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**Physical characteristics, health-related behaviors and attitudes
of mothers who delivered optimal and low-birth weight infants in
Michigan, 1987 – 1988: A retrospective study.
(Volumes I and II)**

Friesen, Carol Ann, Ph.D.

Michigan State University, 1990

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PHYSICAL CHARACTERISTICS, HEALTH-RELATED BEHAVIORS AND
ATTITUDES OF MOTHERS WHO DELIVERED OPTIMAL AND LOW BIRTH
WEIGHT INFANTS IN MICHIGAN, 1987-1988: A RETROSPECTIVE STUDY

Volume I

By

Carol Ann Friesen

A DISSERTATION

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ABSTRACT

PHYSICAL CHARACTERISTICS, HEALTH-RELATED BEHAVIORS AND ATTITUDES OF MOTHERS WHO DELIVERED OPTIMAL AND LOW BIRTH WEIGHT INFANTS IN MICHIGAN, 1987-1988: A RETROSPECTIVE STUDY

By

Carol Ann Friesen

Birth weight is the most important determinant of an infant's survival. Low birth weight (LBW; < 2,500 g) is a major contributor of infant mortality and morbidity, making its prevention a priority public health issue. The purpose of this retrospective, case-control study was to determine factors which differed between mothers who delivered LBW and optimal birth weight (OBW; 3,500-4,000 g) infants. Specific objectives included: 1) to determine if a weight gain to 120% of one's Metropolitan reference weight-for-height at term, or a minimum gain of seven kilograms if obese prior to pregnancy, reduced the incidence of LBW, and 2) to identify characteristics, behaviors and attitudes that differed between mothers who delivered OBW and LBW infants.

Six hundred white and 825 black infant:mother pairs were randomly selected by a computer search of Michigan birth certificates. Subjects were included in the sampling frame if the mother was a healthy black or white Michigan resident, 20-34 years of age, who delivered a singleton as her first or second child, assisted by an MD/DO, after a 37-42 week gestation. A mail survey was used to obtain anthropometric, nutritional, behavioral, attitudinal and medical data from the white subjects and their prenatal care providers. Only medical information from the black subjects' prenatal care providers was obtained, due to a 14% response rate from the subjects in the pilot.

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Results indicated the following were risk factors for LBW: 1) a weight gain to less than 120% of one's 1983 term Metropolitan reference weight (white and black), 2) a weight gain of less than 7 kg (15.5 lbs) if the mother was obese prior to pregnancy (black), 3) a pre-pregnant weight-for-height less than 90% of reference (white), 4) a weight gain of 27 pounds or less (white and black). In addition, results of the white Michigan mothers' survey indicated the following risk factors were associated with the delivery of a LBW, as compared to an OBW, infant: 1) maternal birth weight less than 2,500 g, 2) cigarette consumption, 3) consumption of 100 g alcohol/week, 4) consumption of more than 300 mg caffeine/day, 5) consumption of a less nutrient-dense diet and 6) a more positive attitude toward weight gain.

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DEDICATION

In honor of my mother and my Grandma Blaiser,
and in memory of my Grandma Friesen
and my father, Richard E. Friesen,
who instilled in me the value of hard work...
rewarded by an occasional
hot fudge sundae.

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Any successful research results not from the efforts of a single individual, but as a cooperative venture among many. It is impossible to conduct a study of this scope without accumulating numerous debts to many special people.

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study using the State of Michigan vital statistics and the financial assistance, supplies and services necessary to complete this study. In addition, he provided statistical, methodological and political counsel throughout the entire project. Despite his allegiance to that "other University" down the road, I am sincerely grateful to him for his participation in this study and my development as a researcher.

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Thank you, Aubrey. We made it.

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CHAPTER I

INTRODUCTION

Each year, nearly 40,000 infants in the United States die before their first birthday. In 1987, the infant mortality rate (IMR) was 10.1 deaths per 1,000 live births, ranking the United States behind 21 other industrialized nations (NCHS, 1989). The black IMR in the United States was twice that of white infants (17.9 vs 8.9) (NCHS, 1989). The 1987 Michigan IMR (10.9) was higher than the national average, with the black IMR (22.0) the second highest in the nation (MDPH, 1989; Hughes et al, 1989).

Birth weight is the single most important determinant of an infant's survival and subsequent growth and development (Institute of Medicine, 1985), with low birth weight (less than 2500 g at birth) being a major determinant of mortality. It has been estimated that a low birth weight (LBW) infant is 40 times more likely to die in the first month of life than a normal weight infant (Institute of Medicine, 1985). In 1987, the United States LBW rate was 6.9 per 100 live births (5.7 white, 12.7 black), the highest level since 1979 (NCHS, 1989). In Michigan, the 1987 LBW rate was 7.2 (5.5 for white infants, 14.4 for black infants), with the black LBW rate higher than the national average (MDPH, 1989).

In addition to increasing the risk of mortality, LBW is associated with increased infant morbidity. A LBW infant, and the infant's subsequent problems, often places a substantial emotional and financial stress on young families (Institute of Medicine, 1985). It has been estimated that every LBW birth averted saves between \$14,000 and \$30,000 in first-year hospital and long-term health care costs alone (Office of Technology Assessment, 1988).

For these reasons, the prevention of LBW infants is a priority public health issue at both the state and national level (MDPH, 1989; DHHS, 1989a). The Year 1990 Health Objectives for the Nation (DHHS, 1979) recommended that, by the year 1990, 1) infant mortality be reduced to no more than nine deaths per 1000 live births, with no county, racial or ethnic group having an IMR in excess of 12, and 2) LBW be reduced to no more than five cases per 100 live births, with no county, racial or ethnic group having a LBW rate greater than nine. It appears unlikely that either of these goals will be attained. These exact goals were repeated in the preliminary Year 2000 Health Objectives for the Nation (DHHS, 1989). If they are to be met, significant progress must be made in identifying modifiable infant mortality risk factors and implementing effective educational and preventive programs to address these issues.

Although many factors contribute to LBW, weight gain during pregnancy consistently accounts for the largest proportion of variation in the birth weight of infants born at term (Anderson et al, 1984; Brown et al, 1986). Pre-pregnancy weight status (as determined by weight-for-height values), especially if underweight, has the second strongest effect on the birth weight of term infants (Niswander and Jackson, 1974;

Brown et al, 1986). The close association between infant birth weight and health, and the concomitant relationship between prenatal weight gain and birth weight, make weight gain recommendations according to pre-pregnant weight classification an important public health issue (Brown, 1988).

Agreement on what constitutes a desirable prenatal weight gain, however, has been hampered by the lack of an accepted standard for identifying desired infant outcome. Birth weight-specific fetal, perinatal and neonatal mortality rates from the United States, Sweden and Norway have indicated a birth weight between 3500 and 4000 g is associated with the lowest mortality and can be considered an "optimal" birth weight for both black and white infants (Brown, 1988). The median birth weight of infants born in the United States, however, is 3370 g (DHHS, 1987). One factor possibly contributing to this less-than-optimal weight may be an insufficient weight gain recommendation during pregnancy. Since 1974, the American College of Obstetricians and Gynecologists and the American Academy of Pediatrics have recommended a 22-27 pound weight gain during the course of a normal pregnancy (ACOG, 1982), at the rate specified by a single-line curve (Appendix 1). Recent research indicates this weight gain curve, and concomitant weight gain recommendations, underestimate appropriate gains in underweight women, overestimate gains for obese women, and may be inappropriate for very tall or very short women (Rosso, 1985; Brown, 1986).

To correct these discrepancies, Rosso (1985) developed a multi-lined weight gain chart which considered both a woman's pre-pregnant weight and her height (Appendix 2). These curves were based on the

hypothesis that a weight gain to 120% or more of one's reference weight (Society of Actuaries, 1959; Appendix 3), or a minimum gain of 7 kg if an individual weighs 120% or more of reference prior to pregnancy, is associated with optimal infant birth weight. This should be the target weight women should be advised to attain by term, according to Rosso (1985).

Rosso's chart was based on data from black and Hispanic, 20-25 year old, non-smoking, non-drinking, healthy women in New York City, and validated on a low-income, non-smoking, non-drinking, 20-39 year old Chilean population (Rosso, 1985). Because neither population is representative of the United States, the underlying premise must be examined on a more representative group before the observation can be generalized to the universe of pregnant black, Hispanic and white women between the ages of 20-34. In addition, the 1959 Metropolitan Life reference standard has been revised (Appendix 4). Validation of Rosso's hypothesis using the revised 1983 Metropolitan standard is warranted.

Many risk factors, in addition to pregnancy weight gain and pre-pregnancy weight status, have been associated with LBW. These include demographic characteristics, medical risks that can be identified before pregnancy, medical problems detected during pregnancy, behavioral and environmental risks and the health care risks of absent or inadequate prenatal care (Institute of Medicine, 1985). Additional risk factors hypothesized to influence birth weight include: 1) maternal birth weight (Hackman et al, 1983; Klebanoff and Yip, 1987), 2) low diastolic blood pressure (Naeye, 1981; Grunberger, Leodolter and Parschalk, 1979),

3) both low and high maternal hemoglobin values (Higgins et al, 1982; Murphy et al, 1986; Sagen et al, 1984), 4) caffeine intake (Martin and Bracken, 1987), 5) diet quality during pregnancy (Phillips and Johnson, 1977), including dietary protein in excess of 20% of one's caloric intake (Rush et al, 1980) and 6) attitudes toward weight gain during pregnancy (Pomerance et al, 1980; Palmer et al, 1985).

Statement of the Problem

To say LBW is multifactorial is an understatement. To that end, the prevention of LBW will require specific attention to all factors associated with birth weight. Based on the need: 1) to reduce the incidence of LBW in Michigan, as well as in the United States, 2) to determine if a weight gain during pregnancy to 120% of one's pre-pregnant reference weight at term, or a minimum gain of 7 kg if obese prior to pregnancy, is associated with optimal birth weight of 3500 to 4000 g in a representative sample of white and black women and 3) to understand both the independent and interactive effects of maternal birth weight, blood pressure and hemoglobin/hematocrit values, caffeine intake, diet quality and maternal attitudes on birth weight, while accounting for the acknowledged risk factors of race, socioeconomic status (income and educational level), level of prenatal care, smoking and alcohol consumption, the following research objectives and hypothesis were proposed.

Research Objectives

The objectives of this case-control study comparing maternal characteristics and behaviors of mothers who were delivered of either an optimal or a low birth weight infant were:

1) To determine if a weight gain to 120% or more of one's pre-pregnant reference weight-for-height at term, or a minimum gain of seven kilograms if pre-pregnancy weight is greater than 120% of one's reference weight, is associated with delivery of an optimal birth weight infant (OBW; 3500-4000 g), rather than a low birth weight infant (LBW; less than 2500 g), in healthy black and white women between the ages of 20 to 34 years; and

2) To determine what maternal characteristics and behaviors differ between mothers who deliver OBW and LBW infants and can be used to predict infant birth weight.

Research Hypotheses

H_{01} : A weight gain to 120% or more of one's pre-pregnant reference weight-for-height at term, or a minimum gain of seven kilograms if pre-pregnancy weight is greater than 120% of one's reference weight, does not reduce the incidence of LBW, and is not associated with an optimal birth weight between 3500 and 4000 g, in healthy black and white women between the ages of 20 to 34;

H0₂: After controlling for the pregnancy risk factors of race, age, parity, length of gestation, plurality, predisposing medical conditions, complications of pregnancy and attendant at delivery (through subject selection criteria), the following maternal characteristics and behaviors do not differ between mothers who were delivered of an optimal or a low birth weight infant, and cannot be used either individually or interactively to predict infant birth weight :

1. Medical Risk Factors Predating Pregnancy
 - a) maternal birth weight
 - b) low weight-for-height
2. Medical Risk Factors During Pregnancy
 - a) poor weight gain
 - b) hemoglobin/hematocrit values
 - c) diastolic blood pressure
3. Behavioral/Environmental Risk Factors
 - a) cigarette consumption
 - b) alcohol consumption
 - c) caffeine consumption
 - d) diet quality
 - e) maternal attitude
4. Health Care Risk Factors
 - a) Kessner Index

CHAPTER II

REVIEW OF THE LITERATURE

Low birth weight (less than 2,500 g) is a major determinant of neonatal and infant mortality and morbidity, imposing economic, social and emotional burdens on both families and the Nation as a whole. Many risk factors, including demographic characteristics, medical risks identified before pregnancy, medical problems detected during pregnancy, behavioral and environmental risks and absent or inadequate prenatal care, have been associated with low birth weight (Institute of Medicine, 1985). This review of the literature focuses on the relation between medical, behavioral and environmental risk factors and birth weight.

Demographic Risk Factors

Demographic risk factors associated with low birth weight (LBW), include: 1) age less than 17 and older than 34, 2) black race, 3) low socioeconomic status, 4) single marital status and 5) low level of education (Institute of Medicine, 1985). The interrelationships among these factors makes the precise association between any single factor and LBW difficult to ascertain.

Medical Risk Factors Predating Pregnancy

Medical and obstetric factors which predate pregnancy and are linked to low birth weight include: 1) parity (zero or more than four), 2) low weight-for-height, 3) genitourinary anomalies, 4) diseases such as diabetes and chronic hypertension, 5) non-immune status for selected infections such as rubella, 6) poor obstetric history, including a previous low birth weight infant or multiple spontaneous abortions and 7) maternal genetic factors, such as low maternal birth weight (Institute of Medicine, 1985). This section of the literature will focus on the risk factors of maternal birth weight and weight-for-height.

Maternal Birth Weight

Although many factors associated with low birth weight are modifiable (i.e., smoking, poor weight gain), evidence from both human and animal studies suggest there may be at least one factor influencing a woman's reproductive performance over which she has no control: her own birth weight.

Epidemiologic Studies

Hackman et al (1983) examined a cohort of 748 white women who delivered singletons at the University of Washington Hospital in Seattle to determine the relationship between maternal birth weight (MBW) and the birth weight of her baby (BBW). The mothers' birth weights were obtained from birth certificates. Data about the mothers' pregnancy,

delivery and outcome were abstracted from clinic and hospital records. The simple correlation between MBW and BBW ($r=0.16$) explained 3% of the variance in infant birth weight. After adjusting for maternal height, pre-pregnant weight, smoking, maternal age and parity, MBW still was significantly related to BBW ($r=0.11$). Together, MBW, prepregnant weight ($r=0.12$) and maternal smoking ($r= -0.24$) accounted for approximately 8% of the variance in infant birth weight ($r=0.273$, $p < 0.001$). The simple correlation between weight gain and BBW ($r=0.298$; $p < 0.001$) accounted for 8.9% of the BBW variance. Thus, the preconceptional factors of mother's birth weight, prepregnant weight and smoking predicted birth weight almost as adequately as the amount of pregnancy weight gain.

To study the association between maternal and infant birth weights, Klebanoff and Yip (1987) linked the birth certificates of 43,891 infants born in Tennessee from 1979 to 1984 to the birth certificates of their mothers who were born in Tennessee between 1959 and 1966. A highly significant association ($p < 0.0001$) was found between maternal birth weight and infant birth weight for both blacks and whites. Women who weighed 4000 to 4499 g at birth were at the lowest risk for delivery of a small for gestational age (SGA) infant (5.9% for whites, 4.8% for blacks). The risk of giving birth to an SGA infant increased with decreasing maternal birth weight, reaching a maximum of 19.8% for white mothers who weighed 2000 to 2499 g at birth and 20.0% for black mothers who weighed 1000 to 1499 g at birth. The rate of preterm birth, in contrast to the rate of delivering an SGA infant, did not vary significantly by maternal birth weight or race. These data suggest maternal birth weight exerts a stronger influence on

intrauterine growth than on the length of gestation, and that women who were smaller than average at birth should be considered at high risk for delivery of an SGA infant.

Ounsted and Ounsted (1973) collected data on 405 infants delivered in the Radcliffe Infirmary and Churchill Hospital in Oxford, England. The infants were divided into three groups (n=115/group): 1) small-for-date (SFD; birth weight two standard deviations below the mean for length of gestation), 2) large-for-date (LFD; birth weight two standard deviations above the mean for the length of gestation) and 3) all others or controls. Mean birth weights of the mothers of the SFD, controls and LFD infants were 2919, 3258 and 3669 g, respectively. Data were collected on the birth weights of 1144 relatives of the SFD group. A clear sequence in descending order was observed, with the strongest correlation in birth weight occurring between the subjects' liveborn siblings and their mothers (Table 2.1). The authors concluded it is likely the maternal system, and not the paternal system, that constrains fetal growth in utero.

Table 2.1 Birth weights of 1144 relatives of the small-for-date group (n=115) (Ounsted and Ounsted, 1973).

Relationship	Birth Weight, Kg
Liveborn siblings	2.63
Mothers	2.85
First cousins through maternal aunts	3.08
Maternal aunts and uncles	3.22
Fathers	3.27
First cousins through maternal uncles	3.40

Animal Experiments

Cross-breeding experiments between large and small strains of domestic animals concur with results of human studies which suggest a strong maternal effect on infant birth weight. The classical work of Sir John Hammond and his group at Cambridge (Walton and Hammond, 1938) demonstrated foals sired by Shetland stallions' semen which had been artificially inseminated into Shire dams were, at birth, roughly the same in weight as foals of the pure maternal breed. Shire semen used to fertilize Shetland dams generated cross-bred foals whose birth weight was similar to that of pure Shetlands. Thus, maternal regulation determined the rate of intra-uterine growth when these extreme-sized adult horses were cross-bred. Similar results were obtained when Dexter and South Devon cattle (Joubert and Hammond, 1958), two breeds of sheep (Hunter, 1956) and large and small breeds of rabbits (Venge, 1950) were crossbred.

Summary: Maternal Birth Weight

Both animal and human studies suggest maternal birth weight exerts a strong influence on the birth weight of the offspring. Paternal influence does not appear to be as highly correlated to the birth weight of the offspring. Thus, evidence from both animal and human research indicate a maternal, and not paternal, influence on infant birth weight which may be genetic (Robson, 1978) or as a result of an adverse intrauterine environment which concomitantly interfered with the growth and development of one or more organ systems, including the reproductive and/or endocrine systems (Hackman et al, 1983).

Maternal Weight-For-Height

Women who enter pregnancy below their reference weight-for-height are at increased risk for delivering a low birth weight infant (Naeye, 1979; NCHS, 1980). After gestational age, pregravid weight status and antenatal weight gain have the greatest impact on infant birth weight, accounting for approximately eight and six percent of the variation in birth weight, respectively (Metcoff et al, 1981b).

In the United States, women who are underweight at conception (10% or more below one's reference weight) have had more premature births and low birth weight infants (Simpson et al, 1975; Tompkins et al, 1955; Edwards et al, 1979; Brown et al, 1981), shorter infants (Peckham and Christianson, 1971), lighter placentas (Naeye, 1979) and infants with low Apgar scores (Edwards et al, 1979), than do normal weight women. In contrast, although associated with a decreased incidence of LBW, anemia and premature deliveries, women who entered pregnancy obese (greater than 135% of reference weight) have been at increased risk of gestational diabetes, hypertension, pregnancy-induced hypertension (PIH) and primary cesarean delivery (Abrams and Parker, 1988; Edwards et al, 1978). Data from the 1980 National Natality and National Fetal Mortality Surveys (Taffel, 1986) indicated fetal death rates were highest among the heaviest (greater than 72 kg) women.

Entering pregnancy underweight, combined with a low gestational weight gain, places women at a high risk for perinatal mortality (Naeye, 1979) and low birth weight (NCHS, 1980). A sharp decline in perinatal

mortality is noted as maternal weight gain rises. Luke et al (1984) examined the influence of prenatal weight-for-height and prenatal weight gain on infant birth weight in 696 uncomplicated pregnancies. Each gravida was classified by maternal stature as short (5'2" or less), medium, or tall (5'6" or more). Mean infant birth weights paralleled increasing maternal delivery weight in all three groups. The effect was most pronounced in the short gravidas, where a 10% increase in delivery weight was associated with an increase of 127 g in mean birth weight, compared with 74 g and 87 g in the average and tall groups, respectively.

Abrams and Laros (1986) determined the effect of maternal prepregnant weight status and weight gain on birth weight in 2946 live term births in San Francisco. The sample was stratified into the four prepregnancy weight-for-height categories according to body mass index (BMI). The BMI's were classified based on the values proposed by Garrow (1981) to reflect the 1959 Metropolitan Reference standard for a woman of medium frame: 1) underweight (<90% reference standard, BMI <18), 2) ideal weight (90-120% reference, BMI 19-22), 3) moderately overweight (121-135% reference, BMI 23-28), and 4) very overweight (>135% reference, BMI >28). For the underweight, normal weight and moderately overweight women, each kilogram of maternal weight gain increased birth weight by 25.9, 28.3 and 17.8 g, respectively. In the very overweight category, however, the slope of the line did not differ from zero. Results indicated that, while weight gain has a significant influence on birth weight in underweight, normal weight and moderately overweight women, weight gain did not influence birth weight in the obese women, a

finding the authors stated contradicted other researchers. When multiple regression was used to evaluate the effect of prepregnancy body mass and weight gain on birth weight, while holding constant the effects of maternal age, race, socioeconomic status, cigarette smoking, parity and gestational age, 24% of the variance in birth weight was explained. Prepregnancy body mass and maternal weight gain accounted for 1.5% and 4.6% of the variance, respectively.

Rosso (1985), based on results of 262 healthy, non-smoking, low-income black and Hispanic women, reported women who gained to 120% of their reference weight (1959 Metropolitan Reference; Appendix 3), or a minimum weight gain of 7 kg if prepregnancy weight was greater than 120% reference, delivered infants with significantly higher birth weights than did mothers who do not meet this goal. A weight gain in excess of 120% of reference did not increase birth weight further.

These data suggest underweight women can reduce their risk of delivering a low birth weight infant by establishing a higher prepregnancy weight and/or by gaining extra weight during the prenatal period. These studies underscore the importance of determining a woman's prepregnant weight status so a more appropriate, individual weight gain recommendation can be made.

Medical Risk Factors During Pregnancy

A large number of medical and obstetric risk factors that arise during pregnancy have been linked to low birth weight. These include: 1) multiple pregnancy, 2) poor weight gain, 3) short interpregnancy interval, 4) hypotension, 5) hypertension/preeclampsia/toxemia, 6) selected infections such as symptomatic bacteriuria and rubella, 7) first or second trimester bleeding, 8) placenta previa or abruptio placenta, 9) hyperemesis, 10) incompetent cervix, 11) spontaneous premature rupture of membranes and 12) fetal anomalies (Institute of Medicine, 1985). This section of the literature review will focus on the selected medical risk factors of maternal weight gain and the clinical indices of iron status (hemoglobin/hematocrit values) and diastolic blood pressure.

