpose of analysis they were further recoded into 4 classes : Class I (professional/ managerial), Class II (clerical/ sales/ service/ agricultural), Class III (operators/labourers) and Class IV (housewife/unemployed).

For maternal educational attainment, there were 4 categories for coding[32] : Group I (no formal education), GroupII

(Primary), Group III (Secondary) and Group IV (College /University). For total family income (RM/month) they were categorised into 4 groups : Group I (<376.00) , Group II (376.00-750.00), Group III (751.00-999.00) and Group IV (> 999.00). For period of gestation at delivery (week), there were two categories for coding: Group I (28-36) , Group II (> 36). For parity there were 3 categories for coding: Group I (para 1), Group II (para 2-5) and Group III (> para 5). Categorisation of the variables were based on the ones used by the Department of Statistics[32] and the Ministry of Health[35], Malaysia in the "Guideline for management of high risk cases in pregnancy" manual and other studies by Kramer[5] and Mavalankar et al[25].

The period of gestation refers to the number of weeks the baby was in the mother's womb before birth. It has been calculated from the first day of the last normal menstrual period. For the unsure of date mothers, the period of gestation was determined based on the ultrasound scan findings (done by obstetricians at the Maternity Hospital or General Practitioners).

For gestational age of previous birth (weeks) noted in their antenatal cards, there were 2 categories for coding:
Group I (28-36, premature) and Group II (> 36). For number of

antenatal visit, there were 3 categories: Group I (< 5), Group II (5-7) and Group III (> 7). For maternal height (cm), there were 4 categories: Group I (< 145), Group II (145-149), Group III (150-154) and Group IV (> 154). For interpregnancy interval (month), there were 3 categories: Group I (< 24), Group II (24-60) and Group III (> 60). For maternal haemoglobin (Hb) level (g/100ml) there were 3 categories: Group I (< 8), Group II (8-10) and Group III (>10). For use of iron and /or vitamin supplements (weeks), there were 3 categories: Group I (<2), Group II (2-4) and Group III (>4). For maternal prepregnancy weight (kg),there were 4 categories for coding: Group I (<41), Group II (41-45), Group III (46-50) and Group IV (>50). For total pregnancy weight gain (kg; maternal weight at birth minus maternal prepregnancy weight), there were 2 categories: Group I (<7) and Group II (7 and above).

Immediately after delivery, the antenatal records of the babies' mothers were reviewed and the mothers were interviewed. In 7 cases where required information was not available (either from their records or maternal interviews), paternal interviews and visits to Kuala Lumpur City Hall Antenatal Clinics (where mothers had their first antenatal visits) were also made.

There were 21 mothers (2.4%) with unsure of dates, therefore their period of gestation were based on the ultrasound scan findings. All the findings were recorded in their antenatal cards and bed head tickets. These are kept by the hospital under strict confidentiality guidelines. Birthweights were taken from the "measurement book" in the labour room. Babies were weighed immediately after birth by a staff-nurse and then recorded into the book. An electronic scale (DETECTO) with capacity of 18 kg X 0.005 kg which was regularly calibrated was used to weigh babies. Maternal pre-pregnancy weights used were based on recall by mothers. Maternal weights at birth were taken from their admission cards. It is a normal practice at the maternity hospital that all mothers who came in labour were routinely weighed by admitting staff-nurse at the admission room before being transferred to the labour room.

In developed countries alcohol consumption and cigarette smoking have been well documented to be significant risk factors for low birthweight[5]. However, since there were so few cigarette smoking and alcohol taking mothers, these two risk factors were not included in the study. They are presumed not to contribute to risk of low birthweight in Malaysia. Since the study was conducted during fasting month (Ramadhan), I decided to include "fasting" as a risk factor to see whether there is any effect of it on birthweight among Muslim mothers.

5.10 Verification

In order to ensure accuracy in birthweight readings, a random sample of 10% (90) of the babies were weighed by me immediately after the first reading taken by the staff-nurse, and I found that 96% (86) of the readings were in agreement. The difference in the other four babies ranged from -4 to 6g. Since maternal pre-pregnancy weights were based on recall by the mothers, and knowing very well that recall bias could potentially be introduced, 10% (60) out of 642 mothers who were able to recall were randomly selected and their status compared with their first reading recorded in the antenatal cards within the first two months after their last normal menstrual period. 85% (51) of the recalls were in agreement. The difference in the other 9 readings was in the range of -2 to 4 kg.

5.11 Analysis strategy

In order to use and manage the data in a computerised format, all collected information was converted to proper names, labels and codes (appendix 3). Data from the questionnaire survey were compiled using dBASE IV. Statistical analysis were performed using EPI INFO version 5 and Statistical Package for the Social Sciences (SPSS-PC) version 4.0. The SPSS-PC statistical package was also used for logistic regression analysis. The 5% level (alpha = 0.05) for statistical significance was used.

Prevalence of low birthweight overall and according to ethnic origins was calculated. Descriptive statistics and the distribution of risk factors between low birthweight cases and controls were assessed. Analysis of variance for the association of birthweight and categorical variables was carried out. The levels of significance were assessed by the standard "F" test for all variables where the assumption of homogeneity of variances was met. To evaluate a possible "dose-response" relationship for the risk factor of interest, the relative risk (estimated by the odds ratio, OR) and the chi-square for trend were calculated using one category usually that with the least risk, as the reference group.

In order to assess the impact of ethnic origin on birthweight, controlled for potential confounders (maternal pre-pregnancy weight, maternal height, parity, interpregnancy interval, maternal age, total family income, use of iron and/ or vitamin supplements, gestational weight gain and antenatal care), analysis of covariance was used.

Since many risk factors are correlated namely between parity and maternal age, total family income and antenatal care visits and between maternal height and maternal pre-pregnancy weight, correlation tests were carried out to investigate their correlations. Since there may be potential interaction between these variables, two-way analysis of variance was also performed (in this analysis, only those interactions which I have prior reason to be concerned about or which make biologic sense as suggested by Kramer[5] were formed). These variables i.e. maternal age, parity, maternal height, pre-pregnancy weight, total family income and antenatal care visit are each known to have the potential to produce interaction effects on birthweight. A forward stepwise logistic regression analysis was performed to evaluate the importance of each variable in the model. The significance of each variable was assessed by the likelihood ratio chi-square test (improvement chi-square) and its corresponding p-value. Adjusted ORs and their 95% confidence interval (CI) were calculated for each independent variable in the model. The overall logistic regression equation was estimated.