Weight Gain

The relationship between maternal weight gain during pregnancy and pregnancy outcome has been explored in several studies. Weight gain has been shown to account for the largest proportion of variation in the birth weight of term infants (Anderson et al, 1984; Niswander and Jackson, 1974; Brown et al, 1986), with birth weight increasing linearly with increasing prenatal weight gain (Mitcher and Lerner, 1989). In general, each kilogram increase in maternal body weight during pregnancy has been associated with a 20-25 g increment above the unadjusted mean birth weight (Eastman and Jackson, 1968; Niswander et al, 1969; Simpson

et al, 1974; Thomson and Billewicz, 1957; Abrams and Laros, 1986). The correlation between birth weight and weight gain in most surveys was usually around 0.20 to 0.30, accounting for only four to nine percent of the variance in infant birth weight (Metcoff et al, 1981b).

Metcoff et al (1981b), in a sample of 527 mother/baby pairs having uncomplicated pregnancies, found a statistically significant correlation ($p < 0.05$) between birth weight and maternal weight gain. After adjusting for duration of gestation, maternal age, height, prepregnancy weight and smoking, the correlation between birth weight and weight gain was $r=0.23$, accounting for less than 5% of the variance in adjusted birth weight.

Brown et al (1986) measured the impact of weight gain on the birth weight of 384 healthy-sized (3,000 to 4,500 g) infants of low-income women in Cleveland (54% black, 32% white and 14% "other"). Infant birth weight was significantly correlated with prenatal weight gain ($r=0.20$, $p < 0.001$). Mean prenatal weight gain associated with the birth of term infants weighing 3,000 to 4,500 g was significantly higher than that associated with term infants weighing 2,000 to 3,000 g (30 ± 0.9 lb vs 25 ± 0.7 lb, $p < 0.001$). Multiple regression analysis indicated gestational length (explaining 7.3% of the variance in birth weight), weight gain during pregnancy (2.8%), prepregnancy weight status (4.9%), cigarette smoking (3.6%) and parity (1.9%) were independently associated with birth weight. The contribution of each factor to the variability in birth weight, however, differed according to prepregnancy weight status. The influence of gestational length on birth weight weakened as prepregnancy weight status increased. Gestational length, weight gain

and cigarette smoking were not significantly related to birth weight among very obese women (greater than 150%, 1959 Metropolitan Reference). Weight gains associated with optimal birth weights between 3,000 and 4,500 g were 33, 32, 29 and 19 lbs for underweight, normal weight, overweight and very obese women, respectively.

The National Natality Survey (NNS) and the National Fetal Mortality Survey (NFMS) have provided national data correlating weight gain with fetal outcome (NCHS, 1980). The NNS, a probability sample of all livebirths that occurred in the United States in 1980, and the NFMS, a probability sample of fetal deaths after 28 weeks gestation, or delivery weight of 1,000 g or more, examined 3581 women (2917 white, 554 black). The average weight gain of white mothers in this study was 29.1 pounds, 2.3 pounds higher than the black mothers. The rate of low birth weight was more than twice as high among blacks (12.5%) than among whites (5.6%). Results indicated one out of every five white mothers, and one out of four black mothers, whose pregnancy extended to at least 40 weeks, gained less than 21 pounds. Overall, 23% of women giving birth in 1980 gained less than 21 pounds, with 12% gaining less than 16 pounds. As weight gain increased, the LBW rate and fetal mortality rates decreased. A weight gain of 26 to 35 pounds was associated with the lowest LBW and infant mortality rates. Black mothers were twice as likely as white mothers to gain less than either 21 pounds (33% vs 22%) or 16 pounds (20% vs 11%). After controlling for mother's prepregnant weight, age, education, period of gestation, live birth order and infant's sex, mothers who gained less than 21 pounds were 2.3 times more likely to bear a LBW infant as mothers who gained 21 pounds or more.

Mitchell and Lerner (1989) studied the relationship between antenatal weight gain and pregnancy outcome in 362 pairs of underweight (<90% 1983 Metropolitan Reference Weight) and normal weight (90% to 110%) women who were matched for age, occupation, height, parity, race and smoking habits. Birth weight was positively correlated with maternal weight gain ($p < 0.001$). Each kilogram increase in maternal weight was associated with a 12.85 g increase in birth weight of infants born to underweight women, and a 8.59 g increase in birth weight of infants born to normal weight women. Both underweight and normal weight women who gained less than 9 kg delivered infants with mean birth weights of 367 g and 251 g less, respectively, than infants of mothers who gained more than 9 kg ($p < 0.001$). Weight gains of less than 9 kg in both groups of women were associated with significantly lower birth weights ($p < 0.05$). This study confirmed results of numerous investigators (Kennedy et al, 1982; Gormican et al, 1980; Love and Kinch, 1965; Picone et al, 1982a,b) in which antenatal weight gain and prepregnancy weight status were significant determinants of birth weight in normal and underweight women.

Weight Gain Recommendations

The current pregnancy weight gain recommendation of the Committee on Maternal Nutrition (1970) is 24 pounds. This recommendation is based on data from a longitudinal study of 60 pregnant women in the mid-1950's. Since then, new data have indicated the optimal weight gain is higher than 24 pounds. Data from the Perinatal Collaborative Study (Naeye, 1979) of 50,000 women between 1959 and 1965, clearly documented

that increased maternal weight gain was related to larger birth weights and a decreased incidence of LBW and neonatal mortality. LBW occurred four times more frequently among women who gained less than 14 pounds, than among those who gained 30-35 pounds. Results indicated the best obstetrical outcome occurred among normal weight women who gained 27 (range 22-33) pounds (Niswander and Gordon, 1972). Based on these results, the American College of Obstetricians and Gynecologists have recommended a pregnancy weight gain of 22-27 pounds (ACOG, 1982).

Although the Committee on Maternal Nutrition's 24-pound weight gain curve is still used in prenatal care facilities (Appendix 1), Rosso (1985; Appendix 2) and Brown (1983) have developed new weight gain charts which account for prepregnancy weight-for-height. A committee of experts appointed by the National Research Council to evaluate new weight gain data will most likely recommend a similar pregnancy weight gain chart which accounts for prepregnant weight status in the near future (King, personal communication, 1989). Weight gain recommendations during pregnancy according to prepregnancy weight status are briefly reviewed.

Brown (1983) and Rosso (1985) both recommended emphasizing ranges of normal weight gain when counseling pregnant women, rather than specifying one particular target number. Rosso (1985) recommended a weight gain to 120% of one's 1959 Metropolitan reference weight (Appendix 3). For the normal weight adult woman whose stature is between 5'0" and 5'10", this is equivalent to a weight gain of 22 to 30 pounds. Similarly, Brown (1983) recommended a weight gain range for normal-weight, adult women of from 24 to 32 pounds at term.

Women who are underweight at conception need to gain more weight to accommodate both "catch up" growth and adequate growth to support the pregnancy. Naeye (1979), using the perinatal mortality rate as an index of pregnancy outcome, noted optimal outcome was associated with a weight gain of 30 pounds (13.6 kg) for underweight women. Brown et al (1986) reported a weight gain of 33 pounds or 15 kg (range 28-36 pounds) was associated with an optimal birth weight of 3,000 to 4,500 g if the woman was underweight prior to pregnancy (less than 95% of one's 1959 Metropolitan reference weight). Rosso (1985) recommended a weight gain to 120% of one's 1959 Metropolitan reference standard. Although a gain to 120% reference is equivalent to a 22-30 pound weight gain for the woman at her reference weight, a woman who enters pregnancy underweight will have to gain more than 22-30 pounds to attain 120% of reference, with the exact amount dependent upon her degree of underweight.

Excessive weight gain and obesity in pregnancy are associated with health risks (Garbaciak et al, 1985; Abrams and Parker, 1987). Data from the Collaborative Perinatal Project (Naeye, 1979) indicated that, regardless of pre-conceptional weight status, women who gained over 32 pounds (14.5 kg) during pregnancy had higher rates of perinatal mortality than mothers with weight gains in the 80-120% range of the recommended 27 pounds (i.e., 22-32 pounds). Mothers who were obese prior to pregnancy had the best outcomes with a 15-16 pound (7 kg) weight gain. Brown et al (1986) noted weight gains of 29 pounds (13 kg) for overweight (115-150%, 1959 Metropolitan Reference) and 19 pounds (8.5 kg) for obese women (greater than 150%, 1959 Metropolitan Reference) were associated with optimal infant birth weights of between 3,000 and

4,500 g. Rosso (1985) recommended obese women gain a minimum of 7 kg, an amount equivalent to the weight of the conceptus.

Hemoglobin/Hematocrit Values

During pregnancy, iron is needed for the manufacture of hemoglobin in both maternal and fetal red blood cells (Vander et al, 1985). If necessary, the fetus acts as a true parasite, assuring its own production of hemoglobin by drawing iron from the mother (Worthington-Roberts, 1987). Although red blood cell production is stimulated during pregnancy, the increase is not as large as the 50% increase in plasma volume that accompanies pregnancy. Thus, the hematocrit, which is normally around 35% in women, can drop as low as 29% to 31% during pregnancy. The amount of hemoglobin in each red blood cell does not change, but because there are fewer red blood cells per 100 ml blood, hemodilution occurs. Nonpregnant hemoglobin values of 13 to 14 g/100 ml can drop as low as 10 or 11 g/100 ml in the early months of pregnancy, but as long as the red cells are normochromic and normocytic, the women are not anemic (Varner et al, 1985).

Estimates of the frequency of iron deficiency anemia during pregnancy vary, with an estimated range of from 5% to 15% in the United States (Worthington-Roberts, 1987). Data from the National Collaborative Perinatal Project (Garn et al, 1981) indicated a 15% increase in the incidence of low birth weight when mothers had hemoglobin levels of 8.0 g/dl as compared to mothers who had hemoglobin values of 10.0 g/dl or higher.

While low hemoglobin levels are often assumed to be correlated with low birth weight, this association has never been definitively established (Koller et al, 1979). In contrast, high maternal hemoglobin values are generally believed to be associated with favorable perinatal outcome (Worthington-Roberts, 1989). Recently, however, three studies have noted an association between high maternal hemoglobin values and increased fetal risk.

Koller et al (1979) hypothesized there would be an inverse relationship between birth weight of the baby and the mother's hemoglobin level based on the following line of reasoning: First, hemodilution, caused by a disproportionate increase in plasma volume compared to increased red blood cells, is common during pregnancy. The linear relationship between increased plasma volume and infant birth weight has been demonstrated (Duffus et al, 1971; Hytten and Paintin, 1963; Pirani et al, 1973). Conversely, a decreased plasma volume is associated with an increased risk of intrauterine growth retardation (IUGR) and fetal death before labor in apparently normal pregnancies (Dunlop et al, 1978; Liley, 1970). Lastly, in non-pregnant women, a low hemoglobin level indicated a relatively high plasma volume (Chelsey, 1972; Liley, 1970).

To test the hypothesis that there would be an inverse relationship between infant birth weight and maternal hemoglobin level, Koller et al (1979) monitored the hemoglobin levels of 120 non-anemic women with uncomplicated pregnancies. Seven women delivered infants with birth weights less than the 2.5th percentile. The hemoglobin value of these women at approximately week 32 of gestation was significantly higher

(14.12 vs 12.18 g/dl, $p < 0.001$) than that of women who delivered infants with higher birth weights. The authors suggested "it seems reasonable to associate this phenomenon with an inadequate increase in the plasma volume" (Koller et al, 1979, p. 12), with an adequate plasma volume a hallmark of a successful pregnancy (Hytten, 1976).

This hypothesis was tested again by Sagan et al (1984) in a group of 577 apparently normal pregnancies in Bergen, Norway. Maternal hemoglobin levels were not influenced by maternal age or by smoking habits. Maternal weight gain was reduced significantly as the hemoglobin levels increased. Weights and lengths of the newborns, as well as the placental weights, declined in relation to increasing maternal hemoglobin levels. The average birth weight of infants born to mothers with a hemoglobin value exceeding 13.0 g/dl was 580 g lighter (15.5%) than infants born to mothers with hemoglobin values below 12.0 g/dl. The placental index (placental weight/birth weight) remained unchanged, indicating both fetal and placental growth decreased in inverse proportion to increasing maternal hemoglobin levels.

A third study (Murphy et al, 1986) tested the hypothesis that a high hemoglobin value is associated with a reduction in infant birth weight. After review of data from 54,382 singleton pregnancies, these investigators found both high (greater than 13.2 g/dl) and low (less than 10.4 g/dl) hemoglobin levels were associated with adverse pregnancy outcome. A high hemoglobin level between weeks 13 to 19 of gestation, as compared to an intermediate hemoglobin level (10.4-13.2 g/dl), was associated with increased incidence of perinatal mortality, low birth weight and preterm delivery. A striking relationship was noted between a

woman's initial hemoglobin value and subsequent frequency of hypertension ($p < 0.001$). The frequency of hypertension in primiparas ranged from 7% at hemoglobin levels under 10.5 g/dl to 45% at hemoglobin concentrations over 14.5 g/dl. The authors postulated the higher hemoglobin concentration reflected some failure in the plasma volume to expand, resulting in a deleterious effect on the uteroplacental circulation. Murphy et al (1986) concluded that the optimal hemoglobin range at the first prenatal visit is between 10.4 and 13.2 g/dl, and that a level higher than this should alert the clinician to the possibility of a reduced plasma volume and an adverse pregnancy outcome.

Diastolic Blood Pressure

Adequate blood supply to the uteroplacental unit is necessary to transmit energy and nutrients to the fetus. Impairment of this function can result in growth retardation and an increased rate of premature births (Kauppinen, 1967; Raiha and Kauppinen, 1963; Grunberger et al, 1979). Uteroplacental flow depends primarily on the maternal cardiac output which, during pregnancy, increases approximately 30% to 50% by week 32 of gestation. The increased cardiac output, caused by a 500 to 800 ml rise in plasma volume, increases the stroke volume (cardiac output = heart rate x stroke volume; Vander et al, 1985).

Other important factors influencing uteroplacental flow are maternal heart rate and mean arterial pressure. Under normal conditions, the mean arterial pressure near term is 105 mm Hg (Grunberger et al, 1979). Maternal hypotension reduces the placental perfusion pressure,

which concomitantly reduces the uteroplacental flow rate (Bech-Jansen et al, 1972).

Although maternal hypertension is monitored closely throughout pregnancy, maternal hypotension receives little attention (Grunberger et al, 1979). Grunberger hypothesized a drop in mean maternal arterial pressure, even if the blood volume and heart rate remain constant, leads to an excessive reduction of the uteroplacental flow. Because the quantity of the maternal-fetal gaseous exchange depends primarily on the placental flow rate, Grunberger et al postulated maternal hypotension could lead to a deficiency in the supply of oxygen to the uterus. This would be manifested by a significant drop in the partial pressure of oxygen in the fetal blood, and might result in decreased fetal growth and low birth weight.

To test this hypothesis, Grunberger et al (1979) conducted a three year prospective study on 70 pregnant women with diagnosed hypotension (blood pressure readings less than 110/65 mm Hg). Placental flow was measured using radioisotopic methods. Results indicated that, although endocrine parameters revealed no abnormalities. Placental flow was significantly reduced in more than 80% of these subjects. Forty of the 70 subjects were subsequently given an injection of deoxycorticosterone trimethylacetate to increase their blood pressure pharmacologically. A significant improvement in the placental perfusion rate was noted in the treated subjects. Both the average term birth weights and placental weights were higher in the treated group as compared to controls (birth weight, 3308 vs 2860 g; placental weight, 527 vs 512 g, respectively).

Naeye (1981) analyzed data collected in the United States Collaborative Perinatal Project and noted that, as peak diastolic blood pressures during pregnancy increased, both pregravid body weights and net pregnancy weight gains increased. The low infant birth weight associated with low prepregnancy body weights progressively disappeared as maternal peak diastolic blood pressures increased. Birth weights became independent of diastolic blood pressure at readings between 90 to 99 mm Hg in underweight women; birth weights decreased, however, when peak diastolic pressure exceeded 99 mm Hg. In contrast, birth weight became independent of blood pressure as the mothers' pregravid body weight increased. Naeye concurred with Grunberger (1979) that the fetal growth effects often attributed to nutrition are most likely mediated through maternal blood pressure and uteroplacental perfusion.

Behavioral and Environmental Risk Factors

Many behavioral and environmental risk factors have been associated with low birth weight. These include: 1) smoking, 2) poor nutritional status, 3) alcohol and other substance abuse, 4) DES exposure and other toxic exposures, including occupational hazards, and 5) high altitude (Institute of Medicine, 1985). Additional behavioral and environmental factors hypothesized to impact birth weight include caffeine intake (Martin and Bracken, 1987) and maternal attitude (Pomerance, 1980). This review will focus on the LBW risk factors of smoking, alcohol and caffeine intake, diet quality during pregnancy, and maternal attitudes.

Cigarette Consumption

Adverse effects of smoking during pregnancy on infant birth weight were first documented by Simpson (1957). Since that time a considerable body of epidemiological, clinical and laboratory evidence has reported a reduction in birth weight, generally ranging between 150 to 250 grams, among offspring of women who smoked during pregnancy, with the decrement in birth weight proportional to the number of cigarettes smoked (Abel, 1980; Hasselmeier et al, 1980; Longo, 1982). This consistency has persisted in spite of the reported reduction in the average tar and nicotine yields of cigarettes marketed (Stein and Kline, 1983). Additionally, the association between cigarette smoking and reduced intrauterine growth remains firm and stable over time, through the social classes, over age groups and geographical locations (Stein and Kline, 1983), leading to the coining of the term "fetal tobacco syndrome" (Nieburg et al, 1985).

Effect of Smoking on Birth Weight

The prevalence of delivering a LBW infant has been estimated to be 54% higher in light smokers (less than one pack a day), and 130% higher in heavy smokers (one pack or more per day), as compared with nonsmokers (Meyer et al, 1976). Analysis of the 1980 National Natality Survey indicated that, after controlling for maternal age, live birth order, sex of child, education, height and weight, the odds of low birth weight increased by 26% for every 5 additional cigarettes smoked per day during

pregnancy (timing of smoking during trimesters of pregnancy was not recorded) (Kleinman and Madans, 1985).

A review of five studies, comprising nearly 113,000 births in the United States, Canada and Wales, found 21% to 39% of the incidence of LBW was attributed to maternal smoking (Meyer et al, 1976; Table 2.2). Of the factors studied, maternal smoking affected birth weight more than hospital status (private or public), mother's birthplace, mother's height, mother's prepregnant weight, sex of the child, previous pregnancy history, parity or maternal age.

Cigarette smoking has consistently been associated with a 150 to 250 g decrease in birth weight (Abel, 1980). Values reported in the literature include decreases of 130 g (Higgins, 1976), 180 g (Spira, 1976), 184 g (Picone et al, 1982b), 186 g (Silverman, 1977), 200 g (Davies et al, 1976), 209 g (Yerushalmy, 1971), 234 g (Rush, 1974) and 241 g (Brooke et al, 1989) in women who smoked during pregnancy. These values were determined after controlling for a variety of confounding factors such as alcohol consumption, social class, education level, height, prepregnancy weight and age. Not all factors, however, were controlled for in each study, and several factors associated with a reduction in birth weight (i.e., diet quality and prepregnancy weight-for-height) were not controlled for in any of these studies.

TABLE 2.2 Relative and attributable risks of low birth weight by maternal smoking habits (adapted from Meyer et al, 1976).

Study	Nonsmokers N	Smokers N	# LBW per 1000 live births		Relative Risk (%)	Attributable Risk (%)
			Nonsmokers	Smokers		
Cardiff (1)	7,176	6,238	4.1	8.1	1.98	31
US Collaborative (2)						
White	8,466	9,781	4.3	9.5	2.21	39
Black	11,252	7,777	10.7	17.5	1.64	21
Kaiser Permanente (3)						
White	3,189	2,145	3.5	6.4	1.83	25
Black	934	479	6.4	13.4	2.09	27
Montreal (4)	3,954	3,004	5.2	11.4	2.19	34
Ontario (5)	27,316	21,062	4.5	9.1	2.02	31

(1) Andrews and McGarry, 1972; (2) Niswander and Gordon, 1972; (3) Yerushalmy, 1971; (4) Fabia, 1973; (5) Ontario Department of Health, 1967.

Effect of Smoking and Diet on Birth Weight

Few studies have determined the effects of both smoking and diet with birth weight. Luke et al (1981) observed infants (n=91) born to nonsmokers who only gained 0-15 pounds during pregnancy weighed 243 g more than infants (n=33) born to smokers gaining the same amount of weight ($p < .009$); conversely, only a 94 g difference in birth weight was noted when both smokers (n=24) and nonsmokers (n=160) gained 36 or more pounds during pregnancy (NS). Luke concluded encouragement of a weight gain higher than normally recommended in 1980 may help to correct the growth retardation observed in infants born to women who smoke.

Picone et al (1982a, 1982b) studied the roles of diet, cigarette smoking and psychological stress on pregnancy weight gain (less than 15 lbs and greater than 15 lbs) in 60 low socioeconomic patients who

registered for prenatal care at an urban Connecticut hospital clinic. An average of five 24-hour recalls were obtained from each subject by an experienced dietitian. Food intake data were coded and analyzed for 14 nutrients by computer analysis. When the nutrient intake of smokers ($n=32$) and nonsmokers ($n=28$) was compared, smokers consumed significantly more calories (2119 vs 1810 kcal/day; $p < .01$), fat (94 g vs 74 g; $p < .01$) and calcium (1241 mg vs 721 mg, $p < .01$) than nonsmokers. In addition, even though smokers consumed approximately 300 kcal more/day, infants of smokers weighed significantly less than those of nonsmokers (2875 ± 522 g vs 3059 ± 511 g; $p < .04$). For nonsmokers, differences between the intakes of low weight gain subjects (1617 kcal/day) and adequate weight gain subjects (1905 kcal/day) were significant ($p < .02$), with calorie intake correlated with weight gain ($r=0.55$, $p < .02$). Picone concluded that a low weight gain among nonsmokers (< 15 pounds) is associated with lower food intake. In contrast, they hypothesized smoking may cause low weight gain by reducing the utilization of calories for weight gain. The authors proposed nicotine caused both an increased metabolic rate and an increased heat loss from the body, resulting in an impaired efficiency of dietary energy and, thus, an increased energy requirement in smokers.

Higgins (1976) assessed the daily intake of calories and protein in 230 smokers and 309 nonsmokers. She reported smokers consumed approximately 300 more kcal and 9 grams more protein per day than nonsmokers. Smokers, however, gave birth to infants weighing 130 g less than infants born to nonsmokers. The methods used to collect and analyze the data were not reported.

Hayworth et al (1980) also attempted to determine whether the fetal growth-retarding effect of maternal cigarette smoking was due to a lower dietary intake in a group of smokers (n=208) and nonsmokers (n=175). Dietary intake was assessed by calculating the average daily nutrient intake from both a dietary history and a 24-hour recall. Food models were used to help assess serving sizes. The two estimates of daily nutrient intake were averaged for each subject. Hayworth, like Picone (1982b) and Higgins (1976), reported smokers consumed significantly more energy (2587 vs 2421 kcal/day; $p < .025$), fat (118 vs 104 g; $p < .001$) and niacin (26 vs 24 mg/day; $p < .04$) than nonsmokers. Despite consuming a greater number of calories, the infants of smokers weighed 224 grams less than infants of nonsmokers. Hayworth et al concluded that, in their opinion, fetal growth retardation in smokers is caused by factors other than the mother's diminished intake of food.

Smithells et al (1977) assessed the daily nutrient intake of 195 women in the first trimester of pregnancy. A five-day weighed dietary record was obtained from each subject. A minimum of two supervisory visits were made to each mother after initial diet recording instructions were given. In contrast to previous research cited, Smithells found no difference between the energy and nutrient intake of smokers (n=77) and nonsmokers (n=118) during the first trimester, with smokers consuming an average of 1933 kcal per day, as compared with 1971 kcal per day consumed by nonsmokers. Likewise, no difference was observed when data was analyzed according to number of cigarettes smoked per day, with mean intakes of 2043 (n=25), 1851 (n=38) and 1904 (n=14) kcal consumed by those who smoked between one to nine, ten to nineteen

and greater than twenty cigarettes per day, respectively. Smithells et al did, however, find significant differences in both energy and nutrient consumption between mothers from social classes I and II (upper-class) as compared with classes III, IV and V (2183 kcal vs 1892 kcal, $p < .001$; protein intake 76.4 g vs 65.2 g, $p < .001$). The nutrient intake of smokers vs nonsmokers was not statistically corrected for social class (Hollingshead classification).

Proposed Mechanisms of Action

The mechanism of action responsible for the effects of smoking on birth weight is not clear. Proposed hypotheses include a suboptimal food intake during pregnancy (Rush, 1974), reduced fat stores in women who smoke (Garn et al, 1978), carboxyhemoglobin-induced fetal hypoxia (Astrup et al, 1972), decreased uteroplacental perfusion (Lehtovirta and Forss, 1978) or the effect of one or more of the estimated 3000 chemical compounds found in cigarettes/smoke on the basal metabolic rate (BMR) of the woman and the transport of nutrients to the fetus (Longo, 1982).

Authors of several carefully controlled studies have concluded the effects of cigarette smoke on birth weight appear not to be mediated through a decreased maternal appetite or weight gain as cited earlier. The impact of smoking on growth appears most likely to be mediated through the effects of either carbon monoxide, nicotine, cyanide and/or cadmium on placental perfusion and oxygen transport to the fetus (Picone et al, 1982a, 1982b). Carbon monoxide displaces oxygen in hemoglobin to form carboxyhemoglobin which increase in concentration by four to five percent, a level associated with physiological alterations in adults

(Longo, 1977). The accumulated carboxyhemoglobin can reduce oxygen release, oxyhemoglobin displacement and fetal blood oxygen tension by as much as 25% (Hammer et al, 1981; Longo, 1976). Nicotine, a known vasoconstrictor, decreases uterine blood flow, resulting in as much as a 22% reduction in placental perfusion (Lehtovirta and Forss, 1978). Thiocyanide, a hypotensive agent which reduces the cells ability to use oxygen, has been found in concentrations two to four times greater in the blood and urine of smokers' infants as compared to nonsmokers' infants (Pettigrew, 1977). Meberg (1979) reported thiocyanate concentrations were positively correlated with cigarette consumption and inversely correlated with birth weight. Recently, a cadmium-zinc interaction, resulting in a reduced zinc availability for DNA and RNA production, has been proposed as a possible mechanism for the reduced birth weight seen in infants of smokers (Kuhnert et al, 1987).

As cited above, nicotine may act indirectly to reduce the efficiency of calories in women who smoke by increasing their BMR (Picone et al, 1982a, 1982b). Nicotine has been shown to increase the BMR by increasing the sympathetic stimulation of epinephrine, which causes an increased heart rate, blood pressure, rate of lipolysis (Winternitz and Quillen, 1977), and a decrease in placental amino acid transport (Rowell and Sastry, 1977). The increased BMR may have a substantial effect on energy requirements (Hiestad et al, 1940). Several studies have suggested a greater food intake in smokers, accompanied by a concomitant greater prenatal weight gain, will result in a higher infant birth weight (Gormican et al, 1980; Luke et al, 1981; Papoz et al, 1982), particularly in a WIC population (Metcoff et al, 1985).

Others, however, have disputed this theory based on the observation that smokers who gained significantly more weight than nonsmokers have delivered infants of lower birth weight than nonsmokers (Ounsted and Scott, 1982).

Although the exact mechanism of action of cigarette smoke on birth weight is at present unclear, the reduction in birth weight appears to be a direct effect of smoking on fetal growth (DHHS, 1983). Although mothers who smoke have higher rates of premature deliveries, their newborns are smaller than those born to non-smokers at every gestational age, displaying symmetrical fetal growth retardation in crown-heel length and chest and head circumference as well as birth weight (DHHS, 1983; Miller et al, 1976).

Prevalence of Smoking During Pregnancy

Data from the 1980 National Natality Survey for married mothers age 20 and over indicate 25% of white and 23% of black pregnant women are smokers (Kleinman and Kopstein, 1987). Striking differences exist in the percent of smokers by educational level, with the proportion of mothers who smoke during pregnancy ranging from 43% for those with less than 12 years of education to 11% for those with 16 or more years of education. It has been estimated that, of those who enter pregnancy as smokers, only an estimated 17% quit smoking and 40% cut down on the number of cigarettes smoked (Kleinman and Kopstein, 1987). Sadly, Campbell (1985) reported only 16% of pregnant women had been informed by their physician that smoking during pregnancy is hazardous.

Conclusion: Effect of Cigarette Smoke on Birth Weight

The present body of literature supports the conclusion that women who smoke during pregnancy are putting their infant at an increased risk of LBW. Although several factors have been demonstrated to affect birth weight, smoking appears to have one of the greatest measurable effects (Kleinman and Madans, 1987). The exact mechanism for this affect is as yet unknown.

Alcohol Consumption

The classic report by Jones et al (1973) in which a characteristic pattern of fetal malformations was coined "fetal alcohol syndrome", served as a major stimulus for research on the adverse effects of alcohol intake during pregnancy. In 1981, the U.S. Surgeon General issued an advisory that pregnant women, or women planning a pregnancy, should not drink alcohol (Surgeon General, 1981). Nevertheless, human studies have yielded inconsistent and contradictory results, raising serious questions about the relative importance of alcohol intake to poor neonatal outcome (Stein and Kline, 1983). Harmful effects of alcohol during pregnancy have been implicated in three specific areas: 1) the fetal alcohol syndrome, 2) intrauterine growth retardation and 3) neonatal neurobehavioral dysfunction. Only the effects of alcohol on intrauterine growth retardation will be presented.

Definition and Classification of Alcohol Intake

The amount of absolute alcohol consumed by subjects in all studies reviewed here was self-reported. A "drink" is defined as a 12-oz can of beer, a 4-oz glass of wine or one mixed drink. It was assumed each "drink" contains approximately 1/2 oz, or 10 g, of absolute alcohol.

The classification of subjects as "rare", "light", "moderate" and "heavy" drinkers varies from study to study, making comparison of results difficult. In general, individuals who consume five or more drinks on one occasion, with at least 45 drinks per month, or 10 per week, are classified as "heavy drinkers". Individuals who consume more than one drink per month, but less than the heavy drinker, are classified as "moderate drinkers". Those who consume one alcoholic beverage per month or less and have never consumed more than five drinks on one occasion are classified as "rare drinkers" (Oullette et al, 1977; Rosette et al, 1983; Mullins and Gazaway, 1985). Analysis of published studies indicate heavy drinkers comprise an estimated two to 13% of pregnant women, moderate drinkers comprise approximately 35-40%, and rare drinkers comprise approximately 47-63% of pregnant women (Mullins and Gazaway, 1985).

Johnson et al (1987) reported use of cigarettes and recreational drugs during pregnancy was associated with a lower socioeconomic status, while alcohol consumption was associated with higher social status. Although cessation of cigarettes and recreational drug use was more common among professionals and the college-educated, these same two characteristics, along with a higher income level, were associated with failure to quit drinking during pregnancy.

Association Between Alcohol and Birth Weight

Rosett et al (1983) examined the effects of heavy (n=43), moderate (n=164) and rare alcohol consumption (n=262) on fetal development in a prospective study of mother-infant pairs. Effects of heavy drinking in early and late gestation were evaluated by separate analysis of neonates born to women who reduced consumption before the third trimester. No differences in fetal development were observed between offspring of rare and moderate drinkers. Infants born to women who reduced their heavy drinking during pregnancy did not differ in growth from offspring of rare and moderate drinkers, but did demonstrate a higher frequency of abnormalities. In contrast, women who were sustained, heavy drinkers throughout pregnancy (n=25) delivered infants with significantly lower birth weights, lengths and head circumferences below the tenth percentile for gestational age ($p < 0.001$). These findings were independent of gestational age, pre-pregnant weight, baby's sex, race, number of cigarettes smoked, education level attained and parity. The authors concluded sustained, heavy drinking during pregnancy represented a major risk.

Brooke et al (1989), in a prospective study of 1433 women, reported a trend toward reduced birth weights with increased consumption of alcohol. Women who had consumed 100 g or more of absolute alcohol in the week prior to their first prenatal visit (approximately 9 or more drinks), delivered infants who were 137 g lighter than infants of non-drinkers. There were no differences in birth weight between non-smoking, heavy drinkers and non-smoking rare-drinkers. For smokers, however, a strong alcohol-effect remained. A seven percent reduction ($p < 0.003$) in

birth weight was observed between infants born to non-drinking smokers and smokers who reported drinking 100 g of alcohol or more per week at the initial interview.

Wright et al (1983) examined the relationship between infant birth weight and alcohol consumption immediately prior to the recognition of pregnancy in 900 white women. After adjustment for social class and cigarette smoking, moderate drinking (50-100 g/week; 5-10 drinks) did not result in a significantly increased relative risk for birth weight less than the tenth percentile ($RR=1.24(0.8-1.58)$). Heavy drinking (100 g alcohol/week; 10 or more drinks) prior to recognition of pregnancy was associated with a significant increase in the number of infants with weights below the tenth percentile ($RR=2.27(1.36-3.86)$), especially among smokers ($RR=3.43(1.52-7.54)$). Of the heavy drinkers who reduced their consumption of alcohol to less than 100 g/week during pregnancy (62%), 30% delivered a light baby. The authors concluded alcohol consumption of more than 100 g a week (10 drinks or more) around the time of conception carried an increased risk of low birth weight and that the reduction of heavy drinking only in the later stage of pregnancy, in both smokers and non-smokers, did not benefit the infants' growth status.

Little et al (1977) examined the relation of moderate alcohol consumption to infant birth weight in a prospective study of 262 paying members of a health maintenance organization. Alcohol consumption prior to, in early, and in late pregnancy was estimated. A multiple regression equation was computed for each of the these three time periods. After controlling for maternal age, height, parity, daily cigarette

consumption, gestational age and sex of the child, ingestion of one ounce of alcohol daily before pregnancy (two drinks) was associated with an average decrease in birth weight of 91 g ($p < 0.01$). Ingestion of one ounce of alcohol daily in late pregnancy (months five to eight) was associated with a 160 g decrease in birth weight ($p < 0.01$). Maternal weight gain was not reported in this study.

Mills et al (1984) analyzed data of 32,870 subjects in the Kaiser-Permanente study. After controlling for confounding variables, these researchers demonstrated that the consumption of one to two drinks per day during pregnancy reduced infant birth weight by 83 g ($p < 0.01$),

Oullette et al (1977) evaluated the effects of heavy drinking on the offspring of 633 women. Nutritional status (24-hour recall), drug, smoking and alcohol habits were assessed at the first prenatal visit. Women were classified as heavy, moderate or rare drinkers. Nutritional intake did not differ among the women in all three groups. Infants born to heavy drinkers ($n=58$) had twice the abnormalities ($p < 0.001$), shorter birth lengths ($p < 0.05$) and lower birth weights ($p < 0.001$) than rare drinkers ($n=326$). Fifteen heavy drinkers significantly reduced their alcohol intake during pregnancy; 10 of the 15 had normal babies. In contrast, only two of the 27 women who drank heavily throughout pregnancy had infants that were assessed as normal at delivery.

The effect of abstinence during pregnancy by women who had a previous history of heavy alcohol intake was examined in a second study by Little et al (1980). Three groups of fifty women were recruited (1=history of alcoholism prior to conception who reported abstinence during the entire pregnancy, 2=history of heavy alcohol ingestion prior

to, as well as during, the entire pregnancy and 3=no history of alcoholism). The mean birth weight of infants born to abstinent alcoholics was 258 g less than the mean birth weight of the control infants ($p < 0.05$). Infants of drinking alcoholics weighed 493 g less than control infants ($p < 0.001$). After controlling for race, age, education, smoking, maternal height, parity, sex and gestational age, the adjusted birth weights (3137 ± 466 , 2786 ± 485 and 3520 ± 419 , respectively), were still significantly different ($p < 0.05$). Results suggest maternal alcoholism continues to be a risk factor for fetal growth failure, independent of alcohol use during pregnancy.

No Association Between Alcohol and Birth Weight

Data from the Boston City Hospital Study of 1690 mother-infant pairs (Hingson et al, 1982) indicated infants whose mothers drank two or more drinks per day weighed 228 g less than infants of non-drinkers. However, after controlling for more than 40 potential confounding variables, this difference was reduced to 51 g (NS). Maternal drinking prior to pregnancy was significantly related to a shortened gestation.

Marbury et al (1983) assessed patterns of alcohol consumption in 12,440 pregnant women interviewed at delivery. Ninety-two women (0.7%) reported drinking 14 or more drinks per week, with most of these consuming less than 21 per week. Crude data analysis indicated the consumption of at least 14 or more drinks per week during the first trimester was associated with a variety of adverse outcomes, including low birth weight. When confounding variables were controlled by logistic regression analysis, smoking, and not alcohol consumption, was found to

be responsible for the increased likelihood of delivering a low birth weight infant. However, within each group of alcohol use (0, 1-13, 14 or more drinks per week), women who concomitantly smoked more than 10 cigarettes per day delivered babies who weighed 250 g less than babies of non-smokers (abstainers: 3353 g, non-smokers vs 3119 g smokers; moderate drinkers: 3495 g, non-smokers vs 3158 g, smokers; heavy drinkers: 3373 g, non-smokers vs 2919 g, smokers).

Kline and Stein (1987) examined the relation of cigarette smoking and alcohol intake during pregnancy to birth weight in two prospective studies (Phase I and Phase II) of 2815 pregnant women in New York City. While cigarette smoking during the last half of pregnancy was associated with significant decreases in mean birth weight of 159 g (Phase I) and 202 g (Phase II) ($p < 0.001$), only beer drinking in Phase II was associated with a significant decrement of 8.4 g in birth weight per ounce of absolute alcohol consumed (2 standard drinks; $p < 0.01$). Neither wine or liquor drinking in Phase II, nor any of the three beverages in Phase I, was associated with a decrease in birth weight.

Tennes and Blackard (1980) recorded drinking histories of 278 Colorado women before the twentieth week of gestation. Three percent of the women in the study averaged more than one and one-half drinks per day during the first trimester. Although a statistically significant association between alcohol and decreased gestational age was observed (explaining two percent of the variance), no association between alcohol consumption and birth weight was observed. Similarly, Mau (1980), in a prospective study where alcohol intake was measure qualitatively, found

no relationship between alcohol intake and infant birth weight, length or head circumference.

Summary: Alcohol Intake and Birth Weight

Inconsistencies in the literature have been attributed to incomplete control of the following confounding variables: 1) recall bias (Marbury et al, 1983), 2) under-reporting by individuals who drink the most (Fitzgerald and Mulford, 1978), 3) type of alcoholic beverages consumed (Kuzma and Sokol, 1982), 4) differences in the way alcohol exposure has been defined (Stein and Kline, 1983), 5) the varying percentage of heavy and moderate drinkers in different studies, and 6) lack of attention to timing of alcohol exposure during pregnancy (Zuckerman and Hingson, 1986).

Results indicate women whose alcohol consumption is high during pregnancy (14 or more drinks per week), are at increased risk of having an infant with intrauterine growth retardation. Evidence of the effects of moderate or rare drinking is less convincing. Two reviews of more than 900 research reports on alcohol and pregnancy concurred that, in no instance, in either clinical or experimental reports, have persistent effects of the consumption of low levels of alcohol been observed (Rosett and Weiner, 1984; Abel, 1984). In contrast, several studies indicate an increased risk of growth retardation following exposure to high blood alcohol concentrations at all stages of gestation and in the absence of other risk factors (Weiner and Rosett, 1985). An editorial in the American Journal of Public Health has stated, it is "unlikely that regular drinking of fewer than two drinks daily, either before or during

pregnancy, is an important determinant of intrauterine growth retardation" (Stein and Kline, 1983, p.1156). These inconsistent findings suggest the need for further studies, especially regarding the inter-relationship of alcohol with other factors.

Caffeine Consumption

Despite widespread use in beverages and foods, the effects of caffeine on the developing fetus are not completely known (Martin and Bracken, 1987). Pharmacologically, caffeine stimulates the central nervous system. Physiologically, caffeine ingestion has been implicated in reproductive and fetal effects in animals, including embryoletality, cleft palate and digit deformities (Collins et al, 1982). Human data are limited and contradictory. Caffeine is known to cross the placenta and enter the fetal circulation (Goldstein, 1962), where it is metabolized at a rate three times slower than in nonpregnant women (Knitti et al, 1982). The fetus does not have the enzymes necessary to metabolize caffeine until several days after birth (Martin and Bracken, 1987). Because the chemical structure of caffeine is similar to that of purine molecules in DNA, it has been hypothesized that caffeine could interfere with cell division, growth and metabolism (Martin and Bracken, 1987).

Animal Studies and Caffeine

The potential toxicity of caffeine to the developing fetus was first reported by Knoche and Konig (1964). Cleft palates were observed in mice after daily administration of 50 mg/kg of caffeine (Knoche and Konig, 1964) and digital deformities (ectrodactyly) have been observed in mice, Wistar rats and rabbits after daily caffeine administration at 50, 100 and 125 mg/kg, respectively (Bertrand et al, 1965).

Grossier, Rosso and Winnick (1982) reported offspring of rats who were fed coffee during pregnancy had reduced total body, liver and brain weights at birth as compared to controls. By 39 days, these offspring had recovered in size; however they demonstrated increased locomotion, decreased grooming time and decreased time spent with a novel object. Dunlop and Court (1981) also found moderate amounts of caffeine, introduced into the diet of rats throughout pregnancy and lactation, resulted in growth-retarded offspring.

Collins et al (1982) intubated rats with 0, 6, 12, 40, 80 and 125 mg caffeine/kg body weight during the first 19 days of gestation. Male and female rats, intubated with 80 and 125 mg/kg, weighed significantly less and were shorter; females intubated with 40 mg/kg weighed significantly less and had a shorter crown-rump length. Ectrodactyly was observed in fetuses of animals dosed with 80 and 125 mg/kg caffeine. Hypoplastic nails and missing digits were observed in both groups, but a significant increase in the number of missing digits in the 125 mg/kg group was noted. The absence of the third digit on the left back paw was most commonly observed. Reduced and delayed ossification increased with increasing caffeine dosage; the incidence of misshaped, poorly ossified,

fused and absent bones increased significantly in rats fed the three highest dose levels. These results prompted the United States Food and Drug Administration (FDA) to advise pregnant women to avoid, or use sparingly, caffeine-containing foods, beverages and drugs (Goyan, 1980).

Human Studies and Caffeine

Implications of findings from animal studies for humans are unclear, primarily due to differences in the mode of exposure, amount consumed and metabolism (Goyan, 1980). Several epidemiologic studies have examined the relation of caffeine intake during pregnancy to birth weight; all but one have indicated a negative association.

Kirkinen et al (1983) reported administration of 200 mg caffeine to pregnant women, an amount equivalent to that found in two to three cups of coffee, significantly reduced blood flow to the placental villi and increased maternal epinephrine levels. The researchers hypothesized this decreased blood flow reduced the nutrient supply to the fetus, resulting in intrauterine growth retardation.

Beaulac-Baillargeon and Desrosiers (1987) investigated the effect of caffeine and cigarette consumption on fetal growth in a retrospective study of 913 newborns. Results showed caffeine consumption during pregnancy had a negative effect on the birth weight of babies born to smokers of 15 or more cigarettes per day. Doses of 300 mg or more of caffeine per day accentuated the decreases in birth weight caused by smoking. After adjusting for length of gestation and sex, a significant caffeine-cigarette interaction was observed for both birth weight and placental weight. Birth weight was 206 g lighter for babies whose

mothers consumed 300 mg or more caffeine and smoked 15 cigarettes or more per day. Among women who consumed less than 300 mg caffeine daily, placental weight increased with increasing cigarette consumption due to an apparent compensatory placental hypertrophy. In contrast, placental weight was significantly reduced among women who smoked 15 cigarettes or more per day if they concomitantly ingested 300 mg or more caffeine as compared to women who consumed the same number of cigarettes but less caffeine. These results indicated the concomitant consumption of caffeine and cigarettes constituted a high risk for the fetus.