In order to see the actual statistical power I had in this study, and based on the prevalence of low birthweight for different ethnic groups found in the study, a "backward" calculation of statistical power, using the same formula used by Kelsey[34] was done.

Each variable was coded into either binary, nominal or ordinal categories. Classification of risk factors namely haemoglobin value, maternal height, parity, antenatal visit and interpregnancy interval was based on the "Guideline for management of high risk cases in pregnancy, second edition: 1991; Ministry of Health Malaysia[35]. Classification of occupation and educational attainment was based on the ones used by the Department of Statistics, Malaysia, July 1990, and the Yearbook of Statistics 1989[32]. Classification of total family income was based on the Guideline for Development Programme for The Poorest, Prime Minister's Department, 1990. Classification of total gestational weight gain was based on the classification used by Haas[36]. Classification of other risk factors was based on those used by Mavalankar et al[25].

6. RESULTS

Total deliveries at the Maternity Hospital Kuala Lumpur from April 1st to June 13th 1993 were 5155, out of which 387 were low birthweight babies. Of the 5155 babies, 2817 were Malays (out of which 189 were low birthweights), 910 Chinese(45 low birthweights), 701 Indians (85 low birthweights) and 688 Indonesians (60 low birthweights). The overall prevalence of low birthweight was 7.5%. The prevalence of low birthweight according to ethnic origins i.e Malays, Chinese, Indians and Indonesians were 6.7%, 4.9%, 12.1% and 8.7% respectively (Table 1).

Out of 387 low birthweights, 92 (23.8%) were excluded according to exclusion criteria. There were 34 twins, 29 cases of eclampsia or pre-eclampsia, 10 fresh and or macerated stillbirths, 7 complicated pregnancies (i.e placenta praevia major ended with caesarean section prematurely), 6 other races (i.e 2 Thais, 1 Myanmarese, 1 Pakistani, 1 Vietnamese and 1 Kampuchean), 3 multiple congenital abnormalities and 3 diabetics. Among the 624 controls identified, 34 (5.4%) were excluded by the same exclusion criteria. There were 17 eclampsia and pre-eclampsia, 7 diabetics, 7 other races (i.e 2 Pakistanis, 1 Vietnamese, 3 Thais and 1 Filipino) and 3 twins (Table 2).

The summary of results of univariate analysis of the association of categorical risk factors of low birthweight among cases and controls are presented in table 3. Cases were more frequent than controls among the Indians (24% vs 15%) and Indonesians (16% vs 15%) but less frequent among the Malays (51% vs 52%) and Chinese (9% vs 18%). The overall chi-square was 19.35 ($p < 0.001$). Mean birthweights among different ethnic groups were significantly different. The "F" probability is equal to 0.01.

There were more cases belonging to the shorter maternal height groups (5% vs 3% for < 145 cm, 15% vs 8%, 145 - 149 cm group and 43% vs 38% among mothers with height for 150 - 154 cm) but less frequent among taller (> 154 cm) mothers (36% vs 51%). The overall chi-square was 26.19 ($p < 0.001$). Cases tended to be more frequent than controls in the group of maternal pre-pregnancy weight of less than 41 kg (11% vs 5%), 41 - 45 kg group (15% vs 9%) and 46 -50 kg (15% vs 14%) but less frequent in the group of > 50 kg (28% vs 46%). The overall chi-square was 35.14 ($p < 0.001$). Mean birthweights in different pre-pregnancy weight and maternal height groups were highly significantly different ($F < 0.001$ for both risk factors). There was no significant difference between cases and controls for infant sex. Mean birthweights were also not significantly different between males and females. Ethnicity (i.e. Indian, Indonesian and Malay), maternal height < 155cm and pre-pregnancy weight < 50kg were associated with significant risk of LBW (p < 0.05). There was a significant trend of increasing risk of LBW associated with decreasing in maternal height and pre-pregnancy weight (p < 0.001).

There were more cases in the young (< 20 yr) maternal age group (9% vs 5%) but less frequent in the age group of 20 - 34 year (79% vs 83%) and older than 34 year (12% vs 13%). The overall chi-square was 6.59 (p = 0.04). Mean birthweights were significantly different among different age groups (F= 0.002). More cases belonged to the group of mothers with no formal education (14% vs 7%) but less often in primary (50% vs 53%) and secondary attainment groups (34% vs 37%). The proportion of cases was about the same as the proportion of controls whose mothers were college/university educated. The overall chi-square was 9.73 (p = 0.02). Mean birthweights were significantly different among different maternal educational attainment groups (F = 0.02). Cases tended to be more frequent in the lowest (< RM 376.00/month) total family income group (6% vs 2%) but less frequent in 376.00 - 750.00 (64% vs 66%) and 751.00 - 999.00 groups (11% vs 13%). The overall chi-square was 9.51 (p = 0.02). There were no significant differences between cases and controls for mother's and father's occupation. Mean birthweights in different family income, mother's and father's occupation groups were also not significantly different.

There were more cases among mothers with low (< 7 kg) total gestational weight gain (30% vs 18%) but less often in more than or equal to 7 kg group (39% vs 56%). The overall chi-square was 22.92 ($p < 0.001$). More cases belonged to mothers with no or brief use of iron/vitamin supplements during pregnancy (54% in the 2 - 4 weeks and < 2 weeks groups vs 36% of controls) but less frequent in more than 4 weeks groups (46% vs 64%). The overall chi-square was 34.59 ($p < 0.001$). Mean birthweights in different use of iron/ vitamin supplements and gestational weight gain categories were highly significantly different ($F < 0.001$ for both).

In these data, more cases were found among mothers with low haemoglobin (Hb) levels (10 g/100ml and below) at the first and last readings during pregnancy (29% vs 20% and 15% vs 12% respectively) but less often in mothers with Hb group of more than 10g/100ml (71% vs 80% and 79% vs 88% respectively). The overall chi-squares were 9.85 ($p = 0.002$) and 7.21 ($p = 0.03$) respectively. Mean birthweights were significantly different in different first and last Hb level groups ($F = 0.004$, 0.008 respectively). Maternal age < 20 year old, mothers with no formal education, family income less than or equal to RM

375/mth, gestational weight gain < 7kg, no or brief use of iron/ vitamin supplements and anaemia (i.e first Hb value < 11g%) showed significantly more risk of LBW. There was also a significant trend of increasing risk of LBW associated with decrease in maternal education ($p = 0.04$) and use of iron/vitamin supplements ($p < 0.001$). The effect of fasting was also evaluated for Muslim mothers. There was no significant risk of LBW among those who did fast.