Martin and Bracken (1987) observed a dose-dependent, increased risk of delivering a low birth weight singleton after 36 weeks gestation in mothers who consumed one of four levels of caffeine during their pregnancy. Seventy-seven percent of the 3,891 women in this prospective study, conducted at Yale-New Haven Hospital, ingested caffeine from coffee, tea, colas and drugs; over one quarter of the women consumed more than 150 mg daily. Average daily caffeine exposure (mg/day) was determined from consumption of non-decaffeinated coffee and tea and caffeine-containing colas most frequently consumed. Caffeine content was estimated at 107, 34 and 47 mg/serving for coffee, tea and colas, respectively. Four levels of caffeine consumption, 0 mg, 1-150 mg, 151-300 mg and greater than 300 mg/day, which estimated 0, <1.5, 1.5-3 and >3 cups per day, were compared. After adjusting for the confounding factors of age, marital status, ethnicity, education, daily cigarette consumption, alcohol intake, marijuana use, parity, weight gain and body mass index, the relative risks of low birth weight were 1.4 (95% CI 0.87-3.0) for 1-150 mg caffeine/day, 2.3 (1.1-5.2) for 151-300 mg/day

and 4.6 (2.0-10.5) for over 300 mg caffeine/day. Decreases in mean birth weight between cases and controls were 6, 31 and 105 grams, respectively, compared with a 137 g decrease for cigarette smoking. The authors concluded maternal caffeine resulted in a two-fold risk of delivering a low birth weight infant if the equivalent of 2-3 cups of coffee were consumed per day during pregnancy; women who consume the caffeine equivalent of more than three cups per day had a four-fold risk of delivering a low birth weight baby.

In a retrospective study of 12,205 non-diabetic, non-asthmatic women, Linn et al (1982) found no association between low birth weight, preterm delivery or congenital malformations and heavy coffee consumption (four or more cups per day) after controlling for smoking, demographic characteristics and medical history. However, the methods and statistical analysis reported by Linn (1982) drew much criticism (Bracken et al, 1982; Steinmann, 1982; Luke, 1982). The lack of caffeine consumption from sources other than coffee, the limitation of data collection to only the first trimester, and failure to account for pre-pregnancy weight and gestational weight gain were the major objections.

Summary: Caffeine Intake and Birth Weight

Present studies indicate a potential risk for delivering a reduced birth weight infant when as little as 151-300 mg caffeine/day is consumed. The interaction between cigarette smoking and caffeine ingestion greater than 300 mg/day has been shown to reduce both infant birth weight and placental weight. Present research findings appear to

support continuation of the FDA's warning about possible risks of caffeine consumption during pregnancy.

Nutrition

Due to the complex interactions of physiologic, behavioral, environmental, sociodemographic and methodologic factors, the exact role of nutrition in pregnancy outcome is difficult to determine. This section of the literature review will focus on: 1) confounding factors which interfere in the establishment of the exact role of nutrition in pregnancy outcome, 2) established relationships between nutrition and pregnancy, highlighting the role of energy, protein and zinc, as determined by animal, human, historical and prospective studies, 3) current energy, protein and zinc nutrient recommendations for pregnant women, 4) methods to evaluate usual dietary intake in a retrospective study, and 5) methods to assess the impact of total diet quality on pregnancy outcome.

Confounding Factors

Maternal diet and nutritional status have long been considered important factors influencing fetal growth and pregnancy outcome. The complex physiological relationships between the pregnant woman, placenta and fetus, however, makes the quantitative definition of nutrient needs during pregnancy difficult to determine (Metcoff et al, 1981).

Compounding the physiologic complexities are three important methodologic problems that, according to Hebert and Miller (1988), could

prevent the observation of a true association between dietary factors and the outcome variable in question (i.e. birth weight). First, available diet assessment methods are inadequate to estimate true exposure with sufficient accuracy and precision, especially over long periods of time, due to difficulties in recalling true dietary intake. Second, use of retrospective diet assessment methods in case-control study designs can often introduce an important bias, particularly between cases (i.e., mothers who deliver a LBW baby) and controls (i.e., mothers who deliver a 3500-4000 g infant). Third, sufficient within-study group contrasts are often lacking (i.e., the true range of intake of any nutrient may not be sufficiently large to statistically detect a difference).

Many confounding factors, in addition to a woman's nutritional status prior to and during pregnancy, influence fetal outcome. These factors often co-vary with dietary behavior, further complicating researchers' ability to discern the true relationship between nutrient intake, per se, and fetal outcome.

For these reasons, remarkably little information exists about the specific relation between nutrient intake and human fetal outcome. Indeed, Metcalf (1981a, p. 656) stated "although it may seem obvious that human fetal malnutrition is the result of inappropriate delivery of nutrients to, or utilization by, the growing fetus, a specific relationship to the nutritional state of the mother has NOT been identified". Nonetheless, data from epidemiologic studies, food supplementation trials, historical observations and animal

investigations provide support for the premise that maternal nutrition influences human fetal growth.

Despite the complexities in determining a relationship between nutrient intake and human fetal outcome, research in this area should not be abandoned. New diet assessment tools and statistical methods can be used to clarify the inter-relationships which influence fetal outcome. By focusing on this "seamless web" of factors, rather than on individual factors in isolation, an enhanced understanding of modifiable factors influencing birth weight will be attained (Jacobson, 1986).

Research Studies

Very little specific information was available about diet and pregnancy before the 1930's. Four types of research have been used to examine the effect of nutrition during pregnancy on birth outcome: animal studies, human war and famine studies, nutritional intake/fetal outcome correlational studies and experimental nutrition intervention studies. In general, all studies point to a common conclusion: good nutrition has a positive influence on birth weight, but the magnitude of the effect is unclear (Institute of Medicine, 1985).

Animal Studies.

Controlled rat studies indicate extreme nutritional deprivation (50% reduction in energy intake) results in a 25-30% decrease in litter birth weight (Chow and Lee, 1964; Berg, 1965). The observed reduction in birth weight was consistently less than the magnitude of the dietary reduction. Metabolic, tissue and cellular deficits in rat pups have been

associated with dietary restriction of the mother during pregnancy (Winick and Noble, 1965; Winick and Noble, 1966; Winick et al, 1973). Caloric restriction during the final stage of pregnancy has been associated with the largest birth weight deficits in rats (Wallace, 1945).

Growth failure in rodents can be attributed to either "intrinsic" or "extrinsic" causes. Intrinsic intrauterine growth failure (i.e., growth retardation caused by factors other than inadequate maternal-fetal transport, such as chromosomal abnormalities, drugs, maternal infection), typically results in normal-sized placentas. Extrinsic intrauterine growth failure, however, is usually manifested by placentas that are reduced in size and incapable of supplying the fetus with adequate nutrition for optimal growth (Winick et al, 1973). Extrinsic intrauterine growth failure has been produced experimentally in rats by ligating a uterine artery (Winick et al, 1973). This procedure, usually done at 17 days gestation after hyperplastic growth of the placenta is complete, cuts off the blood supply to one of the uterine horns.

Severe protein restriction of rats during pregnancy produces extrinsic growth retardation by reducing the supply of nutrients for the synthesis of placental and fetal cells. Both vascular and nutritional extrinsic growth failure produced placentas which were reduced in size in proportion to fetal weight. In both ligated animals and late maternal malnutrition (reduced total dietary intake), the reduction in placental size was attributed to a decrease in the average size of the cells.

In contrast, maternal protein restriction throughout gestation decreased both the placental size and cell number (Winick et al, 1973).

In addition to placental changes, maternal protein restriction during the last days of gestation resulted in a growth retardation pattern similar to that produced by vascular insufficiency, resulting in rats with proportionally bigger heads and smaller bodies. When protein restriction was maintained throughout gestation, a 15-25% decrease in cell size and number of all organs, including the brain, was noted. Results suggest fetuses are not perfect parasites that can survive intrauterine insults without adverse consequences (Winick et al, 1973).

Human Famine Studies.

Famine caused by war has provided an opportunity to examine the impact of dietary restriction on human birth outcome. Studies of the effects of famine on pregnancy outcome during World War II in Leningrad (Antonov, 1947) and Holland (Smith, 1947) indicate extreme, sustained nutritional deprivation can compromise pregnancy outcome and increase the incidence of low birth weight.

Extreme hardships were endured by the people of Leningrad, during the siege by the Nazis from 1941 to 1943. Conditions were especially severe between September, 1941, to February, 1942 (Antonov, 1947). Food was insufficient in quantity and inferior in quality. Bread, made from one-half rye flour and the rest cellulose, malt or bran, was the principal food. Bread rations for manual workers during December of 1941 were 250-300 g; rations for mental workers were only 125-200 g. Which of these two rations was made available to pregnant women was not specified. Under these extreme conditions, a 500 g reduction in average birth weight, a 50% LBW rate, a 41.2% prematurity rate and a 32.2%

overall infant mortality rate occurred. Only 4% of the infants born in the first six months of 1942 weighed more than 3500 g. Antonov (1947, p. 259) concluded "we can say on the basis of our material that the condition of the host, the mother's body, is of great consequence to the fetus, and that severe quantitative and qualitative hunger of the mother decidedly affects the development of the fetus and the viability of the newborn child".

The Holland famine (Smith, 1947) differed from the Leningrad famine in that it was of sharp onset, limited to a six month period of time, and was not accompanied by deprivations as severe as those experienced during the siege of Leningrad. In addition, the women of Holland were considered to have had fairly good diets before the food shortage. During the famine, dietary intake was reduced to less than 1000 kcal/day, and protein was limited to 30-40 g. Because the famine only lasted six months, babies conceived before and during it were exposed for varying lengths of time, with none exposed for the entire course of gestation. Thus, it was possible to consider how the timing of maternal dietary restrictions affected fetal growth.

On average, birth weights of infants exposed to the Holland famine were reduced by 200 g. Birth weights were lowest for babies exposed to the famine during the entire last half of pregnancy. Added exposure to the famine before the last half of pregnancy did not reduce birth weight any further; in fact, babies who were exposed to the famine during the first 27 weeks of gestation, but finished their terms after the famine ended, had higher average birth weights than those who were only exposed during the last three weeks of gestation. Data for stillbirths and

congenital malformations followed a different pattern, with rates lowest for infants conceived before, and highest for those conceived during, the famine. These results indicated poor nutrition in the latter part of pregnancy affected fetal growth, whereas poor nutrition in the early months affected development of the embryo and its capacity to survive.

Stein et al (1975) re-examined effects of the Holland famine on human development by comparing the mental and physical health status of those exposed to the famine during gestation and early infancy to the status of those who escaped exposure. The authors concluded:

- 1) below a threshold value of food rations, the fertility rate declined parallel with the availability of food (NOTE: although "threshold level" was not stated, a level less than 1,500 calories was implied;
- 2) above a threshold value of food intake, the mother appeared to afford the fetus protection from nutritional deprivation;
- 3) below the nutritional threshold, the fetus was vulnerable to some extent in the first trimester of gestation to abnormal development of the central nervous system, premature birth and very low birth weight, and perinatal death;
- 4) below the nutritional threshold, the fetus was most vulnerable in the third trimester of gestation to intrauterine growth and early postnatal mortality, with weight being most sensitive to nutritional effects, and length and head size the least sensitive;
- 5) if prenatal brain cell depletion occurred in fetuses exposed to the famine during the third trimester, the surviving fetuses were quite resilient; any organic impairment did not manifest itself in dysfunction; and

- 6) among adult survivors (25 years post-famine), there was no evidence to indicate prenatal nutrition had impaired mental competence; if postnatal learning compensated for the adverse effects of prenatal nutrition deprivation, the authors concluded it did so equally across the social classes.

Correlational Studies.

Early correlational studies which examined the relationship between maternal nutritional intake and infant birth weight provided inconsistent results (Deckman et al, 1951; Woodhill et al, 1955; Kasius et al, 1958; McGarity et al, 1954). These inconsistencies most likely resulted from inadequacies in the diet assessment techniques and the incompleteness of the nutrient data base, confounded by methodologic, socioeconomic and cultural differences. Unfortunately, these conflicting results created a period of disillusionment and disinterest in the medical community about the relationship between nutrient intake and fetal outcome. Even as late as 1968 a popular obstetrics text stated "It seems fair to conclude that, in normal circumstances, maternal nutrition is not a limiting factor to foetal growth" (Dawes, 1968, p. 258).

Recently, several studies have examined the relation between decreased fetal weight and the nutrition-related factors of maternal weight gain and pre-pregnant body size and hemodynamic factors of diastolic blood pressure and hemoglobin measures. These studies were reviewed in the "Medical Risk Factors During Pregnancy" section in the literature review of this dissertation. In addition, several nutrition supplementation studies have been conducted in the last decade.

Experimental Nutrition Supplement Studies.

Supplementation studies have been conducted to determine whether nutritional intake during pregnancy improves birth outcome. The most recently published study analyzed the impact of the Higgins Nutrition Intervention Program (Montreal Diet Dispensary Study; 1963-1979) on the birth weights of 552 sibling pairs whose mothers' participated during the pregnancy of the second-born, but not the first born, member of her pair (Higgins et al, 1989).

The Higgins program, developed as an adjunct to routine prenatal care, attempted to compensate for the negative impact of high-risk factors associated with low-income women on birth outcome through individualized nutrition assessment, education and supplementation. Women who could not afford the diet prescribed by clinic dietitians were provided supplemental milk, eggs and oranges in amounts relevant to their needs. Each woman was seen by the same dietitian every two to four weeks throughout pregnancy. Because of the matching system employed, the intervention infants were all of later parity than the non-intervention infants. To correct for this bias, data from the Collaborative Perinatal Study (Niswander and Gordon, 1972) were used to decrease individual sibling pair differences by values corresponding to the mean increase in birth weight associated with the given change in parity. Analysis of covariance was used to adjust for the effect of infant sex. Intervention infants weighed 107 g more than their matched siblings at birth (3,340 vs 3,233, $p < 0.01$). Intervention had a greater impact on the birth weight of infants born to undernourished (+275 g) and stressed (+319 g)

women. The LBW rate was 50% lower among the intervention infants than among their siblings (4.9% vs 8.9%; $p < 0.01$). While not statistically significant due to the small numbers, perinatal mortality was lower among the intervention group as well (9.1 vs 16.3 deaths/1000 live births; NS). These findings support the individualized (personal interview, needs assessment and instruction) approach to prenatal nutrition intervention and supplementation.

Ten classic supplement studies, including three studies analyzing the Supplemental Program for Women, Infants and Children (WIC), are reviewed in Table 2.3. When considered together, they indicate that dietary supplementation can have a small, but generally positive, benefit to the fetus (Institute of Medicine, 1985).

Table 2.3. Supplementation studies involving pregnant women and their effects on maternal weight gain and infant birth weight.

Author & Location	Study Type	Sample Size	Population/ Treatment Group	Supplement	Results
Rush et al (1980) New York	Random, double blind	768	Poor black, previous LBW; protein intake < 50 g/day; < 110 lb; low weight gain in pregnancy; control plus 2 treatments	Flavored drink to 2 groups, medical attention to all; 1) 40 g protein, 470 kcals, 2) 6 g protein, 322 kcals, 3) no kcal/pro; all received vit/minerals	<u>Mother</u> : increased weight gain in suppl mothers (p < .05); greater if early enrolled. <u>Birth Weight</u> : High protein decreased by 32 g, low protein group increased by 41 g (NS).
Rush (1981) Montreal	Foods given at dispensary	2426	Low SES; inadequate diet; supplement group plus control group	Eggs, milk and oranges	<u>Mother</u> : higher weight in suppl mothers (0.3 lbs, NS). <u>Birth Weight</u> : increased 40 g (3251 vs 3291 g, p < 0.05).
Viegas et al (1982a, 1982b) Birmingham	Not random; suppl given to Asian women in first preg.	142	Supplement given independent of nutritional status; 3 supplemented groups	1) 30 mg vit C + 30 mg Fe; 2) #1 plus 273 kcals; 3) #2 plus 26 g protein	<u>Mother</u> : increased weight gain in second trimester (fat); higher gain in lighter women. <u>Birth Weight</u> : no difference between any groups.
Lechtig et al (1975) Guatemala	Supplement given to women in 4 communities; voluntary	405	Rural Guatemala; 2 supplemented groups, no control group	1) Atole: 163 kcal and 11 g protein; 2) Fresco: 59 kcal and 0 g protein; ad libitum	<u>Mother</u> : increased calories correlated with increased weight gain (r=0.21; p<0.05). <u>Birth Weight</u> : intake > 20,000 kcals 3105 g; intake < 20,000 kcals 2994 g (p < 0.01); 8% LBW among high vs 17% among low-supplemented group.

Table 2.3, cont.

Author & Location	Study Type	Sample Size	Population/ Treatment Group	Supplement	Results
Mora et al (1979) Bogota	Random assignment	385	Poor; women with at least 50% of children with < 85% wt/age; diet before suppl 1600 kcal/35 g protein; 1 suppl and 1 control group	Dry skim milk, enriched breads, vegetable oils for whole family; net increase of 155 kcal and 20 g pro; controls had no suppl foods	<u>Mother</u> : increased weight gain only in women bearing males. <u>Birth Weight</u> : 2978 vs 2972 g (NS); 95 g increase observed in males (suppl vs control; $p < 0.05$); No effect on females; no effect on LBW rate.
McDonald et al (1981) Taiwan: Bacon Chow Study	Random, double-blind	506	Poor women with at least one son; previous diet 1200 kcal and 40 g protein; 2 suppl groups, no control	1) 800 kcal/40 g protein 2) 80 kcal/ 0 g protein	<u>Mother</u> : no difference in weight gain between groups. <u>Birth Weight</u> : 52 g increase in males (3135 vs 3083) and a 63 g increase in females (3042 vs 2980) in the high suppl group (NS); % LBW was NS.
Prentice et al (1987) Gambia	All pregnant women of the community	379	Rural population; previous diet 1480 & 1300 kcals during wet & dry season; all received suppl; compared to baseline	Groundnuts, biscuits, tea with vitamins added; approx 1000 kcal and 40 g protein added.	<u>Mother</u> : increased weight gain over baseline was noted; <u>Birth Weight</u> : supplementation ineffective during dry harvest season; highly effective in wet season (+225 g, $p < 0.001$); LBW dec from 23.7% to 7.5% (wet) 12.5% to 8.6% (dry; $p < 0.002$).

Table 2.3, cont.

Author & Location	Study Type	Sample Size	Population/ Treatment Group	Supplement	Results
Stockbauer (1987) Missouri	case-control	9411 cases 9411 controls	Missouri WIC participants who delivered in 1982; controls matched by mother's age, education, number born this pregnancy and race	Nutrition education and vouchers for supplemental foods high in protein, iron and vitamins A, C and D	<u>Mother:</u> not reported. <u>Birth Weight:</u> WIC assoc with 19 g decrease in whites (NS) and 36 g increase in blacks ($p < 0.05$); sig decreases seen in LBW (7.8% vs 9.2%), prematurity (9.7% vs 12.0%), inadeq prenatal care (30.5% vs 31.7%) and increase gest. age (39.9 wks vs 31.7 wks); Seven months participation needed before improvements in birth weight outcome noted.
Kennedy et al (1984) Massachusetts	case-control	418 cases 418 controls	Massachusetts WIC clients who delivered 1973-1978; controls selected from WIC waiting-list; controls matched for racial/ethnic group, age, parity, marital status and income	Same as above	<u>Mothers:</u> not reported. <u>Birth Weight:</u> partic in WIC associated with 107 g increase in birth weight ($p < 0.012$) and 4% decrease LBW ($p < 0.06$); teens, blacks & Hispanic women showed greater benefits.
Metcoff et al (1985) Oklahoma	randomized controlled nutrition intervention	238 WIC 172 no-WIC	Oklahoma mothers who were predicted to have small ($n=226$) or normal birth weight infants ($n=184$)	Same as above	<u>Mothers:</u> WIC mother heavier at entry; maternal wt held constant;g no significant difference in wt gain noted. <u>Birth Weight:</u> WIC smokers had 168 g heavier babies than non-WIC smokers (> 10 cigs/day; $p<0.017$).

Current Recommended Nutrient Allowances

Because pregnancy is a time of growth, the need for nutrients is increased. Current Recommended Dietary Allowances (RDAs) are intended to be interpreted as safe and adequate levels--not minimal, optimal or absolute levels--which incorporate a margin of safety intended to account for the presumed variability among people (NRC-RDA, 1989). For the sake of brevity, only those nutrients which have been directly implicated with low birth weight (energy, protein and zinc) will be reviewed here.

Energy

Two factors that determine energy requirements during pregnancy are: 1) changes in usual physical activity and 2) the increase in basal metabolism for the growth of maternal tissues, the fetus and placenta. The cumulative energy cost of this extra work, assuming delivery of a 3.3 kg infant and a weight gain of 12.5 kg, has been estimated to be 80,000-85,000 calories (Hyttén and Leitch, 1971). This figure was used to determine energy allowances by both the World Health Organization (WHO, 1985) and the Food and Nutrition Board of the National Research Council (NRC-RDA, 1989).

Several recent studies, however, have challenged this figure (Durnin, 1987a,b; Durnin et al, 1987; Forsum et al, 1988; van Raaij et al, 1990). Alternative assumptions concerning the composition of tissue gained, observations of energy intake by pregnant women and measurements of resting metabolism and energy expenditure during physical activity, have led to caloric estimates of the cost of pregnancy from as low as

18,642 kcal in women of the Gambia (Durnin, 1987) to as high as 110,000 kcal in healthy Swedish women (Forsum et al, 1988).

In light of the substantial controversy about the energy requirements of pregnancy and the degree to which these needs are met by extra food, a series of studies was carried out in five countries around the world (Durnin et al, 1987; Lawrence et al, 1987; Thongprasert et al, 1987; Tuazon et al, 1997; and van Raaij et al, 1987). This integrated undertaking took place in two developed countries, Scotland and the Netherlands, and three developing countries, the Gambia, Thailand and the Philippines. Methods were standardized in the five centers and all women were recruited for participation early in pregnancy or in the preconception period. Effort was made throughout pregnancy to evaluate body weight, body fat, energy intake, basal metabolic rate (BMR) and daily energy expenditure.

Longitudinal studies of Durnin and colleagues demonstrated that the resting metabolic rate (RMR) dropped in early gestation, remained below pregravid levels until the 30th week of gestation and then increased. These results indicated any researcher who assessed the RMR only in the later stages of pregnancy may have grossly overestimated the total resting energy needs for pregnancy.

Observations made in the Gambia (Lawrence et al, 1987) suggested maternal nutritional status influences the RMR during gestation. Unsupplemented women who consumed only 1500 kcal per day had lower resting metabolic rates in the second and third trimesters than women who received supplements and consumed about 1950 kcal per day. Calculations estimated supplemented women required 13,000 additional

kcal for RMR, while unsupplemented women only required 1,000 additional kcal. It would appear that a smaller rise in RMR may enable underfed pregnant women to sustain adequate fetal growth and development, even with limited energy stores.

Analysis of the results of the five-country study indicated several important findings (Durnin, 1987b):

- 1) Although weight gain differed substantially among the populations (7.3 kg, the Gambia; 8.5 kg, Philippines; 8.9 kg, Thailand; 10.5 kg, the Netherlands; 11.7 kg, Scotland), when weight gain was expressed as a percent of the initial weight of the mother, more similarity is seen (14%, the Gambia; 19%, Philippines; 19%, Thailand; 17% kg, the Netherlands; 20%, Scotland);
- 2) The Dutch women, although bigger (62.5 kg vs 57.3 kg pre-pregnant weight) and slightly fatter than the Scottish women (28% vs 26% body fat), deposited only about two-thirds the amount of fat as the Scottish women, despite a higher energy intake and similar energy expenditure;
- 3) No group came close to gaining the 3.5 kg fat proposed by Hytten and Chamberlain (1980); mean fat gains (kg) were 0.6, the Gambia; 1.3, the Philippines; 1.4, Thailand; 2.0, the Netherlands; 2.3, Scotland);
- 4) The total increase in BMR over the whole pregnancy differed by at least a factor of 10 between the Gambian women and those from the other centers, demonstrating a remarkable physiological adaptation in the face of severe nutritional stress;
- 5) If the differences in the energy cost of pregnancy from the five centers were standardized for body weight (Table 2.4), total energy costs were about 59,750 kcal for all groups except the Gambian women;

the small differences between groups were attributed to the variable amount of maternal fat stored during pregnancy; in developed countries, it is estimated this total energy cost translates into an intake of only 100 extra kcal per day during pregnancy; and

6) Energy intakes did not conform to the theoretically expected quantities (i.e., 80,000 to 85,000 kcal), raising questions about the general recommendation for energy during pregnancy.

Table 2.4. Energy cost (kcal) of pregnancy in the five-country study*.

	Scotland	The Netherlands	The Gambia	Thailand	Philippines
ENERGY COST. (KCAL)					
Fetus	8,126	8,222	7,146	7,146	6,907
Placenta	729	741	559	600	600
Maternal Tissue	2,891	2,940	2,486	2,486	2,414
Maternal Fat	25,334	21,998	6,296	15,391	14,292
BMR	30,114	34,416	1,888	23,900	18,881
TOTAL:	67,159	68,345	18,642	49,712	43,259

*Based on data from Durnin (1987b)

Despite availability of the above data, the subcommittee of the Food and Nutrition Board of the National Research Council (NRC-RDA, 1989) based the current energy allowance for pregnant women in the United States on the WHO (1985) recommendation which was based on the

80,000-85,000 kcal figure of Hytten and Leitch (1972). Dividing this value by the 280 days of pregnancy yields an average increase of 300 kcal/day for the entire pregnancy. The NRC-RDA subcommittee cautioned any reduction in activity with advancing pregnancy may reduce the energy requirement. Also, unless a woman begins pregnancy with depleted body reserves, additional energy intake is probably not required during the first trimester. Thus, the 1989 recommended energy intake during pregnancy in the U.S. is an additional 300 kcal/day during the second and third trimesters of pregnancy (NRC-RDA, 1989).

Protein

Protein requirements during pregnancy are based on the needs of the non-pregnant reference woman plus the extra amount needed for growth. An estimated 925 grams of additional protein are deposited in a normal weight fetus and in maternal accessory tissues during pregnancy (Hytten and Leitch, 1971). Dividing this value by the 280 days of pregnancy results in an average of 3.3 g additional protein (0.53 g nitrogen) needed each day throughout pregnancy. Nitrogen retention, however, is not constant throughout pregnancy. Nitrogen deposition has been estimated to be 0.11, 0.52 and 0.92 grams/day during the first, second and third trimesters of pregnancy, respectively (WHO, 1985). Evidence in humans indicates protein turnover increases by the twelfth week of pregnancy (de Benoist et al, 1985), remains high throughout the second trimester, and the same (Jackson, 1987), or lower (Fitch and King, 1987) in the third trimester.

The Food and Nutrition Subcommittee of the National Research Council (NRC-RDA, 1989) concurred with the WHO (1985) that protein estimates during pregnancy should be based on the factorial method. Therefore, assuming a 15% coefficient of variation in birth weight and a 70% efficiency in the conversion of dietary protein to fetal, placental and maternal tissue (the efficiency of protein for growth in infants and children), an estimated 1.3, 6.1 and 10.7 grams of additional protein are needed per day during the first, second and third trimesters, respectively (NRC-RDA, 1989). Allowing for a maintenance requirement of the lean tissue, and accounting for the uncertainty about the rate of tissue deposition, the 1989 NRC-RDA subcommittee recommended an additional 10 g of protein per day throughout pregnancy. This is a decrease of 20 g per day from the 1980 Recommended Dietary Allowance (NRC-RDA, 1980), when the subcommittee assumed a conservative 25%, rather than a 70%, efficiency in the conversion of dietary protein.

Adverse consequences of protein deficiency during pregnancy are difficult to separate from the caloric contribution of the rest of the diet. Almost all cases of limited protein intake are accompanied by limitations in calories, due to its caloric contribution of 4 kcal/gram. As previously indicated in Table 2.3, provision of supplemental calories to women with deficient levels of dietary protein was as effective in increasing infant birth weight as supplementation with both calories and protein (Lechtig et al, 1975). Calloway (1974) estimated an extra 100 calories from carbohydrate or fat, in a protein-sparing capacity, had the same effect on nitrogen retention as an additional 0.28 g of nitrogen per day (1.75 g protein). It has been estimated that energy

intake should never fall below 36 kcal/kg body weight/day to maintain normal protein metabolism during pregnancy (Pitkin, 1981).

Adverse effects of excessive protein during pregnancy are poorly understood at the present time. The New York supplementation study (Rush et al, 1980; Table 2.3) provoked much discussion of this issue when results indicated the high-protein supplement was associated with an increased number of premature infants and excessive neonatal deaths. Mothers who delivered a premature infant and consumed the high protein supplement (n=51), delivered infants weighing significantly less than the premature infants of mothers who consumed either the low protein/high calorie supplement or no supplement (2,254 g, 2577 g, 2587 g, respectively; $p < 0.01$). No differences were noted in any measurement of physical stature between any of the supplemental groups at one year of age. However, infants born to mothers who had consumed the high protein supplement throughout pregnancy had significantly lower scores on three psychological measures (visual habitation, visual dishabitation and mean length of free play episodes) at one year of age.

Meta-analysis of human supplementation studies (Rush, Stein and Susser, 1980) has suggested providing a supplement with more than 20% of the calories from protein was associated with retarded fetal growth. Supplements providing less than 20% of the calories from protein yielded positive increases in infant birth weight. Picone and Allen (1984) have reported women consuming a high-protein diet (17.5-25% of energy) had shorter gestations, less placental DNA and protein, lower neonatal ponderal indices and smaller neonatal head circumferences. Greco et al (1986) reported a high protein diet (60% energy protein; 40% casein, 20%

lactalbumin) fed to rats from the first day of pregnancy, in addition to inducing morphological alterations of liver, adrenal cortex, heart and kidney, caused smaller litters and a higher mortality rate when compared to controls (23% protein).

Although these data suggest too much protein may have adverse effects on pregnancy course and outcome, data are limited. It seems reasonable to conclude, however, that a high-protein diet (20% or more of energy from protein), or a high-protein supplement when protein is adequate, promotes no recognizable benefit to the pregnant woman or her fetus (Worthington-Roberts, 1985).

Zinc

Both animal and human studies have related maternal zinc deficiency to poor fetal outcome, including increased spontaneous abortion, intrauterine growth retardation, stillbirth and a variety of congenital abnormalities (Hurley and Mutch, 1973; Jameson, 1976; Meadows et al, 1981; Soltan and Jenkins, 1982; Baumah et al, 1984). Dietary intake of pregnant women in the United States averages considerably less than the current Recommended Dietary Allowance (NRC-RDA, 1989). In addition, recent evidence indicates iron and folate supplementation, both common during pregnancy, interfere with zinc absorption and use (Solomons, 1986; Hambridge et al, 1987; Simmer et al, 1987). Finally, there is increasing evidence that pregnant women who smoke are at risk for low serum zinc levels (Kuhnert et al, 1988a). For these reasons, a comprehensive review of current literature relating zinc status to pregnancy outcome is presented.

Zinc Status During Pregnancy

In rapidly growing tissues, such as the fetus, zinc deficiency retards the synthesis of DNA, RNA and protein, impairing cellular division, growth and repair (Solomons, 1988). Progressive decreases in plasma zinc are commonly observed during pregnancy beginning in the tenth week; this decrease is not reversed with zinc supplementation (Belizan and Fitch, 1988). Determination of the true role of zinc in human reproduction is hampered by lack of a sensitive indicator of zinc status (Apgar, 1985; Lazebnik et al, 1988). Currently, plasma zinc is the most widely used parameter for assessment of human zinc status. In mild zinc deficiency, however, plasma zinc may remain normal without any overt evidence of deficiency (Prasad, 1988). Recently, several researchers have found leukocyte zinc to be a more sensitive method of determining zinc status (Prasad, 1988; Kuhnert et al, 1988a, 1988b).

Sandstead (1973) estimated the additional need for zinc during pregnancy was less than 0.1, 0.4 and 0.75 mg/day during the first 10, second 10 and last 20 weeks of gestation, respectively. More recently, Swanson and King (1987) estimated the daily zinc need during pregnancy to be 0.1, 0.2 and 0.6 mg/day for these same time periods. Recent evidence indicates zinc absorption does not increase during pregnancy (Swanson et al, 1983). Therefore, the 1989 RDA for zinc of 15 mg/day (3 mg/day higher than the non-pregnant state) was based on the same 20% absorption efficiency as in the non-pregnant state (NRC-RDA, 1989). This value represents a reduction from the 20 mg/day recommended in both the 1974 (NRC-RDA, 1974) and 1980 (NRC-RDA, 1980) RDA's.

Hambridge et al (1983) reported a mean zinc intake of 11 mg/day in 36 pregnant, middle-income women. Hunt et al (1979) reported a mean zinc intake of 9 mg/day (47% of the RDA) in 213 low-income Hispanic pregnant women; 85% of the women in this study had intakes below 33% of the RDA. The nutrient data base for zinc, however, is incomplete at the present time, making it difficult to accurately estimate zinc intake.

Zinc Status and Birth Weight

The relationship between circulating zinc levels and birth weight has been a focus of investigation since Hurley and Swenerton (1966) demonstrated the average weight of zinc-deprived pups was less than that of controls. Since that time, several studies have reported a similar relationship in humans.

Metcoff et al (1981b) observed a high mid-pregnancy circulating zinc level in mothers who delivered small babies and, conversely, a lower mid-pregnancy zinc serum concentration in mothers delivering normal-weight infants. The authors suggest this phenomenon is explained by the maternal-to-fetal transfer of circulating zinc. The exact mechanism is as yet unknown, but both the "push" and "pull" theories have been suggested. The "push" theory suggests those mothers capable of mobilizing their zinc reserves to benefit their fetuses will have larger babies; in this explanation the lowering of maternal zinc is seen to influence birth size. The "pull" theory suggests fetuses that are growing more vigorously in utero will demand more of the maternal zinc to sustain this normal growth; in this explanation, the lowering of

maternal zinc seen in the mothers who delivered optimal birth weight infants, is a consequence of fetal health (Solomons et al, 1986b).

Several studies have suggested birth weight may be related to maternal zinc status when leukocyte zinc, rather than serum zinc, is used as the index of zinc status. Meadows et al (1981) took leukocyte samples from 17 mothers of preterm infants, 44 mothers of small-for-gestational age infants (SGA) and 150 mothers of normal term infants. The white cell zinc content of mothers of SGA infants (43.0 ng/mg) was significantly lower than controls (52.3 ng/mg). Mothers of preterm infants had a mean level of 49 ng/mg, indistinguishable from controls.

In a subsequent study, Meadows et al (1983) collected cord blood from newborns of 110 mothers to determine fetal leukocyte zinc levels. Leukocyte zinc levels of normal weight infants (n=63) averaged 54.2 ng/mg. In contrast, a mean leukocyte zinc content of 50.7 ng/mg ($p < 0.05$) was observed in 19 children who were born small-for-gestational age with the growth failure of recent origin ("acute" IUGR), and 42.4 ng/mg ($p < 0.01$) in eight infants with "chronic" IUGR. The maternal leukocyte levels showed a similar and parallel association, with mothers from both groups of IUGR babies having significantly lower leukocyte zinc levels in their peripheral white cells.

Simmer et al (1985) obtained similar results when they measured plasma, red cell, polymorphonuclear leukocyte and mononuclear leukocyte zinc levels in 79 mothers within 24 to 48 hours postpartum. Forty-three of the women delivered normal birth weight infants; 36 had SGA newborns. Levels of plasma and red cell zinc did not correlate with birth weight,

but the levels for both types of white cells were significantly lower ($p < .001$) for the mothers with SGA infants.

Kynast and Saling (1986) evaluated the effect of zinc supplementation during pregnancy on birth weight. Women supplemented with 20 mg of zinc per day ($n=179$) delivered infants with a mean birth weight of 3318 g as compared to 3236 g in unsupplemented controls ($n=345$). Though not statistically significant, the authors believed an 84 g difference was clinically significant.

In contrast, several investigators have not found a clear relation between indicators of zinc status and birth weight. Campbell-Brown et al (1985) found no association between crude or adjusted birth weight and hair zinc, serum zinc or urinary zinc output. Tuttle et al (1985), in a study of 33 healthy primigravid women and 31 primigravidas with a high risk of delivering a low birth weight infant, found no differences in plasma zinc concentrations at 30 and 35 weeks gestation. Blood volumes, however, were 600 ml lower on average in the high-risk group of mothers ($p < 0.001$). When the mass of zinc in the intravascular compartment was computed for the two groups, there was 12% to 20% less circulating zinc in the high-risk women ($p < 0.001$). Lastly, a cross-sectional survey of pregnant women in Hong Kong (Ghosh et al, 1985) found a positive correlation of infant birth weight with serum zinc and a negative correlation with hair zinc levels. This pointed to zinc redistribution as a potential factor influencing pregnancy outcome, and re-emphasized the fact that a sensitive, accurate indicator of zinc status is lacking.

Effect of Zinc Status and Smoking on Birth Weight

It is well established that smoking during pregnancy results in infants with lowered birth weights (Kleinman et al, 1985). This phenomena has been attributed most often to hypoxia from carbon monoxide and constriction of the uterine blood vessels from nicotine (Abel, 1980). Kuhnert et al (1987), however, have proposed an alternate hypothesis. It is known that cadmium, obtained from cigarette smoke, increases the production of metallothionein, a storage protein for heavy metals. Each cigarette consumed is estimated to contribute 1 ug of cadmium to the body's cadmium pool (Solomons, 1988). In addition to trapping cadmium, the authors hypothesized the increased metallothionein also traps zinc, thus decreasing the amount of zinc available to the fetus. Their research indicated a "trapping" of zinc in the placenta which was directly related to levels of circulating cadmium. The level of circulating cadmium, in turn, was directly related to the number of cigarettes smoked. Kuhnert et al (1987) suggested this trapped zinc reduced the transfer of zinc to the fetus and could be responsible, in part, for the lowered birth weight of infants born to smokers.

Kuhnert et al (1988a, 1988b) reanalyzed their 1987 data to further investigate the effect of smoking on zinc status and birth weight. A significant relationship between mean cord vein red blood cell (RBC) zinc and birth weight ($p < 0.001$) was found. No relationship between maternal and fetal indices of zinc status was observed in nonsmokers. In contrast, a negative correlation between maternal plasma zinc and fetal RBC zinc (i.e., high maternal zinc=low fetal RBC zinc), and a positive correlation between maternal and fetal alkaline phosphatase and plasma

zinc, was observed in smokers. The authors hypothesized this high maternal plasma zinc level, and concomitant lower fetal RBC zinc, is due to an inability of the zinc to cross the placenta in smokers. Kuhnert suggested fetal zinc, not maternal zinc, is related to fetal birth weight. This inverse relationship between high maternal plasma zinc and low birth weight in smokers provides further support for the hypothesis that the inability of zinc to reach the infant of smokers is due to the "trapping" of cadmium and zinc in the placenta. This "trapping" resulted in an increased placental zinc level (10%), and a decreased cord RBC zinc level (9%), in smokers as compared to nonsmokers.

Conclusion: Zinc and Pregnancy Outcome

Several scientific studies indicate a relationship between zinc and pregnancy outcome. Research is hampered, however, by both the lack of a sensitive biologic indicator of zinc status and a deficient nutrient data base. Nonetheless, present studies indicate the availability of zinc to the fetus, as measured by cord RBC zinc, may exert a role in infant birth weight. Evidence links maternal smoking with increased placental metallothionein, which appears to trap zinc as well as the toxic metal cadmium. This trapping appears to prevent the transfer of zinc to the fetus, thus contributing to a lower birth weight by the concomitant reduction in synthesis of DNA, RDA and cellular proteins.

Evaluation of Dietary Intake in a Retrospective Study

To determine the impact of maternal nutrition on birth weight, a valid and reliable estimate of usual dietary intake must be used. Although several diet assessment methods are commonly used in nutrition research (i.e., 24-hour recall, diet records, diet histories, weighed food records, observation of diet intake and food frequency questionnaires), none is without its own unique biases and subsequent error. Because of its low cost, ease of administration and method of data collection, the food frequency questionnaire (FFQ) is the only practical diet assessment tool which can be used in a large-scale, retrospective epidemiologic study without a personal interview (Mullens et al, 1984; Sampson, 1985). Most importantly, it is also the most appropriate tool to assess usual food intake or food patterns over a period of time (Block, 1986; Sampson, 1985).

The Food Frequency Questionnaire (FFQ)

Typically in epidemiological studies, the FFQ is a short (60-120 items), relatively inexpensive tool that can be mailed and self-administered. The willingness of subjects to complete the FFQ has been shown by high return rates of 75% (Mullens et al, 1984) to 93.5% (Browe et al, 1966). The FFQ can be used to define current or past intake for individuals or groups (Sampson, 1985). The aim of the FFQ is to characterize food intake over an extended period, even though specific details of an individual's food consumption may be sacrificed.

The FFQ has been used to rank individuals according to food or nutrient intakes. The extremes (typically high intake vs low intake, tertiles or quartiles of the distribution) are then identified and compared with an outcome variable (i.e., birth weight, cancer, heart disease). Epidemiologists have used this classification or ranking of individuals in broad categories of low, medium and high intake because accurate quantitative measures of nutrient intake cannot be obtained retrospectively (Block, 1982).

Semi-Quantitative Food Frequency Questionnaire (SQFFQ)

Recently, two semi-quantitative food frequency questionnaires (SQFFQ), where subjects select the frequency of a specific quantity of food consumed as well as indicate the frequency of consumption, have been developed. The SQFFQ allows for the calculation of reasonably accurate quantitative measures of nutrient intake (i.e., 12 mg iron) (Willett, 1988). Increased confidence in the validity of the SQFFQ, and the observation that people within the upper and lower ends of the ranking scale are often "unusual" or "outliers" who had over- or underestimated their frequency of food intake (Colditz, personal communication, 1989; Sower, personal communication, 1989), has resulted in researchers using estimates of the actual daily nutrient intakes in preference to ranking of individuals in data analysis. The two most widely used SQFFQ at present have been developed by Gladys Block (Block, 1986) for the National Cancer Institute and Walter Willett et al of the Harvard Medical School (Willett et al, 1985) for the Nurses Health Study. Both tools were developed for epidemiologic and clinical use,

with special emphasis on nutrients previously associated with cancer, such as vitamins A, C and lipid fractions.

Block's SQFFQ.

Block's (1986) 99-item SQFFQ was developed using dietary data from 11,658 adult respondents to the Second National Health and Examination Survey (NHANES II). Food items were selected on the basis of their contribution to the total populations intake of energy and each of 17 nutrients in the NHANES II data. The food items represent over 90% of the total intake for each of those nutrients. Associated nutrient composition values were determined from the NHANES II database using frequency of consumption data in that survey. A unique feature of Block's SQFFQ is that portion sizes associated with each food item (small, medium and large), derived from observed portion size distributions in NHANES II using three-dimensional food models, must be selected by the subject filling out the form. Correlations between nutrients estimated by one-day diet records of 50 healthy 25-77 year old subjects (17 male, 33 female) and nutrients estimated by the Block-SQFFQ ranged from 0.73 for fat to 0.94 for vitamin A. At least 80% of nutrients were placed in the same or an adjacent quartile of the distribution. No nutrient was grossly misclassified, based on the one-day diet records and the SQFFQ.

Block believed the following developmental and design features of her SQFFQ were notable (1986). 1) The SQFFQ is targeted toward assessment of the whole diet, not one or a few similar nutrients, making it possible to reanalyze data sets if new nutrients become of research

interest in the future. 2) The food list is based on major nutrient contributors as determined by population data (NHANES II) which results in the inclusion of a few, sometimes overlooked, foods. 3) The inclusion of standard portion sizes based on population data and identified by the respondent adds personal variability in food preferences and quantity to the age-sex component. 4) The SQFFQ is capable of being self-administered, thus considerably advancing epidemiologist' ability to understand the relationship of diet and disease.

Willett SQFFQ.

Willett and colleagues (1988) developed a 116-item SQFFQ from refinement of their original 61-item SQFFQ (Willett et al, 1985). The Willett questionnaire was designed to categorize individuals by intake of select nutrients hypothesized to affect the occurrence of cancer and heart disease. Target nutrients included protein, animal fat, vegetable fat, saturated fat, oleic and linoleic acid, cholesterol, carbohydrate, sucrose, dietary and crude fiber, provitamin A, preformed vitamin A, thiamin, riboflavin, vitamin B-6, vitamin E, calcium and iron.

The 116 foods on the Willett SQFFQ were selected in three ways (Willett et al, 1987). Initially, potentially important sources of the specified nutrients were identified by an experienced dietitian. Those foods infrequently consumed were eliminated. Stepwise regression of foods consumed by 1742 female nurses in a pilot study (Willett et al, 1981) was used to identify foods that did not add appreciably to the between-person variation in nutrient intake. Next, nearly 5400 days of diet records, collected during a validation study of the original 61-

item SQFFQ (Willett, 1985), were used to identify any additional foods that might contribute appreciably to absolute nutrient intake. Finally, some foods of special interest with respect to cancer etiology but not important contributors to nutrient intake (i.e., mushrooms) were added. This procedure raised the number of foods from 61 to 116 items. A portion size for each food item was specified, with common units used whenever possible (i.e., slice of bread, eight ounce glass of milk). For foods without a natural portion size (i.e., ice cream or string beans), previously collected diet records from an independent population of United States women was used to identify the portion size most commonly used (Willett, 1985).