There were more cases among primiparous (41% vs 22%) but less frequent in the second to fifth parity (52% vs 69%) and grand multiparous groups (8% vs 10%). The overall chi-square was 35.16 ($p < 0.001$). More cases belonged to mothers with short inter-pregnancy interval of less than 24 months (29% vs 27%) but less frequent in more than or equal to 24 months (30% vs 52%). The overall chi-square was 13.92 ($p = 0.001$). Cases tended to be more often among mothers with previous premature births (5% vs 2%) than controls. The overall chi-square was 14.12 ($p = 0.001$). Mean birthweights in different parity, inter-pregnancy interval and gestational age of previous birth groups were highly significantly different ($F < 0.001$ for all). History of prior spontaneous abortion was significantly more frequent among cases than controls with the overall chi-square of 5.45 ($p = 0.02$). There were no significant differences between cases and controls for history of prior stillbirth and number of prior infant death. No statistically significant differences of mean birthweights between two groups of prior spontaneous abortion, stillbirth and infant death were noticed. Prematurity was significantly more frequent among cases than controls with the overall chi-square of 162.27 (p < 0.001). Mean birthweights were also highly significantly different between pre-term and term deliveries (F < 0.001). Finally, for antenatal care factor, cases were more frequent among mothers with no or less than 5 antenatal visits (40% vs 19%) but less frequent in more than or equal to 5 visits (60% vs 81%). The overall chi-square was 45.56 (p < 0.001). Mean birthweights in different number of antenatal care visit were significantly different (F < 0.001). Among the obstetric factors, primiparous, short interpregnancy interval (i.e less than 2 years), previous premature birth, prior spontaneous abortion, and prematurity were associated with significant risk of low birthweight. Lack of antenatal care visits (< 5 visits) significantly increased the risk of low birthweight. There was also a significant trend of increasing risk of low birthweight associated with decreasing number of antenatal care visits (p-value < 0.001).

Table 4 presents the analysis of association of birthweight with ethnicity adjusting for all potential confounders and p-values. Analyses revealed that there is no significant association ($p > 0.05$) between low birthweight and ethnicity after taking factors (as suggested by Kramer[5]-as potential confounders) namely maternal age prior to pregnancy, total family income, total gestational weight gain, use of iron and/ or vitamin supplements, parity, interpregnancy interval and antenatal care visits as covariates.

Knowing very well that low birthweight can be caused by either short gestational age or by fetal growth retardation, another analysis was carried out controlling for period of gestation at delivery (i.e gestational age) in addition to all the above potential confounders. Table 4a shows that there is no significant association ($p > 0.05$) between ethnicity and low birthweight.

Table 5 shows the summary of results of forward stepwise logistic regression analysis in which all the independent variables and possible interaction terms were entered. For each step the name of the variable that entered at that stage, degrees of freedom, log-likelihood value, improvement chi-square and its p-value, and the goodness of fit chi-square and its p-value are presented. At steps one and two, the period of gestation at delivery and pre-pregnancy weight produced the largest changes in log-likelihood values with significant improvement of chi-square and p-values of < 0.001. At steps three, four, five and six the use of iron/vitamin supplements, interpregnancy interval, maternal height and gestational age of previous birth were entered significantly in the model with the likelihood ratio chi-square for improvement values of 9.0 (p=0.003), 4.9 (0.03), 4.7 (0.03) and 4.0 (0.04) respectively.

Table 6 shows the estimates for slope coefficient, standard error of coefficient, and adjusted odds ratios and their 95% confidence interval (CI).

Thus the logistic regression equation for the derived model is:-

Probability (LBW) =

$$\frac{e^{-3.2846+1.3052GAPBIRTH+0.4896MHEIGHT+0.3768PINTERVA+0.6458VITIRON+2.6093DELPOG+0.6102PPWEIGHT}}{1+e^{-3.2846+1.3052GAPBIRTH+0.4896MHEIGHT+0.3768PINTERVA+0.6458VITIRON+2.6093DELPOG+0.6102PPWEIGHT}}$$

Using term delivery of previous birth as the reference group, the OR was 3.7 (95% CI: 1.0,13.3) for previous pre-term delivery. The OR for maternal height < 145 cm was 4.3 (2.8,6.8), 145-149 cm group 2.7 (1.7,4.2) and 150-154 cm group 1.6 (1.0,2.6) using maternal height >154 cm as the reference group. Using maternal pre-pregnancy weight >50 kg as the reference group, the OR was 6.2 (4.6,8.5) for <40 kg group, 3.4 (2.5,4.6) for 41-45 kg and 1.8 (1.4,2.5) for 46-50 kg group. The risk of low birthweight increased with decreasing maternal height and pre-pregnancy weight.

Using interpregnancy interval 2-5 years as the reference group, the OR was 2.1 (1.5,3.0) for < 2 years group and 1.5 (1.0,2.1) for > 5 years. For use of iron/vitamin supplements, using duration > 4 weeks as the reference group, the OR was 3.6 (2.4,5.6) for < 2 weeks and 1.9 (1.3,2.9) for 2-4 weeks group.

Table 6a shows the summary of results of logistic regression analysis using ethnicity and all significant independent variables identified in forward stepwise logistic regression analysis (table 5) namely gestational age, pre-pregnancy weight, use of iron and/or vitamin supplements, interpregnancy interval, maternal height and gestational age of previous birth as categorical variables.