Subjects completing the Willett questionnaire were asked how often, on the average, they consumed food during the previous year (or any specified time period the researcher chooses). The subjects selected from nine possible responses ranging from "never" to "six or more times a day". The responses were designed to limit the range of intake within each frequency category to a factor of two or less. Additional items not presented in the frequency format include the types of fat used for frying and cooking, type of margarine used, amounts of sugar added to food, usual type of cold breakfast cereal consumed, frequency and brand of multiple vitamin supplements used and the dose, frequency and duration of intake of vitamin and mineral supplements. An open-ended section included at the end of the questionnaire allowed subjects to note any foods eaten once per week but were not included in the SQFFQ.

The Willett 116-item SQFFQ was initially validated in a group of 29 men and women aged 20 to 54 who had previously kept a daily weighed

diet record for one full year as part of a United States Department of Agriculture (USDA) experiment (Willett, 1987). The SQFFQ was mailed to the subjects approximately 18 months after the diet record experiment had been completed. Twenty-seven (93%) subjects, including 12 men and 15 women, returned completed food frequency forms. Overall, compared with the diet records, the SQFFQ tended to slightly underestimate total intake. However, the nutrient estimates were within 10% of the mean diet record measurements for 11 of the 18 nutrients evaluated (Table 2.5), and the difference was less than 25% for all but one nutrient (total vitamin A). Correlation coefficients comparing unadjusted nutrient intakes measured by the two methods ranged from 0.38 (vitamin C) to 0.76 (total fat) with correlations of 0.67, 0.60 and 0.63 obtained for calories, protein and calcium, respectively.

Table 2.5. Percent deviation between mean nutrient intakes as determined by one-year weighed food records and the Willett SQFFQ (n=29) (adapted from Willett et al, 1987).

Nutrient	Diet Record	SQFFQ	% Deviation
Total energy, kcal	2229±707#	2114±1012	-5
Protein, g	82±25	87±40	+6
Total fat, g	90±30	82±46	-9
Total carbohydrate, g	258±96	263±116	+2
Cholesterol, mg	362±122	332±151	-8
Vitamin A, IU	6434±2676	8511±6194	+32
Thiamin, mg	1.5±0.6	1.3±0.6	-13
Vitamin C, mg	125±87	146±88	+17
Calcium, mg	894±446	917±586	+3
Iron, mg	15±6	14±6	-7

Mean ± standard deviation

A second validation study of the 116-item SQFFQ was conducted by comparing responses of 150 Boston-area nurses to the SQFFQ and the mean intake of four-one week weighed diet records, spaced at 3-month intervals, which had been completed four years prior (Willett et al, 1988). Overall, the SQFFQ tended to provide higher total intakes than the diet records (Table 2.6). Calorie-adjusted correlation coefficients ranged from 0.44 for total vitamin A to 0.61 for total carbohydrate. Willett et al (1987, 1988) concluded these data provide further evidence that a simple and relatively inexpensive questionnaire can provide useful information on dietary intake over an extended period of time.

Table 2.6. Percent deviation between mean daily nutrient intakes as determined by mean intake of four one-week weighed food records and the Willett SQFFQ (n=150) (adapted from Willett et al, 1987).

Nutrient	Diet Records	SQFFQ	% Deviation
Total calories	1621±326#	1844±559	+14
Protein, g	68±12	76±22	+11
Total fat, g	69±17	76±25	+11
Cholesterol, mg	307±78	312±119	+ 2
Total carbohydrate, g	171±45	206±79	+20
Total vitamin A, IU	6875±4055	10217±5082	+49
Vitamin C, mg	242±444	292±290	+21
Thiamin, mg	4.4±13	2.4±3.5	-55
Calcium, mg	640±246	832±419	+30
Iron, mg	17±14	15±12	-9

Mean ± standard deviation

Summary: Food Frequency Questionnaires

Sampson (1985) has summarized the use of the FFQ/SQFFQ as a research instrument, including validation and reliability studies. In

general, reliability studies (repeated measures of the same instrument) indicate greater than 60% exact agreement when the selected frequency of consumption is compared (i.e., 1/2 cup of carrots consumed 2-4 times per week); 90% agreement has been observed if "agreement" is relaxed to within one (plus or minus) frequency category (i.e., if the frequency of consumption selected on the first SQFFQ is 1/2 cup carrots 2-4 times per week, acceptable answers on the second SQFFQ can range from "1 per week" to "5-6 per week" for "agreement") (Sampson, 1985). Validity studies have been conducted by comparing responses to FFQs with data from diet histories, food diaries, weighted food records, 24-hour diet recalls and biochemical data. In general, correlations between 0.5 and 0.8 are considered reasonable (Sampson, 1985). Nutrients with correlation values lower than this, typical of vitamin A (Beaton, 1979; Willett, 1988), should be used with caution in hypothesis testing.

Diet Quality

For the many reasons cited above, one of the most pressing, unresolved issues in the field of nutrition is the quantification of the impact of the quality of diet consumed prior to and during pregnancy on infant birth weight (Brown, 1989). Although many studies have investigated the relationship between single nutrient intakes (i.e., protein, calories) and pregnancy outcome, few studies have looked at the relationship between the overall quality of dietary intake, antenatal weight gain and infant birth weight. Two reasons for this include:

1) the lack of a commonly accepted, quantifiable definition of "diet quality" and 2) the difficulty in isolating the effect of diet quality, per se, from the effect of numerous confounding variables known to influence birth weight. Thus, the effect of diet quality on antenatal weight gain and infant birth weight remains poorly understood.

The purpose of this section of the literature review is to define "diet quality", to review four methods to quantify diet quality, and to summarize results of the few studies in which diet quality has been associated with pregnancy outcome.

Diet Quality: A Definition

A diet is comprised of individual foods that provide nutrients which fulfill three generalized functions: 1) provide energy, 2) build and maintain body tissue and 3) regulate body processes (Guthrie, 1977). If a diet is to be rated "nutritious", it should provide, at close to recommended levels, all nutrients for which standards have been established (Guthrie, 1977). A "high quality diet" implies nutritional adequacy (Krebs-Smith et al, 1987), but few researchers have explicitly defined the term. For purposes of this paper the term "diet quality" will be defined as the nutritional adequacy of the diet consumed as compared to the National Research Council's Recommended Dietary Allowances (NRC-RDA, 1989). "Diet quality" will be measured by four different "Diet Quality Scores", each being a numeric description of the quantity of select nutrients consumed compared to the established standard at the time this study was published. A summary of these scores

can be found at the conclusion of the diet quality section of this literature review (Table 2.7).

Methods to Assess Diet Quality

Several methods have been used to measure diet quality. None is considered ideal (Tseng et al, 1986). Five methods of quantifying diet quality will be presented: 1) the Diet Score Rating, 2) the Nutrient Adequacy Ratio (NAR) and Mean Adequacy Ratio (MAR) Score, 3) the Index of Diet Quality (IDQ), also known as the Nutrient Sum Score (NSS), 4) the Index of Nutritional Quality (INQ), also known as the Index of Food Quality (IFQ) and 5) the concept of indicator nutrients.

Burke's Diet Score Rating.

One of the earliest methods used to quantify diet quality was the Diet Score Rating developed by Burke et al (1943a). Burke's Diet Score Rating categorized diets from "very poor" to "excellent" based on the percentage of the Recommended Dietary Allowance (RDAs) consumed (NRC-RDA, 1941). If 100% or more of the RDA for a nutrient was consumed, a score of 4 (excellent) was given; if 80-99% of the RDA was consumed, a score of 3 (good) was given; if 60-79% of the RDA was consumed, a score of 2 (fair) was given; if 50-59% of the RDA was consumed, a score of 1 (poor) was given; lastly, if less than 50% of the RDA for any nutrient was consumed over the time period measured, a score of 0 (very poor) was recorded. Then, the mean of the scores for eight specified nutrients (protein, calcium, iron, vitamins C, A, thiamin, riboflavin and niacin)

was determined. The resulting number was used to rate the diet as "very poor" (0) to "excellent" (4) and was called the "Diet Score Rating".

Burke used the Diet Score Rating to study the relationship between diet and birth outcome in 216 women chosen from the prenatal clinic of the Boston Lying-in Hospital (Burke et al, 1943a). Food records were collected for three consecutive days during each trimester throughout the women's pregnancy. The diets were analyzed, compared to the 1941 RDAs (NRC-RDA, 1941), and the Diet Score Rating determined. Burke reported that, of those women with "good" or "excellent" prenatal diets (n=31), 68% (n=21/31) had a normal prenatal course; the incidence of pre-eclampsia in this group was zero. Conversely, of those women consuming "poor" to "very poor" diets (n=36), only 42% (n=15/36) had a normal prenatal course, while 58% (n=21/36) had complications such as severe nausea and vomiting, edema, severe anemia and staining. Forty-four percent of the women consuming "poor" or "very poor" diets (n=16/36) were diagnosed with pre-eclampsia. Mean birth weight and length both increased concomitantly with the Diet Score Rating ("very poor" = 2637 g, "fair" = 3374 g, "excellent" = 3856 g). Lastly, when physicians rated the babies' physical condition (fair-good-superior) without prior knowledge of the mothers' diet quality score, 56% of babies rated "superior" were born to mothers consuming "good" or "excellent" diets, with only 9% of the babies rated "superior" born to mothers consuming "poor" or "very poor" diets. Conversely, of the babies whose physical condition was rated "fair", only 1% were born to mothers consuming "good" or "excellent" diets while 87% were born to mothers consuming "poor" or "very poor" diets. Burke concluded that the Diet

Score Rating appeared to be positively, linearly related to pregnancy outcome.

Margaret Moore et al (1947) used the Burke "Diet Score Rating" to analyze the relationship between diet quality and stillbirth/infant mortality rate in 69 black and 90 white women at the Tulane University School of Medicine. Moore et al collected diet records for seven consecutive days from each subject once during either the second or third trimester of pregnancy. Three to five visits to each subject's home were made during the recording period in an attempt to increase the validity of the food records. The records were subsequently analyzed, compared to the 1945 RDAs (NRC-RDA, 1945) and categorized according to the method of Burke et al (1943a). Moore found only 4% of the white, and none of the black, women met or exceeded the RDA for the eight nutrients analyzed. Forty percent of the white, but only 13% of the black, women's diets were rated "excellent" or "good"; 49% of the black, and 21% of the white, women's diets were rated "poor" or "very poor". The incidence of stillbirth and infant death did not differ significantly among groups. Moore did not compare the diet ratings to birth weight, gestational weight gain or infant/maternal morbidity.

Nutrient Adequacy Ratio (NAR) and Mean Adequacy Ratio (MAR) Score.

Maddens and Yoder (1972) were the first to develop the Nutrient Adequacy Ratio (NAR) and Mean Adequacy Ratio (MAR) Score as an overall index of dietary adequacy. A NAR is calculated by dividing the actual intake of a nutrient by that nutrient's RDA and multiplying by 100. For example, if a woman consumed 2.3 mg of vitamin B-6, her NAR-B6 would be

$(2.3 \text{ mg B-6 intake} / 2.6 \text{ mg B-6 RDA}) \times 100 = 88\%$. If a person consumed more than 100% of the RDA for any nutrient, that NAR would be truncated at 100%. This prevents the score from being weighted by a nutrient(s) consumed in excessive quantities. The NARs for select nutrients are summed and their average determined. This average of several select NARS is called the Mean Adequacy Ratio (MAR). Thus, the MAR is an index of the percent of recommended intake consumed for several select nutrients.

Phillips and Johnson (1977) used the NAR and MAR concept to examine the relationship between a mother's diet quality during the second half of pregnancy and her baby's birth weight. Forty-seven rural Wisconsin women were instructed to complete a daily food record sheet every eighth day until delivery to estimate dietary intake. A total of 592 food records (range=3 to 30 per person; median=13) were collected. An average of all food records returned was used to estimate each individual's mean daily nutrient intake and a NAR index for 12 nutrients (protein, calcium, iron, vitamin A, vitamin C, thiamin, riboflavin, niacin, magnesium, pantothenic acid, pyridoxine and cobalamin). All values were truncated at 100. Each individual's 12 truncated nutrients were then summed and averaged to create a MAR-12 diet quality score. Calories were not included in the analysis.

The mean group MAR among the 47 subjects was 75 ± 13 (44 to 95). Results indicated a significant, positive correlation ($r=0.30$, $p < 0.05$) between birth weight of the infant and overall quality of the mother's diet (MAR-12). A weak correlation between birth weight and calcium intake ($r=0.25$, $p < 0.10$) and birth weight and magnesium intake ($r=0.26$, $p < 0.10$) was noted. Interestingly, while the MAR-12 index correlated

positively with birth weight, ten of the 12 individual nutrients did not. Birth weights of the 47 infants ranged from 2240 to 4578 g, with a mean birth weight of 3451 ± 491 g. Mean weight gain during prenatal care was 25 ± 9 pounds and ranged from 2.5 to 43.5 pounds. The correlation between MAR-12 and weight gain during pregnancy was not significant ($r=0.27$, $p > 0.10$). The correlation between caloric intake and weight gain was not determined. No detectable changes in dietary intake were noted from the 22nd week to the end of pregnancy. Smoking was negatively related to both weight gain during prenatal care ($r=-0.44$, $p < 0.01$) and birth weight ($r=-0.42$, $p < 0.01$). Those who reported smoking nine to 40 cigarettes per day had a MAR-12 index of 69 ± 13 ($n=8$) compared to 76 ± 11 ($n=32$) for nonsmokers ($p < 0.10$), with the lower MAR-12 index of smokers attributable to lower intakes of all 12 nutrients. Caloric intake was not reported. The mean infant birth weight of the 8 smokers was 3009 ± 457 g, significantly less than the 3540 ± 468 g ($p < 0.01$) in non-smokers. Weight gain during pregnancy was positively related to average daily protein intake ($r=0.31$, $p < 0.05$). Four multiple regression equations which included from nine to twelve independent variables related to birth weight (i.e., MAR-12, smoking, weight gain) were calculated. The percent variation in birth weight explained by the regression equation ranged from 76-86%. Inclusion of the MAR-12 in each equation resulted in a 6-7% increase in the coefficient of determination. The authors summarized that use of an index of dietary quality, such as the MAR-12, provides a way to examine the effect of nutrients on birth weight.

Worthington-Roberts (1989) used the MAR concept to determine if a relationship existed between overall diet quality and cravings in a

group of 173 lactators and 195 non-lactators. Worthington-Roberts calculated a MAR-16 which included NARs for calories, protein, vitamin A, vitamin D, vitamin E, vitamin C, thiamin, riboflavin, niacin, B-6, B-12, calcium, iron, magnesium, zinc and folic acid. When the MAR-16 was included in the regression analysis, it failed to explain any significant portion of the variance in total cravings.

Krebs-Smith (1989) used both a MAR-11 and a MAR-4 score as the standard against which a simplified food frequency score was validated. The MAR-11 formula included protein, calcium, iron, magnesium, phosphorus, vitamin A, thiamin, riboflavin, vitamin B-6, vitamin B-12 and vitamin C. The MAR-4 formula, used to analyze the diets of pregnant and lactating women, included calcium, magnesium and vitamins A and C. These nutrients were identified as "problem nutrients", or nutrients with an average NAR below 80 for pregnant and lactating women in 274 participants in the USDA's 1977-78 Nationwide Food Consumption Survey.

Index of Diet Quality (IDQ) or Nutrient Sum Score (NSS).

The terms "Index of Diet Quality" (IDQ; Worthington-Roberts, 1989) and "Nutrient Sum Score" (NSS; Abdel-Ghaziz, 1974) are identical measures of diet quality. The NSS and IDQ both indicate the total number of nutrients for which the intake meets or exceeds 67% of the RDA selected. Arbitrary cut-off points can then be selected to categorize the quality of the diet or the number can be entered into a regression equation to determine the relationship between IDQ and some outcome variable.

Worthington-Roberts (1989), in addition to calculating the MAR-16, calculated an IDQ-16 to determine if a relationship existed between

overall diet quality and cravings in a group of lactators and non-lactators. The IDQ-16 was calculated by counting the number nutrients consumed in amounts greater than 67% of the RDA (NRC-RDA, 1980). Because 16 components were considered, the maximum IDQ was 16. Although both lactators and non-lactators consumed relatively poor quality diets, the IDQ-16 of the lactators was significantly greater than non-lactators (9.84 vs 8.5, $p < 0.001$). No correlation was found between total cravings and the IDQ-16 score.

Index of Nutritional Quality (INQ).

The concept of nutrient density, a comparison of a food's nutrient content in relation to its energy value, was the basis for the Index of Food Quality (IFQ), later renamed the Index of Nutritional Quality (INQ). The INQ was first presented by Hansen (1973) and Sorenson (Sorenson and Hansen, 1975). The INQ is a numerical score based on the nutritive content of a food and the human allowance for nutrients (Tseng et al, 1986). The United States Recommended Daily Allowance (USRDA) (FDA, 1973), a standard established for nutritional labeling to guide food selection of the population, is often used as the standard against which a food's nutritional content is compared. Because there is no USRDA for energy, 2300 calories is usually chosen as the energy standard (Sorenson et al, 1976). An INQ can be calculated as follows (Tseng et al, 1986):

$$\text{INQ} = \frac{\text{Amount of nutrient in a food sample/US-RDA for that nutrient}}{\text{Number of calories in a food sample/Energy Requirement}}$$

When a specific nutrient in a food has an INQ greater than one, it denotes a relatively higher nutrient-to-calorie contribution than the US-RDA. Conversely, INQ values less than one would identify nutrients in foods of which an excess of calories must be consumed in order to meet the US-RDA for these nutrients (Hansen, 1973; Wyse et al, 1976). Guthrie (1977) suggested classifying a food as nutritious if the INQ for each of four of the eight nutrients required for nutrition labeling was at least one, or if the INQ for two of the eight nutrients was at least two.

Hansen and Wyse (1980) demonstrated that, if the Recommended Dietary allowances (RDAs) were recalculated per 1000 calories (RDA-1000, the RDAs would be constant across all age and sex categories for most nutrients. Nutrient density scores based on the RDA-1000s allows diets of all energy levels, consumed by individuals of all ages and sexes, to be compared due to the common denominator. This method also allows diets of individuals who overestimate or underestimate total dietary intake to be compared. Index values based on 1000 calories of food are calculated as follows (Hansen and Wyse, 1980):

$$\text{INQ-1000} = \frac{\text{Amount of nutrient in 1000 calories of food}}{\text{Human allowance of the nutrient per 1000 calories}}$$

Nutrient density profiles can be developed using either formula (INQ or INQ-1000). To date no researcher has summed and averaged INQs or INQ-1000s for several nutrients to create a single index of dietary nutrient density.

Indicator Nutrients.

Pennington (1976) attempted to identify "indicator nutrients" that, if supplied at adequate levels in a diet, would indicate the probable presence of adequate levels of other nutrients in the diet. A correlation matrix was developed among 45 nutrients and then "eye-balled" to select those nutrients which were highly correlated. Pennington ultimately selected seven indicator nutrients: pyridoxine, vitamin A, calcium, iron, folic acid, magnesium and pantothenic acid. This work was criticized (Jenkins and Guthrie, 1984) for being based on only 202 foods consumed in 100 g portions, and for using a database for which three of the seven selected nutrients were incomplete. Subsequently, Jenkins and Guthrie (1984) analyzed 3318 three-day records from the 1977-1978 Nationwide Food Consumption Survey for 13 vitamins and minerals, carbohydrate and protein. A correlation matrix between the 15 nutrients was constructed and submitted to a factor analysis with an orthogonal varimax rotation. Four factors, or groupings of alike nutrients, were identified. From the grouping, four index nutrients, iron, pyridoxine, calcium and vitamin A, were selected. To date, however, no study has been identified in which these four indicator nutrients were used in a MAR index.

In sum, "Diet quality" was defined as "the nutritional adequacy of the diet consumed as compared to some standard", usually the RDAs (NRC-RDA, 1989) or the USRDAs (FDA, 1973). Five methods of quantifying diet quality were presented. Although several measures of diet quality exist, none is considered ideal (Tseng et al, 1986).

Conclusion: Diet Quality and Pregnancy Outcome

The magnitude of nutritional effects on low birth weight are not easily assessed because nutritional status is difficult to isolate from other socioeconomic characteristics and because the complicated relation between prepregnant weight and weight gain during pregnancy. While researchers have found positive correlations between birth weight and nutritional status, there is wide variability in the degree of these associations. A reasonable conclusion, based on both animal and human studies, is that poor nutritional status before pregnancy and inadequate nutritional consumption during pregnancy appear to have a negative impact on fetal weight gain, thereby increasing the risk of low birth weight.

Table 2.7. Comparison of nutrients used to calculate various diet quality scores.

Author:	Worthington-Roberts	Krebs-Smith	Jenkins/Guthrie	Phillips/Johnson
Year:	1989	1989	1984	1977
Formula:	MAR-16 and IDQ-16	MAR-11 and MAR-4 *	Indicator Nutrients	MAR-12
Nutrients:	calories protein vitamin A vitamin D vitamin E vitamin C thiamin riboflavin niacin B-6 B-12 calcium iron magnesium zinc folic acid	protein * vitamin A * vitamin C * thiamin riboflavin B-6 B-12 calcium iron magnesium * phosphorus	vitamin A B-6 calcium iron	protein vitamin A vitamin C thiamin riboflavin niacin B-6 B-12 calcium iron magnesium pantothenic acid
Purpose:	Relation between diet quality and cravings in a group of lactators and nonlactators.	Validate a simplified food frequency form.	Did not use in a diet quality score; were identified in factor analysis as nutrients which represented total nutrient intake.	Examine relation between diet quality & birth weight in regression analysis.
Results:	No relation between diet quality/cravings were observed with either MAR-4 or MAR-16 in multiple regression analysis.	MAR-4 & MAR-11 were used as the "gold standard" in sensitivity and specificity formulas.		Explained 6-7% of the variance in birth weight.

Maternal Attitude

In addition to medical, sociodemographic and behavioral risk factors, several researchers have tried, with variable success, to correlate psychosocial conditions (i.e., stress, social support system, beliefs and superstitions) with pregnancy outcome (Mamelle et al, 1989; Newton and Hunt, 1984; Nuckolls et al, 1972; Pascoe et al, 1984). This section of the literature review will focus on those few studies which have attempted to determine what relationship, if any, exists between attitudes during pregnancy and pregnancy outcome.

Attitude Toward Weight Gain During Pregnancy

Palmer et al (1985) developed a questionnaire with 18 statements expressing attitudes of pregnant women toward their own pregnancy weight gain. Attitudinal data was obtained prospectively from 29 white, middle-class women enrolled in childbirth classes in Pullman, Washington. Actual weight gain information and infant birth weight were obtained from the participant's physician. Reliability of the Likert-format attitude questionnaire was determined by the Spearman Brown Prophecy split-half formula ($r=0.67$). Scores of the 18 weight gain attitude statements were summed and averaged to yield a composite attitude score for each participant. Possible scores ranged from 1.00 (a very negative attitude toward weight gain) to 5.00 (a very positive attitude toward weight gain during pregnancy).

Questionnaire scores of the 29 subjects ranged from 2.11 to 4.33 (median=3.06; mean score=3.12). The investigators chose to dichotomize the data and analyze results using the nonparametric Chi square test. Any attitude score greater than or equal to 3.00 was classified as a positive attitude (n=17); any score less than 3.00 was classified as a negative attitude (n=12). Mean scores were 3.42 and 2.72 for the positive and negative attitude groups, respectively. No significant relationship was observed between attitude classification and age, number of previous pregnancies or knowledge of appropriate weight gain. There was, however, a significant relationship between the women's weight gain attitude score and actual weight gain (Chi square=5.62, $p < 0.025$), and between weight gain attitude score and the physician's weight gain recommendation (Chi square=4.99, $p < 0.05$). Significant relationships were also indicated between actual weight gained and one's knowledge of appropriate weight gain (Chi square=3.93, $p < 0.05$), and actual weight gained and doctor's weight gain recommendation (Chi square=4.55, $p < 0.05$). Lastly, there was a significant relationship between birth weight and actual weight gain (Chi square=9.35, $p < 0.01$). The relationship between weight gain attitude score and infant birth weight was not determined in this small study.

Pomerance et al (1980) surveyed 195 pregnant women to determine their attitudes toward dieting and weight gain during pregnancy. The researchers asked how much weight the subjects thought they should gain during pregnancy, whether the subject ever dieted immediately before going to the doctor's office, and whether the subject felt her doctor would be upset by "too little" or "too much" weight gain.

Thirty-seven percent of patients believed they should gain 20 pounds or less during pregnancy, 52% responded 21-30 pounds, and four percent thought they should gain more than 30 pounds. Eight percent admitted to dieting before at least one antenatal visit. Although the terms "too little weight gain" and "too much weight gain" were not defined, more patients thought their doctors would be more concerned with "too much" (88%), than "too little (39%), weight gain. No attempt was made in this study to correlate attitude toward weight gain with actual weight gain or with infant birth weight. The authors concluded that, in this select group of pregnant patients, there were substantial deficiencies in the understanding of nutritional guidelines and weight gain in pregnancy, and that obstetricians play a key role in determining dietary practices.

Attitude Toward Nutrition During Pregnancy

Schwartz and Barr (1977) surveyed 150 mothers of newborns in Vancouver to determine their attitudes and practices regarding maternal and infant nutrition. The objective of the study was to provide background information and direction to health professionals involved with the planning of prenatal programs and to identify means through which sound nutrition information could be communicated to the maternal population. The subjects answered 23 statements reflecting their attitude toward various aspects of nutrition during pregnancy and infancy. Each of the 23 attitude statement was scored from zero (negative attitude, incorrect belief) to seven (positive attitude, correct belief). The scores were totaled and a percent-correct score

determined (i.e., "X" points/161 possible points x 100). This score was considered the "attitude toward nutrition during pregnancy and infancy" construct. Demographic data were obtained from the patients' medical charts.

Results indicated the physician was the major source of nutrition information for the pregnant women (62.2%). The highest mean score of 6.8 (maximum=7) was obtained for the attitude statement "Good eating habits during pregnancy are very important to the baby's health". One of the lowest mean scores (4.4) was obtained for the attitude statement "Weight gain during pregnancy should be kept down to 20 pounds to make delivery easier". This score indicated many women agreed with this statement (i.e., the "correct" answer of 7.0 would have been obtained by disagreeing with this statement).

Variables positively related to this 23-question nutrition attitude score included a nuclear family structure ($p < 0.01$), higher socioeconomic status ($p < 0.00001$), having completed a high school education or more ($p < 0.001$) and attendance at prenatal classes ($p < 0.001$). Women who listed prenatal class instructors as their major source of prenatal nutrition information, as opposed to their physician or other source, had significantly higher (more positive) nutrition attitude scores ($p < 0.01$). In contrast, women who named their physician as a source of nutrition information had significantly lower nutrition attitude scores. No information was presented correlating nutrition attitude scores to either the amount of weight gained during pregnancy, birth weight of the infant, or the quality of the mother's diets during pregnancy.

Rosander and Sims (1981) developed and tested an affective-based nutrition education program that promoted improvement of attitudes about nutrition and health as a way to improve dietary behavior during pregnancy. The study was designed to test the hypothesis that behavior change is dependent upon attitude change, and that attitude change precedes both knowledge acquisition and behavior change. The program was tested on a group of 23 WIC participants who attended three affective-based nutrition education lessons. Results were compared to a group of 22 WIC participants who completed a pre- and post-test but did not attend the nutrition classes. Evaluation instruments included a nutrition knowledge test, two attitude questionnaires and a food frequency form. The 14-item attitude questionnaire, consisting of a five-point Likert scale ranging from "strongly agree" (1) to "strongly disagree" (5), contained four or five items for each of three a priori attitude constructs as suggested by Sims (1981). Factor analysis was used to determine the unidimensionality of the attitude questionnaire and to validate the a priori attitude constructs. Results of factor analysis resulted in the original three constructs and 14 items being reduced to two constructs: "Personal Control over Eating Habits" (4 items) and "Food's Effect on Health and Feelings" (5 items). The Cronbach alpha coefficient of reliability for the two scales were 0.63 and 0.64, respectively.

An adaptation of the Dietary Assessment Screening Tool, developed by the California Department of Health Services (Forester and Reynolds, 1979), was used by Rosander and Sims to assess dietary behavior. This tool gave point values for frequency of consumption of each of the

following seven food groups: dairy products, animal protein, vegetable protein, fruit or juice, folacin-rich vegetables, other fruits and vegetables and breads and cereals. A dietary score was computed for each food group and for the total diet.

Results indicated a significant, positive increase in nutrition knowledge ($p < 0.001$) among those subjects who participated in the three affective-based nutrition education interventions. No differences were found between the uninstructed and instructed groups' mean pretest attitude scores on either of the two scales. Upon post-testing, the instructed group had significantly greater mean attitude scores than their own pretest scores ($P < 0.01$) and the post-test scores of the uninstructed group ($p < 0.001$). After nutrition intervention, in addition to developing a more positive attitude toward nutrition, the instructed group presented improved dietary scores for all food groups. Statistically significant improvements in nutrition behavior (dietary intake) were noted for the three targeted food groups (dairy, green vegetable and breads and cereals), as well as in the total diet score.

The authors concluded that, among the WIC clients who attended three sessions, the affective-based approach to nutrition education improved nutrition knowledge, attitudes and behaviors. Neither the correlation between total dietary score and nutrition knowledge, attitude score or infant birth weight were presented.

Anderson and Shepherd (1989) developed a questionnaire to identify the beliefs and attitudes that surround healthful food choices during pregnancy. The aim of their study was to evaluate the role of Fishbein and Azjen's (1975) "expectancy value model" in predicting intention to

try "healthful eating" during pregnancy in order to identify specific variables to target in ante-natal nutrition education programs. The Fishbein and Azjen model states that the two theoretically-linked constructs, attitude (personal feelings) and subjective norm (social pressure), are central to the prediction of the intent to perform a specific behavior. Attitude, in turn, is predicted by individual's beliefs about the outcome of the behavior (i.e., breastfeeding is beneficial to the baby), and modified by the evaluation of the outcome (i.e., whether or not you are concerned about the benefits breastfeeding offers the baby). The subjective norm is predicted by the normative beliefs about whether the individual thinks specific individuals or referents prefer them to act a certain way (i.e., the doctor, husband or mother-in-law think breastfeeding is important to the baby), modified by the individual's motivation to comply with the wishes of these influential individuals.

The questionnaire, comprised of 25 statements with a seven-category Likert response, was completed by 95 women at the Aberdeen Maternity Hospital. Content, face and construct validity were determined. Five constructs (behavioral intention, direct attitude, direct subjective norm, estimated attitude and estimated subjective norm) were designed. Reliability was assessed by Cronbach's alpha. More than half of the women indicated a positive intention to try eating healthier while pregnant. Scores for behavioral intention were strongly correlated with scores for direct attitudes ($r=0.50$, $p < 0.001$), which, in turn, correlated well with estimated attitudes ($r=0.30$, $p < 0.002$). The authors did not correlated any attitude construct with infant birth

weight or with any measure of actual dietary intake. Results suggested a more beneficial educational technique to change dietary habits during pregnancy would be to focus on underlying beliefs and attitudes about nutrition during pregnancy and infancy, rather than simply concentrating on information transfer.

Attitude Toward Being Pregnant and Pregnancy Outcome

Although a causal relationship between a mother's attitude toward being pregnant and negative consequences is plausible (Pohlman, 1969), few data have been published to support or refute this hypothesis. Laukaran and van den Berg (1980) investigated the relationship of maternal attitude toward being pregnant to pregnancy outcome and obstetrical complications in a prospective study of 8,000 gravidas enrolled in the Child Health and Development Study of the Kaiser Foundation Health Plan in San Francisco. Interviews were conducted early in pregnancy. The mother's attitude was determined through a single, open-ended question, "How do you feel about having a baby now?". The responses were categorized as strongly favorable (56.4%), moderately favorable (15.0%), ambivalent (22.4%) and negative (6.2%). Data on pregnancy outcome, duration of labor, analgesic use, pregnancy complications and prenatal accidents were abstracted from the women's medical records.

After controlling for parity, husband's occupation and age of the mother, Cochran's Chi-square and the Mantel-Haenzel adjusted relative risk (RR) were used to compare the risks between the "definitely wanted" and the "definitely unwanted" pregnancies. Women with moderately

positive and ambivalent attitudes were disregarded in the analysis. A negative maternal attitude toward being pregnant was related to an increased incidence of perinatal death (fetal death at 120+ days and neonatal death within 28 days following birth; $p < 0.003$, $RR=1.80$), congenital anomalies ($p < 0.04$, $RR=1.45$), postpartum infection or hemorrhage ($p < 0.004$, $RR=1.66$), clinic visits for psychological complaints related to anxiety state ($p < 0.0001$, $RR=2.66$), accidental injury during pregnancy ($p < 0.00001$, $RR=1.45$) and the need for analgesics during labor ($p < 0.0001$, $RR=1.40$). Maternal attitude toward the pregnancy was not related to infant birth weight, duration of gestation, length of labor, prenatal complications (i.e., eclampsia, pre-eclampsia, placenta previa prior to labor, incompetent cervix or premature rupture of the membrane) or intrapartum obstetrical complications (i.e., hemorrhage, placental abnormalities, prolapsed cord, meconium staining or intrapartum transfusion). Confidence intervals for the relative risks were not reported. These results offer justification for considering maternal attitude a clinically meaningful risk factor regarding fetal outcome.

Conclusion: Attitude and Pregnancy Outcome

Few studies have addressed the relationship between maternal attitudes during pregnancy and maternal weight gain, diet quality or pregnancy outcome. Researchers in this area have not agreed on either a universal definition of "attitude" or appropriate techniques to measure and/or analyze attitude constructs (Sims, 1981). Furthermore, no study to date appears to have investigated the relationship between attitudes

toward specific constructs and subsequent infant birth weight. Additional research is needed before it can be determined if one's attitude toward weight gain during pregnancy, or toward being pregnant in general, influences actual weight gain and/or subsequent infant birth weight, or if one's attitude toward nutrition during pregnancy influences actual dietary intake and/or infant birth weight.

Health Care Risks

Two health care risks have been associated with an increased incidence of LBW: 1) absent/inadequate prenatal care and 2) iatrogenic prematurity, i.e., premature delivery due to some medical intervention (Institute of Medicine, 1985). This section of the literature review will focus only on the relation of prenatal care to birth weight.

Prenatal Care

In this century, the health care service most relied upon to assure positive pregnancy outcome has been prenatal care (DHHS, 1989b). In general, women who receive prenatal care during the first trimester have better pregnancy outcomes than women who have little or no prenatal care (NCHS, 1988).

The recent report Caring for Our Future: The Content of Prenatal Care (DHHS, 1989b, p. 5) stated the objectives of prenatal care for the pregnant woman are: 1) to increase her well-being before, during and after pregnancy, and to improve her self-image and self-care, 2) to

reduce maternal mortality and morbidity, fetal loss and unnecessary pregnancy interventions, 3) to reduce the risks to her health prior to subsequent pregnancies and beyond childbearing years and 4) to promote the development of parenting skills. Objectives for the fetus and the infants are: 1) to increase well-being, 2) to reduce preterm birth, intrauterine growth retardation, congenital anomalies and failure to thrive, 3) to promote healthy growth and development, immunization and health supervision, 4) to reduce neurologic, developmental and other morbidities and 5) to reduce child abuse and neglect, injuries, preventable acute and chronic illness and the need for extended hospitalization after birth.

Despite these well-intentioned objectives, results of an investigation by the Alan Guttmacher Institute (AGI, 1986) estimated 34% of pregnant women, some 1.3 million each year, are getting what is generally considered insufficient prenatal care. An estimated 662,000 do not begin care until the second trimester of pregnancy; 207,000 do not start until the third trimester or get no care at all. An additional 393,000 initiate care in the first trimester, but make very few visits. The percentage of women getting insufficient care is highest among the unmarried (58%), teenagers (56%), the least-educated (53%), blacks (51%), Hispanics (47%) and the poor (47%) (AGI, 1986). Women make an average of 10.5 prenatal visits, somewhat fewer than the 13 recommended by the American College of Obstetricians and Gynecologists (ACOG, 1982), but more than the nine and seven visits recommended by the Panel on the Content of Prenatal Care (NCHS, 1989) for the low-risk, nulliparous, and low-risk parous women, respectively.

Because of the widely-recognized importance of early prenatal care on the health of the mother and the baby, the U.S. Surgeon General set a goal of early (first trimester) prenatal care for 90% of all expectant mothers by the year 1990 (DHHS, 1979). A mid-course review of this objective determined in 1984, 20.4% of white mothers, 37.8% of black mothers, 40% of American Indian mothers and 43% of Hispanic mothers received no prenatal care during the first trimester (DHHS, 1986).

In addition to a two-fold increased risk for delivering a low birth weight baby (10% vs 5%), women who do not obtain sufficient prenatal care are more likely to deliver prematurely (13% vs 8%), and to gain too little weight during pregnancy (28% vs 21%) (AGI, 1986). Twenty-eight percent of women who do not see a physician until they are in labor, as compared to 10% of women who get at least some prenatal care, deliver prematurely; 27% of those who did not seek prenatal care delivered a low birth weight infant, compared to 7% of women who obtained some prenatal care (AGI, 1986). Data from the National Infant Mortality Surveillance (NIMS) project indicated the infant mortality rate among newborns whose mothers' obtained prenatal care during the first trimester was 9.7 per 1000 live births. The IMR rose to 12.5 deaths when care was initiated later in pregnancy, and jumped to 48.7 deaths per 1000 cases when the mother obtained no prenatal care at all (an estimated 2% of pregnant women) (Hogue, 1987).

In Michigan, in 1987, 82.7% of white infants, compared to 68.4% of black infants, were born to mothers who began their prenatal care in the first trimester, with 41.3% of these women initiating care during the second month of pregnancy (MDPH, 1989). The median number of prenatal

visits was 12, 11.8 for mothers of white infants, and 11.3 visits for mothers of black infants. Almost two-thirds (61.9%) of all live births were to women receiving 10-14 prenatal visits. In 1987, 1,303 resident births (9.3 per 1,000) were to women with no prenatal care (as recorded on the birth certificate). The lack of prenatal care was disproportionate among younger mothers and among mothers of black infants. The ratio of live births in which the mother received no prenatal care, to the total number of live births, was almost five times as large for black infants as for white infants (26.5/1000 vs 5.4/1000, respectively) (MDPH, 1989).

The Kessner Index is a measure of the quality of prenatal care obtained during pregnancy. It combines information on the month prenatal care began, the gestational age at birth and the number of prenatal visits. Three levels of prenatal care are defined (MDPH, 1989):

1) Adequate Prenatal Care is defined as care which began within the first trimester and which included an average of at least one or two additional prenatal visits per month of gestation, depending on the length of gestation; 2) Intermediate Prenatal Care is defined as care which began during the second trimester, with corresponding fewer visits, or which began during the first trimester but with fewer visits than would be appropriate for the length of gestation; 3) Inadequate Prenatal Care is defined as care beginning in the third trimester, having had no prenatal care or beginning care during the first or second trimester but less than five visits occurred, when the length of gestation was 34 weeks or more. When the length of gestation was less than 34 weeks, care is defined as inadequate when care began during the

first or second trimester, but even fewer than five visits occurred. In Michigan, the Kessner Index can be calculated from data available on the birth certificate.

In Michigan in 1987, adequate prenatal care was obtained by 73.1% of mothers who delivered live births (75.5% white, 61.8% black). The incidence of low birth weight among infants of mothers who obtained adequate care according to the Kessner Index was 59.5 per 1,000 live births (47.3/1,000 white, 124.0/1,000 black). Inadequate care was received by 6.1% of Michigan mothers (5.2% white, 10.1% black). The incidence of low birth weight among infants born to mothers with inadequate care rose significantly from 59.5/1,000 to 137.6/1,000 (97.3/1000 white, 230.0/1,000 black). The incidence of LBW among infants whose mothers obtained intermediate care was 92.7/1,000 (72.9/1,000 white, 149.9/1,000 black) (MDPH, 1989).

Clearly, adequate prenatal care was associated with a reduced incidence of low birth weight in Michigan. Reducing barriers to prenatal care will require changes in public policy and delivery of health care services (DHHS, 1989). Until that time, the ability of this nation to meet the goal of increasing the proportion of all pregnant women who receive prenatal care in the first trimester to 90%, first established by the U.S. Surgeon General in the Year 1990 Health Objectives for the Nation (DHHS, 1979), and repeated in the draft copy of the Year 2000 Health Objectives for the Nation (DHHS, 1989a), appears unrealistic.

Summary

This review of the literature identifies five major categories of risk factors associated with low birth weight: 1) demographic factors, 2) medical factors predating pregnancy, 3) medical factors during pregnancy, 4) behavioral and environmental factors and 5) health care factors. The following conclusions represent the principal findings relevant to the current study.

1. Low birth weight is multifactorial; identification of risk factors associated with low birth weight must encompass the "seamless web" (Jacobson, 1986) of factors associated with this condition, including sociodemographic, behavioral, medical and attitudinal factors.
2. A birth weight of 3,500 to 4,000 g appears to be associated with the lowest risk of infant mortality and morbidity and could be considered "optimal".
3. Prepregnant weight status is an important determinant of fetal outcome, independent of antenatal weight gain. Percent of reference weight attained at term (120%) appears to predict optimal outcome, although this hypothesis must be validated in a representative population.
4. The impact of the mother's birth weight on her conceptus' birth weight has a public health programming implication and warrants further research.
5. Research is needed to examine the effect of total diet quality on fetal outcome. Use of a validated food frequency tool to determine nutrient intake and a diet quality score during pregnancy has not been reported in the literature to date.
6. Few studies have investigated the relationship between maternal attitudes and pregnancy outcome. Specific information regarding relationship between attitude toward weight gain and actual weight gain, attitude toward the importance of nutrition during pregnancy and actual quality of the diet and how these behaviors, in turn, impact on birth weight need to be determined.

7. Three studies have indicated an inverse relationship between maternal hemoglobin levels and infant birth weight. This issue warrants further investigation.
8. Research indicates a possible relationship between a low maternal diastolic blood pressure and increased risk for low birth weight. This observation warrants further investigation.
9. Lastly, the interaction of all the above factors should be assessed together to determine the causal pathways that influence infant birth weight.

Based on these observations, the following conceptual framework was developed to identify factors associated with birth weight in Michigan. This model provided the theoretical basis by which the study design, questionnaire items and data analytic techniques were chosen.

CONCEPTUAL FRAMEWORK:
A MODEL TO PREDICT BIRTH WEIGHT

MOTHER'S
BIRTH WEIGHT

BEHAVIORAL
RISK FACTORS
--caffeine
--cigarettes
--alcohol

QUALITY
OF DIET

ATTITUDE
--weight gain
--nutrition
--pregnancy

WEIGHT

WEIGHT
GAIN

REFERENCE
WEIGHT AT
TERM

BIRTH

PRENATAL
CARE

CLINICAL
PARAMETERS
--DBP
--Hct/Hb

SOCIAL SERVICE
PARTICIPATION

SOCIODEMOGRAPHIC
RISK FACTORS

CHAPTER III

OPERATIONAL DEFINITIONS

The following list of definitions were used to drive the data collection and analysis, both conceptually and operationally.

OUTCOME VARIABLES

Birth Weight: Weight of infant at time of delivery in grams.

Low Birth
Weight (LBW): Birth weight less than 2,500 grams.

Optimal Birth
Weight (OBW): Birth weight between 3,500 and 4,000 g (Brown, 1988).

PREDICTOR VARIABLES

Reference Weight-
for-Height (RW): Calculation of each woman's reference weight-for-height based on: 1) the 1959 Metropolitan Life Insurance Company's reference standard for women without shoes or clothes (Appendix 3) and 2) the revised 1983 Metropolitan Life Insurance Company's reference standard weight-for-height table (Appendix 4).

Percent Pre-Pregnant
Reference Weight,
(PP-RW): Each woman's self-reported pre-pregnant weight (PPW) will be divided by her 1959 and 1983 RW and multiplied by 100 to calculate a pre-pregnant reference weight-for-height (PP-RW).

Classification
of PP-RW:

Each woman's PP-RW will be used to classify her according to the following categories:

1. Underweight = <90% PP-RW
2. Normal = 90-119% PP-RW
3. Overweight = 120-149% PP-RW
4. Very Overweight = >150% PP-RW

Percent Term

Reference Weight: Calculated by dividing each woman's term weight by her 1959 and 1983 reference weight-for-height and multiplying by 100.