Thus the final logistic regression equation for the derived model is:-

Probability (LBW) =

$$\frac{e^{1.2880-1.3496\mathrm{DELPOG1}-0.9042\mathrm{PPWEIGHT}-0.4754\mathrm{VITIRON1}-0.5982\mathrm{GAPBIRTH1}+0.7018\mathrm{RACE2}}}{1+e^{1.2880-1.3496\mathrm{DELPOG1}-0.9042\mathrm{PPWEIGHT}-0.4754\mathrm{VITIRON1}-0.5982\mathrm{GAPBIRTH1}+0.7018\mathrm{RACE2}}}$$

The table shows only gestational age < 37 weeks ($p < 0.001$), pre-pregnancy weight 46-50 kg ($p < 0.001$), use of iron and/or vitamin supplements 2-4 weeks ($p = 0.01$), gestational age of previous birth < 37 weeks ($p = 0.04$) and ethnic origin (Indian) ($p < 0.007$) were significant.

7.DISCUSSION

This study focused on four groups of risk factors for low birthweight; genetic and constitutional, demographic/ psychosocial and nutritional, obstetric and antenatal care. Since multiple pregnancies are subject to additional restrictions in intrauterine growth compared with singleton pregnancies[5], all multiple pregnancies were excluded in my study. Kramer[5] used similar exclusion criterion in his meta-analysis. Knowing very well that several controversial medical complications during pregnancy namely eclampsia, pre-eclampsia, hypertension, diabetes mellitus and antepartum haemorhage might potentially contribute to low birthweight, mothers with such history were also excluded from the study. They are potential confounders which could seriously affect the validity of findings. Since the number of mothers other than the 4 major ethnic groups were so few (< 1 %), thus likely to have little impact on the findings, they were excluded from the study.

Out of 92 cases excluded 50 (54.3%) were preterm babies. This is expected since period of gestation is associated with birthweight[5,12]. Among the 34 controls excluded, only 7 (20.6%) babies were preterm. Most of the cases excluded (34) were twins, compared to only 3 twins among the controls. Overall , a total of 126 (12.5%) babies were excluded from the study. I am confident that with the small percentage of exclusion, the validity of the results of this study will not be seriously affected. It was expected that from the beginning about 15% of the study subjects might be excluded. I found also that more cases were excluded (92, 23.8%) compared to the controls (34, 5.4%). Overall cases had more reasons of exclusion compared to controls. This is expected since low birthweight is significantly associated with major medical problems (example pre-eclampsia and hypertension)[25].

Bivariate and trend analyses showed that several risk factors namely teenage pregnancy, prior spontaneous abortion, short interpregnancy interval and lack of antenatal care were associated with low birthweight, a common observation in previous studies[20,25]. Other factors such as low maternal pre-pregnancy weight, short stature, low maternal education, low family income, no or brief use of iron/vitamin supplements, anaemia, primiparous and previous premature birth were also associated with low birthweight. This agrees with the observations of Mavalankar[25] in his study in India. However most of the demographic/psychosocial and nutritional (except for use of iron/vitamin supplements) and antenatal care factors lost their significance after adjusted for other factors as demonstrated by stepwise logistic regression analysis.

In order to see whether true genetic differences exist between different ethnic groups, analysis of covariance was carried out. The analysis revealed that there is no significant association between low birthweight and ethnicity after considering all potential confounders as suggested by Kramer[5] and gestational age. This agrees with his suggestions that the differences in birthweights between different ethnic groups could well be due to the above potential confounders. However this needs further investigation with a bigger sample size after knowing very well that I only had 68% power to detect differences of 0.5% between the Malays and Indians (i.e using the same formula as used to calculate sample size[34] and based on the findings [table 1], p_0 =0.07(Malay), p_1 =0.12 (Indian), d =0.05, p= 0.09 and r=2, and the very low power of about 20% to detect differences of 2% between Malays and Chinese (based on the same formula[34] and findings [table 1], p_0 =0.05(Chinese), p_1 =0.07(Malay), d =0.02, p=0.055 and r=2. Also, the p-value for race, adjusted for other factors was 0.051, a borderline significance level. This also suggests that an increased sample size might yet declare ethnicity as a risk factor.

Among genetic and constitutional factors, the most important was maternal pre-pregnancy weight. Since this was a retrospective study, pre-pregnancy weights were obtained by recall of mothers. Validation test on 10 % (60) of mothers who were able to recall showed that 85 % (51) were in agreement with their weights recorded in antenatal cards before or at 8 weeks of period of gestation. Therefore this gives me confidence that even though only 72.5 % (642) of 885 mothers were able to recall their pre-pregnancy weights, the findings of this study are useful and meaningful.

My observations of an independent association between maternal pre-pregnancy weight and low birthweight are in agreement with Mavalankar et al[25] and Ferraz et al[37] , even though these studies used post partum weight as a surrogate for pre-pregnancy weight (i.e pre-pregnancy maternal nutritional status). Given that high odds ratio associated with low pre-pregnancy weights, improvement in nutrition could have a substantial impact on low birthweight. A study conducted by Villar J and Rivera J[38] in Guatemala have shown that a 301 g increase in mean birthweight is attributable to nutritional supplementation. However a cultural point to note here is that it is the practice of some Malay and Indian women in Malaysia to reduce their food intake during pregnancy for fear of producing large babies and consequently facing difficult deliveries, while Chinese women tend to increase their food intake during pregnancy. While there was no significant association between ethnicity and increased risk of low birthweight, it would need a prospective study through pregnancy and delivery to examine the importance of any differential food intake and maternal malnutrition as a potential risk factor of low birthweight[39].

Another important independent risk factor for low birthweight was maternal height. Kramer[5] in his meta analysis observed similar findings after reviewing 79 studies on maternal height. He suggested that diminished maternal height may well be one of the causes of the increased rate of low birthweight in many developing countries, whether caused by a true difference in genetic potential or prior stunting during the mother's childhood. A mother's height during pregnancy is determined by three factors: her genetic potential for growth; her state of skeletal maturity (including age); and the effect of environmental influences during the period of skeletal immaturity. However knowing that these three factors differ in their modifiability, genetic potential is presumably fixed, but delayed child-bearing among young adolescents, and over the long term, general improvements in nutrition might be achieved by health interventions.

The stepwise logistic regression equation showed that only maternal height, pre-pregnancy weight, gestational age of previous birth, interpregnancy interval, use of iron/vitamin supplements and period of gestation at delivery remained independently significantly associated with risk of low birthweight after adjustment for other risk factors.

None of the potential interaction terms were entered into the model. This is supported by the results from two-way analysis of variance where all the F-significance values > 0.05 (i.e interaction between maternal age and parity, signif. of F = 0.2, between total family income and antenatal care visit, 0.4 and between maternal height and pre-pregnancy weight, 0.2), eventhough there was a positive correlation between maternal height and pre-pregnancy weight (correlation cooefficient of 0.38, p <0.01) and maternal age and parity (0.61, p < 0.01). However there was no correlation between total family income and atenatal care visit (0.02, p = 0.5).

It has been shown by Kramer[5] that if the prior gestation resulted in a premature birth, the mother will be at increased risk for a shorter inter-pregnancy interval and a repeat premature or a LBW baby. Probably this may explain the significance of the previous premature delivery as one of the independent risk factors for low birthweight. In many developing countries, particularly among the poor, mothers may not seek antenatal care until rather late in pregnancy, and thus premature labour and delivery may prevent them from receiving any antenatal care at all. So the most possible explanation for the significance of use of iron/vitamin supplements is that mothers of low socioeconomic status may be more likely make less use of antenatal care and therefore receive less or no iron vitamin supplements which is being prescribed routinely by antenatal clinics in this country. Even though Kramer[5] did not find evidence to show that use of iron/vitamin supplements had an effect on birthweight, he did not rule out that iron or vitamin supplementations could be beneficial in developing countries.

The significance of maternal height and pre-pregnancy weight as independent risk factors for low birthweight may be explained by the fact that mothers who begin antenatal care at a late stage in their pregnancy and those who never begin are likely to be undernourished or poor pre-pregnancy weight compared to those who seek early, frequent and regular antenatal care. Similarly mothers who never begin or begin antenatal care visit at a late stage are likely to be young mothers (and more likely to be shorter). Also young mothers are likely to make less visit or often late in seeking antenatal care because their pregnancies are often unplanned and unwanted.

Another important risk factor associated with a significant risk of low birthweight was short (< 2 years) interpregnancy interval. This agrees with observations by Da Vanzo[17], Mavalankar[25], and Lang[37] even though it was associated with only (preterm) low birthweight in the last two studies. The most obvious explanation for this effect on birthweight is nutritional depletion. Mothers are still not fully recovered to prepare for the next pregnancy. So from here, I can see that it would be wise to counsel family planning to prolong interpregnancy intervals to longer than or at least two years.

Period of gestation at delivery was found to be one of the independent risk factors. The high adjusted odds ratio for prematurity associated with low birthweight is expected as shown by Kramer[5] and Da Vanzo[17]. Kramer[5,40] in his study and analysis explained that length of gestation (used to define prematurity) is corresponding to lower birthweight (however premature is not synonymous to low birthweight) as clearly defined by the international classification of diseases[1]. Since these two groups of infants (preterm and full-term) represent two different processes[2,5,41], it might be more useful to conduct a more detailed study for associated risk factors of these two events. Given the high odds ratio associated with prematurity, prolonging length of gestation might be substantial in reducing proportion of low birthweight. Even though nothing much can be done to change this factor, somehow it must be given great emphasis by obstetrician especially in early stages of pregnancy.

When ethnicity and all significant independent variables were entered and declared as categorical variables, the final logistic regression equation showed that only prematurity, pre-pregnancy weight 46-50 kg, use of iron and/or vitamin supplements 2-4 weeks, previous premature birth and Indian ethnic group remained independently significantly associated with risk of low birthweight.

As discussed above the observations of significant independent association between gestational age, previous prematurity, pre-pregnancy weight and use of iron/vitamin supplements were common in other studies[5,17,25,37,40].

My observations of an independent association between Indian ethnic origin and low birthweight are in agreement with Hughes[14]. It has been shown in many parts of the world that Indian babies are smaller than other groups[1,13-18]. Hughes[14] in his study suggested that lower birthweights in Indians to some extent represents factors of ethnic or genetic origin. Kramer[5] in his analysis looking at ethnicity as a risk factor for low birthweight suggested that ethnic origin has direct causal effect on birthweights. Therefore it could be postulated that genetic differences that exist between different ethnic groups could lead to different average birthweights.

8. CONCLUSION

As shown by this study, birthweight is influenced by genetic, prenatal and pregnancy health and nutritional status of the mother. Therefore proper nutrition and care of the mothers during their pregnancy are important in the prevention of low birthweight babies. Poor nutrition (i.e low maternal pre-pregnancy weight), premature birth, poor quality of antenatal care are potentially modifiable risk factors. This suggests that substantial proportion of low birthweight may be averted by improving all these factors.

So it is clear from the multiplicity of causes of low birthweight that there is no universal solution. Interventions have to be cause-specific preferably according to ethnic group. Eventhough in this study, I was not able to formulate different models (equations) for different ethnic groups because of small sample size, logistic regression analysis for categorical variables did show that Indian ethnic origin was significantly independently associated with low birthweight.

Providing quality antenatal care should be emphasised and given priority. These include continuous and regular care, providing special antenatal care programmes targeted for specific at-risk groups (e.g undernourished and poor mothers, mothers with history of previous premature birth) under specialist care, nutrition programmes, health education on the needs of pregnant women and family planning. Indian mothers should be given priority and special attention through out their pregnancies. The existing health education programmes should be intensified in order to encourage and motivate more problematic mothers to continuously participate in such programmes. Hence this study can guide policy makers, health planners and providers in formulating preventive interventions not only in Malaysia but also probably in other developing country settings where resources are scarce.

9.SUGGESTION AND FUTURE RESEARCH

This study, along with most others did not differentiate low birthweight due to preterm birth from that due to intrauterine growth retardation. This distinction is essential because preterm birth and growth retardation represent separate processes, and as such, they can be expected to have different causal factors. Therefore it might be more useful to conduct a more detailed and larger study for associated risk factors of these two events even though this study did provide further epidemiological evidence of the association of several independent risk factors of low birthweight. Bigger study will also help me to produce different models for different ethnic groups and this is very helpful in planning specific health education programmes.

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APPENDIX 1

QUESTIONNAIRE FOR THE STUDY OF
LOW BIRTHWEIGHT
AT THE MATERNITY HOSPITAL, KUALA LUMPUR
MALAYSIA

Sources:

Antenatal cards from:-

Maternity Hospital Kuala Lumpur

Kuala Lumpur City Hall Clinics

Health Centres

General Practioners (GPs)

Admission cards to the Maternity Hospital

Bed head tickets

Birth Register ("Measurement book") in the labour room

Interview

APRIL - JUNE 1993

1.CASE NUMBER		01-04
2.DATE OF BIRTH		05-12
	Day Month Year	
3.SEX	Male............1	
	Female..........2	13
4.RACE	Malay...........1	
	Indian..........2	
	Chinese.........3	
	Indonesian......4	14
5.BIRTHWEIGHT (g)		15-18
6.MATERNAL AGE PRIOR TO PREGNANCY (YEAR)		19-20

7.MOTHER'S OCCUPATION

Professional and related workers.............1

Administrative and managerial workers........2

Clerical and related workers.................3

Sales and related workers....................4

Service workers..............................5

Agriculture, forestry, fishermen and hunters.6

Production and related worker, transport equipment operators and labourers...........7

Unemployed / Housewife.......................8 21

8.MOTHER'S EDUCATIONAL ATTAINMENT

No formal education.........................1

Primary.....................................2

Secondary...................................3

College / University........................4 22

9.FATHER'S OCCUPATION

Professional and related workers............1

Administrative and managerial workers.......2

Clerical and related workers................3

Sales and related workers...................4

Service workers.............................5

Agriculture, forestry, fishermen, hunters...6

Production and related workers, transport
equipment operators and labourers..........7

Unemployed..................................8 23

10.TOTAL FAMILY INCOME (RM / MONTH) 25-29

11.GRAVIDITY 30-31

12.PARITY 32-33

13.HISTORY OF PRIOR SPONTANEOUS ABORTION

Yes.......................1

No........................2

Not applicable............8 34

14.HISTORY OF PRIOR STILLBIRTH

Yes.......................1

No........................2

Not applicable............8 35

15.NUMBER OF PRIOR INFANT DEATH

Not applicable............8 36

16.GESTATIONAL AGE OF PREVIOUS BIRTH (WEEK)

Not applicable...........88 38-39

17.NUMBER OF ANTENATAL VISIT 40-41

18.MATERNAL HEIGHT (CM) 42-44

19.INTER-PREGNANCY INTERVAL (MONTH)

Not applicable..........888 45-47

20.MOTHER'S FIRST HAEMOGLOBIN (g/100ml) READING

Not applicable...........88 48-49

21.MOTHER'S LAST HAEMOGLOBIN (g/100ml) READING

Not applicable...........88 50-51

22.USE OF IRON AND/ OR VITAMIN SUPPLEMENTS (WK) 52-53

23.PERIOD OF GESTATION (POG) AT DELIVERY (WK) 54-55

24.MATERNAL PRE-PREGNANCY WEIGHT (Kg)

Not applicable...........88 57-58

25.MATERNAL WEIGHT (Kg)....AT POG (Wk).....

POG 08 POG 09 POG 10..............POG 42

WEIGHT... WEIGHT... WEIGHT..............WEIGHT

59-128

26.TOTAL GESTATIONAL WEIGHT GAIN (Kg)

(Maternal weight at birth - Maternal

pre-pregnancy weight)

Not applicable...........88 129-130

27."FASTING"

Yes.......................1

No........................2

Not applicable............8 **131**

APPENDIX 2

CONSENT FORM FOR THE STUDY OF LOW BIRTHWEIGHT

AT THE MATERNITY HOSPITAL KUALA LUMPUR

MALAYSIA

Informed consent to participate in the low birthweight study

The importance of identification of risk factors for low birthweight and their significant health implications in Malaysian children. A hospital-based case control study

I, ______________________________ understand that I have been requested to participate in a study to determine the risk factors for low birthweight. By signing, I agree to be interviewed (about 15 minutes) and have the following information gathered: occupation (parents), educational attainment of mother, total family income, use of iron/vitamin supplements, "fasting" (only among the Moslems) and mother's weight before pregnancy.

My participation in this study is entirely voluntary. I may refuse to participate now, or withdraw at any time, without having to specify any reasons.

The information gained from this study may be used in publications, but I am assured that confidentiality of any information will be maintained at all times.

_______________ ____________________

Witness Mother/father

Date____________________

APPENDIX 3

CODE SHEET FOR VARIABLES FOR STUDY OF LOW BIRTHWEIGHT

VARIABLES NAME	VARIABLES LABELS AND VALUES
ID	Identification number: 1 = Case : 1001 - 1295 2 = Control :2001 - 3295
DATE	Birth date of baby
SEX	Sex of baby (1=male, 2=female)
RACE	Race of baby: 1=Malay, 2=Indian 3=Chinese, 4=Indonesian
BWEIGHT	Birthweight of baby (gm)
MAGE	Maternal age prior to pregnancy (year)
MOCC	Mother's occupation
FOCC	Father's occupation 1=Professional, 2=Administrative 3=Clerical, 4=Sales, 5=Service 6=Agriculture, 7=Labourer 8=Unemployed
MEDUC	Maternal education 1=No formal education, 2=Primary 3=Secondary, 4=College/University

FINCOME	Total family income (RM/mth)
PARITY	Parity
HOABORT	History of prior spontaneous abortion (1=Yes, 2=No, 8=Not applicable)
HOSBIRTH	History of prior stillbirth (1=Yes, 2=No, 8=Not applicable)
CDEATH	Number of prior infant death (8=Not applicable)
GAPBIRTH	Gestational age of previous birth (Week) (88=Not applicable)
ANTVISIT	Number of antenatal care visit
MHEIGHT	Maternal height (cm)
PINTERVA	Inter-pregnancy interval (month) (i.e the time between the previous birth and conception of the current pregnancy) (888=Not applicable)
FPOG	First haemoglobin (Hb) reading (g/100ml) (88=Not applicable)
LPOG	Last Hb reading (g/100ml) (88=Not applicable)
VITIRON	Use of iron/vitamin supplements (week)
DELPOG	Period of gestationat delivery (week)

FASTING	History of fasting during fasting month ("Ramadhan") (8=Not applicable)
PPWEIGHT	Pre-pregnancy weight (kg) (88=Not applicable)
TWGAIN	Total pregnancy weight gain (kg) (88=Not applicable)

Interaction terms:

MAGExPARITY	Interaction between maternal age and parity
FINCOMExANTVISIT	Interaction between total family income and antenatal care visits
MHEIGHTxPPWEIGHT	Interaction between maternal height and pre-pregnancy weight

TABLE 1

Prevalence of low birthweight (LBW):

according to ethnic ori‹‹in,

April 1 - June 13 1993

Maternity Hospital, Kuala Lumpur, Malaysia

ETHNIC ORIGINS	NO.OF INFANTS	%	NO.OF LBW	PREVALENCE OF LBW (%)
MALAY	2817	54.6	189	6.7
CHINESE	910	17.7	45	4.9
INDIAN	701	13.6	85	12.1
INDONESIAN	688	13.3	60	8.7
TOTAL	**5155**	**100**	**387**	**7.5**

TABLE 2

Number of cases and controls excluded according to the exclusion criteria

Exclusion criteria	Number excluded	
	Cases	Controls
Congenital abnormality	3	0
Diabetes Mellitus	3	7
Complicated pregnancy	7	0
Fresh/macerated stillbirth	10	0
Eclampsia/preeclampsia/ hypertension	29	17
Twin	34	3
Other races	6	7
Total	92	34

TABLE 3

THE SUMMARY OF UNIVARIATE ANALYSIS OF RISK FACTORS OF LOW BIRTHWEIGHT BABIES AND CONTROLS

Variable	Cases N	Cases %	Controls N	Controls %	Chi-squared (p-value)	Analysis of var. "F" sig.	OR	Chi-squared for trend (p-value)
Total	295	100	590	100				
SEX								
Male	140	47	290	49	0.23		0.9	
Female	155	53	300	51	(0.6)	0.2	1.0	
RACE								
Malay	149	51	309	52			1.8*	
Indian	70	24	86	15			3.1*	
Chinese	28	9	107	18	19.35		1.0	
Indonesian	48	16	88	15	(p<0.001)	0.01	2.1*	
MATERNAL HEIGHT (cm)								
< 145	16	5	15	3			3.1*	
145-149	45	15	47	8			2.7*	
150-154	128	43	225	38	26.19		1.6*	25.56
> 154	106	36	303	51	(p<0.001)	<0.001	1.0	<0.001

continued, Table 3

Variable	Cases		Controls		Chi-squared (p-value)	Analysis of var. "F" sig.	OR	Chi-squared for trend (p-value)
MATERNAL PRE-PREGNANCY WEIGHT (Kg)								
< 41	32	11	27	5			3.9*	
41-45	45	15	53	9			2.8*	
46-50	44	15	84	14	35.14		1.7*	34.98
> 50	83	28	274	46	<0.001	<0.001	1.0	<0.001
unknown	91	31	152	26				
MATERNAL AGE PRIOR TO PREGNANCY (YEAR)								
< 20	27	9	28	5			2.1*	
20-34	234	79	488	83	6.59		1.0	0.24
> 34	34	12	74	13	0.04	0.002	1.0	0.6
MATERNAL EDUCATION								
No education	40	14	42	7			2.1*	
Primary	148	50	315	53			1.0	
Secondary	101	34	220	37	9.73		1.0	4.28
College	6	2	13	2	0.02	0.02	1.0	0.04

continued, Table 3

Variable	Cases		Controls		Chi-squared (p-value)	Analysis of var. "F" sig.	OR	Chi-squared for trend (p-value)
MOTHER'S OCCUPATION								
Professional	7	2	13	2			1.0	
Clerical	41	14	71	12			1.1	
Labourer	28	10	62	11	0.79		0.8	
Housewife	219	74	444	75	0.8	0.6	0.9	
FATHER'S OCCUPATION								
Professional	16	6	31	5			1.0	
Clerical	109	37	245	42	1.74		0.9	
Labourer	170	57	314	53	0.4	0.6	1.1	
TOTAL FAMILY INCOME (RM / MONTH)								
< 376	18	6	13	2			2.7	
376-750	189	64	392	66			0.9	
751-999	33	11	79	13	9.51		0.8	0.65
> 999	55	19	106	18	0.02	0.1	1.0	0.4
TOTAL GESTATIONAL WEIGHT GAIN (Kg)								
< 7	89	30	109	18	22.92		2.3	
7 +	115	39	329	56	<0.001	<0.001	1.0	

continued, **Table 3**

Variable	Cases		Controls		Chi-squared (p-value)	Analysis of var. "F" sig.	OR	Chi-squared for trend (p-value)
USE OF IRON/VITAMIN SUPPLEMENTS (Week)								
< 2	95	32	98	16			2.7*	
2-4	65	22	112	19	34.59		1.6*	34.49
> 4	135	46	380	64	<0.001	<0.001	1.0	<0.001
FIRST HAEMOGLOBIN (Hb) LEVEL (g/100ml)								
8-10	86	29	117	20	9.85		1.7*	
> 10	208	71	473	80	0.002	0.004	1.0	
unknown	1	0	0	0				
LAST HAEMOGLOBIN (Hb) LEVEL (g/100ml)								
< 8	2	1	0	0				
8 - 10	45	15	70	12	7.21		1.4	
> 10	233	79	518	88	0.03	0.008	1.0	
unknown	15	5	2	0				
FASTING								
Yes	143	48	320	54	4.84		0.6	
No	55	19	79	13	0.03	0.02	1.0	
Non muslim	97	33	191	32				

continued, Table 3

Variable	Cases		Controls		Chi-squared (p-value)	Analysis of var. "F" sig.	OR	Chi-squared for trend (p-value)
PARITY								
1	120	41	128	22			2.5	
2-5	153	52	406	69	35.16		1.0	32.17
> 5	22	8	56	10	<0.001	<0.001	1.0	<0.001
INTER-PREGNANCY INTERVAL (MONTH)								
< 24	86	29	157	27			2.0*	
24-60	70	24	258	44	13.92		1.0	13.88
> 60	19	6	46	8	<0.001	<0.001	1.5	<0.001
no previous birth	133	45	148	25				
GESTATIONAL AGE OF PREVIOUS BIRTH (Week)								
28-36	14	5	9	2	14.12		4.6*	
> 36	148	50	433	73	<0.001	<0.001	1.0	
no previous birth	133	45	148	25				
HISTORY OF PRIOR SPONTANEOUS ABORTION								
Yes	43	15	76	13	5.45		1.7	
No	132	45	385	65	0.02	0.1	1.0	
no previous pregnancy	120	41	129	22				

continued, Table 3

Variable	Cases		Controls		Chi-squared (p-value)	Analysis of var. "F" sig.	OR	Chi-squared for trend (p-value)
HISTORY OF PRIOR STILLBIRTH								
Yes	6	2	8	2	1.88		2.1	
No	156	53	434	74	0.2	0.2	1.0	
no previous birth	133	45	148	25				
PRIOR INFANT DEATHS								
none	154	52	424	72	0.22		1.0	
1+	8	3	18	3	0.66	0.1	1.2	
unknown	133	45	148	25				
GESTATIONAL AGE (Week)								
< 37	116	39	32	5	162.27		11.3*	
37+	179	61	558	95	<0.001	<0.001	1.0	
ANTENATAL VISITS								
< 5	117	40	110	19			2.8*	
5-7	114	39	309	52	45.56		1.0	30.15
> 7	64	22	171	29	<0.001	<0.001	1.0	<0.001

* p-value < 0.05

TABLE 4

Analyses of association of birthweight with race adjusting for potential confounders

VARIABLES	**SIGNIFICANCE LEVEL "F"**
Main effects	0.051
Race	0.051
Covariates	< 0.001
Maternal height	0.003
Maternal pre-pregnancy weight	< 0.001
Maternal age prior to pregnancy	0.007
Total family income	0.1
Total gestational weight gain	< 0.001
Use of iron/vitamin supplements	0.06
Parity	0.007
Inter-pregnancy interval	0.3
Number of antenatal care visit	0.004

TABLE 4a

Analyses of association of birthweight with race adjusting for potential confounders including period of gestation at delivery

VARIABLES	SIGNIFICANCE LEVEL "F"
Main effects	0.16
Race	0.16
Covariates	< 0.001
Maternal height	0.002
Maternal pre-pregnancy weight	< 0.001
Maternal age prior to pregnancy	0.16
Total family income	0.23
Total gestational weight gain	0.03
Use of iron and/or vitamin supplements	0.07
Parity	0.08
Interpregnancy interval	0.35
Number of antenatal care visit	0.44
Period of gestation at delivery (gestational age)	< 0.001

TABLE 5

The summary of forward stepwise logistic regression analysis for the association of LBW risk factors

Step #	Variables	df	Log-likelihood	Improvement Chi-square (p-value)	Goodness of fit Chi-square (p-value)
1)	DELPOG	1	-166.3	55.1	285.0
				(<0.0001)	(0.46)
2)	PPWEIGHT	1	-138.7	25.7	284.7
				(<0.0001)	(0.44)
3)	VITIRON	1	-125.9	9.0	286.7
				(0.003)	(0.40)
4)	PINTERVA	1	-121.4	4.9	291.8
				(0.03)	(0.30)
5)	MHEIGHT	1	-118.9	4.7	275.4
				(0.03)	(0.55)
6)	GAPBIRTH	1	-116.6	4.0	271.6
				(0.04)	(0.60)

TABLE 6

The results of forward stepwise logistic regression analysis for LBW

Variables	Coefficient	SE	Adjusted OR (95% CI)
Constant	-3.2846		
PPWEIGHT	0.6102	0.1593	
> 50kg (Reference group)			1.0
46-50kg			1.8 (1.4, 2.5)
41-45kg			3.4 (2.5, 4.6)
< 41kg			6.2 (4.6, 8.5)
GAPBIRTH	1.3052	0.6544	
Term (Reference group)			1.0
Preterm (< 37wks)			3.7 (1.0, 13.3)
MHEIGHT	0.4896	0.2307	
> 154 cm (Reference group)			1.0
150-154 cm			1.6 (1.0, 2.6)
145-149 cm			2.7 (1.7, 4.2)
< 145 cm			4.3 (2.8, 6.8)
PINTERVA	0.3768	0.1793	
2-5 years (Reference group)			1.0
> 5 years			1.5 (1.0, 2.1)
< 2 years			2.1 (1.5, 3.0)

Table 6....continued

Variables	Coefficient	SE	OR (95% CI)
VITIRON	0.6458	0.2152	
> 4 weeks (Reference group)			1.0
2-4 weeks			1.9 (1.3, 2.9)
< 2 weeks			3.6 (2.4, 5.6)
DELPOG	2.6093	0.4292	
Term delivery (Reference group)			1.0
Premature delivery (< 37 weeks)			13.6 (1.4, 2.5)

TABLE 6a

The summary of logistic regression analysis using ethnicity, gestational age, pre-pregnancy weight, use of iron and/or vitamin supplements, interpregnancy interval, maternal height and gestational age of previous birth as categorical variables and adjusted OR (95% CI) for significant categorical variables.

Variables	Coefficient	SE	df	Sig.	OR (95% CI)
Constant	1.2880	0.4124	1	0.002	-
DELPOG<37wk(1)	-1.3496	0.1876	1	<0.001	0.3 (0.2,0.4)
PPWEIGHT	-	-	3	<0.001	-
46-50 kg(1)	-0.9042	0.2149	1	<0.001	0.4 (0.3,0.6)
41-45 kg(2)	-0.2597	0.2550	1	0.31	-
< 41 kg(3)	0.0587	0.2839	1	0.84	-
VITIRON	-	-	2	0.001	-
2-4 wk(1)	-0.4754	0.1899	1	0.01	0.6 (0.4,0.9)
< 2 wk(2)	-0.3599	0.2468	1	0.14	-
PINTERVA	-	-	2	0.1	-
> 5 yr(1)	-0.3714	0.1928	1	0.054	-
< 2 yr(2)	0.1497	0.2621	1	0.57	-
MHEIGHT	-	-	3	0.07	-
150-154cm(1)	-0.5523	0.2884	1	0.06	-
145-149cm(2)	-0.3725	0.2722	1	0.17	-
< 145cm(3)	0.4781	0.3312	1	0.15	-

Table 6a...continued

Variables	Coefficient	SE	df	Sig.	OR (95% CI)
GAPBIRTH					
< 37 wk(1)	-0.5982	0.2886	1	0.04	0.5 (0.3,1.0)
RACE	-	-	3	0.03	-
Malay(1)	0.0823	0.2152	1	0.70	-
Indian(2)	0.7018	0.2582	1	0.007	2.0 (1.2,3.3)
Indonesian(3)	0.0608	0.3201	1	0.85	-