Pre-Pregnant Body

Mass Index (BMI): Each woman's pre-pregnant body mass index (BMI) was determined from her self-reported pre-pregnant weight and height according to the formula:

$$\text{BMI} = \text{weight, kg} / \text{height, m}^2$$

Mother's

Birth Weight:

Self-reported birth weight of the mother who delivered the infant selected for this survey. All birth weights reported in pounds and ounces were converted to grams by use of a standard conversion chart (Appendix 5).

Smoking:

1. Smoked prior to pregnancy.
Self-reported mean number of cigarettes smoked per day prior to pregnancy.
2. Smoked during pregnancy.
Self-reported mean number of cigarettes smoked per day during pregnancy.
3. Change in smoking habits.
The difference (positive, negative, none) in number of cigarettes smoked prior to and during pregnancy; validated by question 13.

Classification
of Smoking:

1. Abstainers = did not smoke.
2. Light smoker = 1-9 cigarettes per day.
3. Moderate smoker = 10-19 cigarettes per day.
4. Heavy smoker = 20 or more cigarettes daily.

Alcohol
Consumption:

1. Alcohol consumption before conception.
Self-reported average number of alcoholic beverages consumed per week or month during the three months prior to conception. A drink was defined as 12 oz beer (1 can), 4 oz wine or 1.5 oz hard liquor.
2. Alcohol consumption during pregnancy.
Self-reported average number of alcoholic beverages consumed per week or month during the subject's pregnancy. A drink was defined as 12 oz beer (1 can), 4 oz wine (1/2 cup) or 1.5 oz hard liquor.
3. Change in alcohol consumption.
The difference (positive, negative, none) in number of alcoholic beverages consumed prior to and during pregnancy; validated by question 12.

Classification
of Alcohol
Consumption:

1. Abstainer/Rare Drinker = less than one drink per month.
2. Light/Moderate Drinker = at least one drink per month, but less than 5 per week (< 50 g/week).
3. Moderate Drinker = five to nine drinks (50-99 g) per week.
4. Heavy Drinker = 10 or more drinks (100 g) per week.

Caffeine Intake: Obtained from the Willett SQFFQ.

Classification of
Caffeine Intake:

1. Abstainer/Low Exposure = < 150 mg caffeine per day.
2. Moderate Exposure = 151-300 mg caffeine/day.
3. High Exposure = greater than 300 mg caffeine/day.

Caloric
Restriction:

Self-reported response to Q.10 "Did you restrict your calorie intake during your pregnancy" and "on whose advice".

Vitamin
Supplementation:

Self-reported response to Q.14 "Did you take a vitamin supplement during your pregnancy" and "on whose advice".

Diet Quality
Score:

Numeric representation of the self-reported quantity of foods and nutrients consumed by the subject, on average, during her pregnancy. Analysis of the Willett SQFFQ was used to calculate three diet quality scores: 1) a MAR-12 score containing the nutrients calcium, iron, zinc, vitamin A, thiamin, riboflavin, pyridoxine, vitamin D, vitamin B12, vitamin E, folacin and vitamin C, 2) a MAR-4 using vitamin A, B-6, calcium and iron, as per the method of Jenkins and Guthrie (1984) and 3) INQ-12 score using these same nutrients, based on the methods of Hansen and Wyse, (1980). All scores were based on nutrient intake without vitamin/mineral supplements as the variable of interest was "diet quality". The RDA/1000 calories was developed using the 1989 RDA's for pregnant women (Table 3-1).:

$$\text{INQ-1000} = \frac{\text{Amount of nutrient in 1000 calories of food}}{\text{Human allowance of the nutrient per 1000 calories}}$$

Table 3.1. Recommended Dietary Allowances (RDA) and RDA/1000 calories for pregnant, adult women (NRC-RDA, 1989).

Nutrient	Recommended Allowance	RDA/1000 Calories
Vitamin A, IU	4000	1600
Vitamin D, IU	400	160
Vitamin E, mg TE	10	4
Vitamin C, mg	70	28
Thiamin, mg	1.5	0.6
Riboflavin, mg	1.6	0.64
Pyridoxine, mg	2.2	0.88
Folacin, mcg	400	160
B-12, mcg	2.2	0.88
Calcium, mg	1200	480
Iron, mg	30	12
Zinc, mg	15	6
Protein, g	60	24
Calories	2500	1000

- Attitude:
1. Toward this pregnancy.
Value recorded by mother (Q.40) ranging from "I wanted this pregnancy", to "I did not want to become pregnant then or at any time in the future".
 2. Toward weight gain during pregnancy.
Mean score of answers given by respondent (Q.18-31) which, in factor analysis, "load" to this concept.
 3. Toward nutrition during pregnancy.
Mean score of answers given by respondent (Q.18-31) which, in factor analysis, "load" to this concept.

Prenatal
Care:

Month prenatal care began and number of prenatal visits as recorded on the subject's birth certificate and the Kessner Index Score as calculated from data provided on the birth certificate.

Kessner
Index:

Classification of prenatal care based on the month of pregnancy in which prenatal care began, the number of prenatal visits and the length of gestation.

1. Adequate Care
2. Intermediate Care
3. Inadequate Care

Education:

That value reported on the birth certificate, given in years of elementary, high school or college attended.

Socioeconomic
Status:

Subjects will be classified according to the 1988-1989 Federal Poverty Threshold Level (effective October 1988) based on family size and net family income. Subjects will be classified into three categories: 1) net income less than 100%, 2) net income greater than 100% but less than 155% and 3) net income greater than 155%. These are the net income cut-offs used for Food Stamps (100%) and WIC (155%) eligibility.

Family Size	100% (Net Income Food Stamp Cap)	155% (Net Income WIC Eligibility)

1	481	746
2	645	1000
3	808	1253
4	971	1505
5	1135	1760
6	1298	2012
7	1461	2265

Public Assistance: Self-reported response to Q.37 in which respondents were asked if they received any assistance from public services or support programs during their pregnancy.

Anemia of Pregnancy: Hematocrit (Hct) and hemoglobin (Hb) values reported by the subject's physician and classified according to Murphy et al (1986).

Classification of Anemia of Pregnancy:

- 1) Deficient = Hb < 10.4 g/dl.
- 2) Moderate = Hb 10.4 - 13.2 g/dl.
- 3) High = Hb > 13.2 g/dl.

Diastolic Blood Pressure (DBP): Value reported by the subjects' physician in mm/Hg.

Classification of Subjects by DBP:

- 1) Low DBP = < 65 mm/Hg.
- 2) Moderate DBP = 65-90 mm/Hg.
- 3) Ideal DBP = 90-99 mm/Hg.
- 4) High DBP = >99 mm/Hg.

CHAPTER IV

METHODS

The purpose of this research was to determine factors which differentiated optimal birth weight (3500 to 4000 g) (Brown, 1988) from low birth weight (less than 2500 g) in Michigan infants. This chapter describes the subject selection, study design, instruments, procedures and statistical analysis used in this retrospective, case-control study. This chapter is divided into three sections: 1) the pilot study, 2) the "Michigan Mothers Survey", a survey of 600 randomly selected white Michigan infants' mothers and their prenatal care providers and 3) "Prenatal Care Survey", a survey of the physician in attendance, as recorded on the birth certificate, of 825 randomly selected black Michigan infants.

Study Approval

Approval to conduct this study was obtained from Michigan State University's (MSU) University Committee for the Review and Investigation of Human Subjects (UCRIHS) (10/11/88; Appendix 6) and the Michigan Department of Public Health's Committee for the Evaluation of Studies

Involving Human Subjects (12/13/88; Appendix 7). In addition, this study was designated as a medical research project under the provisions of the Michigan Public Health Code, P.A. 368 of 1978 as amended, MCL 333.2631-333.2635 (11/23/88; Appendix 8).

Pilot Study

Subjects

Sixty infants (42 black and 18 white) were randomly selected by computer search of the State of Michigan birth certificates dated August 1987 to April 1988. Subjects were included in the sampling frame if the infant's mother was: 1) a black or white Michigan resident 2) between 20-34 years of age and 3) delivered a singleton, who was 4) either her first or second child, 5) assisted by either an MD or a DO, 6) after a gestation period estimated to be between 37 and 42 weeks. The black infant sample frame was subdivided into three birth weight categories: 1) less than 2500 g (n=25), 2) 2500 to 4000 g (n=10) and 3) 4001 to 4500 g (n=7). The white infant sample frame was subdivided into two birth weight categories: 1) 1500 to 4000 g (n=11) and 2) 4001 to 4500 g (n=7).

Design

The pilot study was a retrospective, follow-back study consisting of two surveys mailed to the mother and to the prenatal care provider (physician or clinic) of the 60 randomly selected infants. Protocol followed Dillman's (1978) Total Design Method (TDM).

Instruments

The "Pregnancy Lifestyle Questionnaire" (Appendix 9) and a modified version of the Willett Semi-Quantitative Food Frequency Questionnaire (SQFFQ) (Appendix 10) were sent to each subject. The "Prenatal Care Questionnaire" (Appendix 11) was sent to the physician from whom the mother obtained prenatal care. All questionnaires were evaluated for clarity and accuracy by several graduate students, an education specialist, an epidemiologist, a social survey methodologist and several medical and nutrition experts.

Procedures

The pilot project commenced January of 1989. Names and addresses of the 60 randomly selected infants' mothers were abstracted from the infants' birth certificate. Each mother was sent an individualized letter requesting her participation (Appendix 12). Included with the letter was a copy of the "Pregnancy Lifestyle Questionnaire" (Appendix 9), the Willett SQFFQ (Appendix 10), a number two pencil, a stamped, pre-addressed return envelope, and a plastic bib for the baby as a token of appreciation for completing the survey instruments. A reminder note card was sent one week following the initial mailing (Appendix 13). Three weeks from the initial mailing, a second letter (Appendix 14) and complete survey packet were mailed to each non-responder. All surveys returned with insufficient or incorrect addresses were followed-up by a search of city and telephone directories. Current addresses for nine black subjects (15%) were not located.

Each woman was asked to provide the name and address of her primary prenatal care provider (physician or clinic) and to sign a consent form allowing the release of medical information (Appendix 9, page 7). This individual or clinic was contacted requesting their participation (Appendix 15). A copy of the mother's signed consent form, a stamped, pre-addressed return envelope and a copy of the "Prenatal Care Questionnaire" (Appendix 11) were sent. A reminder note card (Appendix 16) was mailed approximately one week later. Because of the low response rate from black mothers (14%), (Table 3.1), the Prenatal Care Questionnaire (Appendix 11) was sent directly to the physician of record noted on the subject's birth certificate. Therefore, the physicians' response rate for black subjects (33%) is based on the entire sample population (n=42). In contrast, the Prenatal Care Questionnaire was only sent to the white subjects' physician if signed consent was obtained (n=13). Seven completed surveys (54%) were returned (Table 4.1). Any survey received after March 25, 1989 was not included in the analysis.

Table 4.1. Response rates obtained during the pilot test.

Population	Surveys Sent	Response (%)
Michigan Mothers		
Black	42	6 (14.3)
White	<u>18</u>	<u>13 (72.2)</u>
TOTAL	60	19 (31.7)
Michigan Physicians		
Black Infants	42	14 (33.3)
White Infants	<u>13</u>	<u>7 (53.8)</u>
TOTAL	56	21 (38.2)

Analysis

Data were analyzed using SPSS-PC+ 2.0 (SPSS, 1988) on a Zenith microcomputer. Both parametric and non-parametric statistics were used as appropriate. Frequency counts and descriptive statistics were used to eliminate nondiscriminating questions from the Pregnancy Lifestyle Questionnaire and the Prenatal Care Questionnaire. Factor analysis indicated additional attitude questions which loaded to the factors of "nutrition" and "weight gain" were needed.

White Michigan Mother's Survey

Subjects

Six hundred white infants with birth weights ranging between 1000 and 4000 g were randomly selected by computer search of the State of Michigan birth certificates. In addition to the same selection criteria used in the pilot study, an infant was excluded from the sampling frame if the birth certificate indicated the mother experienced any of the following medical complications of pregnancy or concurrent illnesses or conditions affecting pregnancy: 1) pregnancy induced hypertension, chronic hypertension or renal disease with superimposed toxemia, 2) eclampsia, 3) diabetes (gestational or mellitus), 4) babies with congenital anomalies, 5) maternal death, 6) circulatory disease, 7) renal disease, 8) gonorrhea and other venereal diseases and 9) AIDS.

The mean standard deviation of birth weight for all white infants weighing between 1000 and 4000 g born in Michigan between 1985 and 1987 was 523 g. Using this number, and the method of Kraemer and Thiemann (1988), an estimated 170 low birth weight cases (1000-2499 g) and 170 optimal birth weight controls (3500-4000 g) were needed to detect a 100 gram difference in birth weight with 80% power and 95% confidence (Table 4.2). Using the method of Snedecor (1984), only 109 cases and 109 controls were necessary to detect the same statistical difference.

Table 4.2. Estimated sample size of white infants needed to detect a difference with 80% power, 95% confidence and a 523 g SD.

Method	Detection Level	Cases	Controls
Kraemer and Thiemann (1988)	100 g difference	170	170
	125 g difference	115	115
Snedecor (1984)	100 g difference	109	109
	125 g difference	70	70

Based on results of the pilot study, LBW cases and OBW controls were over-sampled by approximately 70% (120 subjects) and 47% (80 subjects), respectively. Thus, the sampling frame consisted of 290 cases and 250 controls (Table 4.3). A 59% response rate from cases (170/290), and 68% from controls (170/250), was needed to detect a 100 g difference with 80% power and 95% confidence. Sixty infants weighing between 2500 and 3499 g (medium birth weight) were included in the sampling frame to

fill in the regression line when analyzing the relation between percent reference weight attained at term and birth weight.

To ensure an even distribution of subjects within each birth weight category, each of the categories was further subdivided (Table 4.3). All subjects were born between July 1, 1988 and November 30, 1988, except for infants weighing 1000 to 1999 g. Due to the small number of surviving infants in this weight category, it was necessary to select all infants born between January 1 and November 30, 1988 for inclusion in this study, introducing unavoidable recall bias in this subgroup.

Table 4.3. Subject selection criteria in the White Michigan Mothers Survey.

Birth Weight Category	Number Needed*	Total MI Population	% of Total Population	Time Period Surveyed
Low Birth Weight (Cases)				
1000-1999 g	88	88	100.0	1-11/88
2000-2499 g	<u>202</u>	<u>350</u>	<u>57.7</u>	7-11/88
Sub-Total:	290	438	66.2	
Moderate Birth Weight				
2500-2999 g	30	2291	1.3	7-11/88
3000-3499 g	<u>30</u>	<u>7380</u>	<u>0.4</u>	7-11/88
Sub-Total:	60	9671	0.6	
Optimal Birth Weight (Controls)				
3500-3600 g	50	1819	2.7	7-11/88
3601-3700 g	50	1325	3.8	7-11/88
3701-3800 g	50	1493	3.3	7-11/88
3801-3900 g	50	1018	4.9	7-11/88
3901-4000 g	<u>50</u>	<u>1026</u>	<u>4.9</u>	7-11/88
Sub-Total:	250	6681	3.7	
GRAND TOTAL:	600	16,790	3.6	

*for 80% power and 95% confidence to detect a 100 gram difference in birth weight estimating a 59-68% response rate.

Design

The White Michigan Mothers Survey was a retrospective, case-control, study consisting of a mail survey sent to mothers of 600 randomly selected white infants. A follow-up questionnaire was sent to the prenatal health care provider of mothers who provided signed consent. Protocol for this survey followed a modified version of Dillman's (1978) Total Design Method (TDM). Adherence to procedures described in this method has been shown to maximize response rates in mail surveys.

Instruments

Three instruments were used to collect data: 1) the Mothers' Pregnancy Lifestyle Questionnaire, 2) the Willett Semi-Quantitative Food Frequency Questionnaire (SQFFQ) and 3) the Physicians' Prenatal Care Questionnaire. These instruments were revised based on results of the pilot study; all were re-evaluated by the same experts.

Mother's Survey Questionnaire.

The "Pregnancy Lifestyle Questionnaire" (Appendix 17) contained 44 questions designed to gather information about the womens' height, pre-pregnancy and delivery weight, maternal birth weight, attitudes toward weight gain, nutrition and pregnancy, engagement in or avoidance of behavior risk factors (i.e., smoking, drinking), food cravings and aversions, social service assistance and socioeconomic status. The questions were adapted from three previously validated national

questionnaires: the 1988 Pregnancy Nutrition Surveillance System (PNSS) questionnaire, the 1980 National Natality Survey (DHHS, 1985) and the 1988 National Maternal and Infant Health Survey's Mothers's Questionnaire (DHHS, 1988). The attitude questions were adapted from those published by Palmer et al (1985), Schwartz and Barr (1977) and Rosander and Sims (1981) and were validated during the pilot survey.

Semi-Quantitative Food Frequency Questionnaire (SQFFQ).

A modified version of the revised Willett SQFFQ (Appendix 18) was selected to estimate the subjects' usual nutrient intake during pregnancy (Willett et al, 1988). The revised SQFFQ format did not contain an example demonstrating how to correctly fill in the SQFFQ responses. Thus, an instruction sheet, prepared by the researcher (Appendix 19), was included with each SQFFQ. Two modifications were made in the SQFFQ instructions: 1) subjects were asked to bypass the first two questions about usual vitamin and mineral use and 2) the respondents were asked to fill in the frequency of consumption which indicated how often, on average, they consumed the amount of food specified "during their pregnancy", rather than "during the past year". These directions were rubber-stamped on each SQFFQ.

The SQFFQ provided frequency of consumption of foods/food groups as well as an estimate of nutrient, caffeine and alcohol intake. Individual nutrient intakes were computed by multiplying the relative frequency of consumption of each food item by the nutrient content of the specified portion size. The primary source of the nutrient data base was the United States Department of Agriculture (USDA) food composition

tables (Adams, 1975; USDA, 1976 to 1983; Orr, 1969; Haytowitz and Matthews, 1984), supplemented with manufacturers' information and other published data (Feeley et al, 1972; McLaughlin and Weilhrauch, 1979). The caffeine data base was comprehensive, including caffeinated and decaffeinated tea, coffee and diet and regular soda, brownies, ice cream sundaes and chocolate candy bars.

The Willett SQFFQ was selected for several reasons: 1) it was developed to analyze more target nutrients than any other SQFFQ, 2) the questionnaire was inexpensive (\$0.25 each), could be self-administered and could be adapted to request information about usual food intake during pregnancy and 3) it could be computer scored at a reasonable cost (\$1.25 each plus \$50.00 to download the data to diskette).

Physicians' Prenatal Care Questionnaire.

The "Prenatal Care Questionnaire" (Appendix 20) consisted of 11 questions about the womens' height, pre-pregnancy and delivery weights, rate of weight gain throughout pregnancy and the highest and lowest hemoglobin, hematocrit and diastolic blood pressure readings recorded during pregnancy. The survey questions were derived from an abbreviated version of the pilot questionnaire, the PNSS questionnaire and the proposed (1989) revision of the State of Michigan birth certificate, from which the list of medical complications was compiled.

Procedures

The names of the 600 white infants randomly selected for the sampling frame were checked against computerized death certificates. Any

subject who had died was removed from the sampling frame and replaced by another randomly selected infant who met the eligibility requirements.

Each infant was assigned a code number. Each infant's name and birth date, and the name and address of each infant's mother, were abstracted from the birth certificate. An individualized letter (Appendix 21) describing the study and requesting participation was sent to each mother. The letter, printed on Michigan Department of Public Health (MDPH) stationery, included the baby's name to assure the mother answered the questionnaire about the appropriate infant. The letter was signed by George H. Van Amburg, MS, MPH, State Registrar and Chief, Office of the State Registrar and Center for Health Statistics and George H. Baker, Jr., MD, Chief, Office of Maternal and Child Health.

In addition to the letter, each mother was sent a Pregnancy Lifestyle Questionnaire (Appendix 17), a copy of the revised Willett SQFFQ (Appendix 18) and instructions for its completion (Appendix 19), a number 2 pencil, and a stamped, return envelope addressed to Van Amburg at the Michigan Department of Public Health. Each subject received a booklet entitled "Nutrition During the First Five Years", donated by the Michigan Beef Council and the National Livestock and Meat Board, and a colorful, plastic bib donated by Gerber, as incentives to complete and return the questionnaire, signed consent form and SQFFQ. The packet was mailed in a white, 6.5 x 9.5 inch envelope clearly stamped "First Class" in red ink.

One week after the initial survey packet was mailed, a reminder note card, enclosed in a white MDPH business envelope, was sent to each subject by first class mail (Appendix 13). The subject was thanked for

her prompt response and, if she had not already done so, was encouraged to return the survey at her earliest convenience. The primary researcher's name and telephone number were provided, and the subject was encouraged to call collect if the survey had been misplaced or not received. Three weeks from the initial mailing a second letter (Appendix 22) and complete packet, minus the incentives, was mailed to all non-responders. Five weeks after the initial mailing, in an attempt to increase the response rate, all non-responders of low birth weight infants (cases) for whom a working telephone number could be obtained were called to encourage the completion of the questionnaire. Mothers of controls (optimal birth weight infants) were not telephoned as sufficient surveys had been received from this group.

Any survey returned by the post office for an insufficient or incorrect address was followed-up by searches of city and telephone directories, Michigan Bell Directory Assistance and, if the forwarding order had expired, personal requests to the postmaster of the city where the person had previously resided (\$1.00 per request). The names of all subjects with unknown addresses were sent to the Michigan Department of Motor Vehicles Commercial Look-Up Unit.

Respondents mailed the completed surveys to the MDPH where they were dated, recorded and inspected. The code number and wave (first mailing, second mailing or post-telephone call) of the returned surveys were recorded daily using a computer database program. The birthdate and birth weight of each infant were transcribed from the birth certificate to the survey. All birth weights reported in pounds and ounces were converted to grams with a standard chart (Appendix 5).

Any incomplete survey or SQFFQ was remailed with a letter (Appendix 23) asking the subject to complete and return it in the enclosed stamped, pre-addressed envelope. If the consent form was not signed (non-consenters), the mother was sent a letter (Appendix 24) requesting her reconsideration. A copy of the Physicians' Prenatal Care Questionnaire (Appendix 20) was sent so the mother knew exactly what information was being requested.

Subsequently, the Prenatal Care Questionnaire (Appendix 20) was sent to the prenatal care provider of all women who provided signed release (consenters). The name and address of the physician, provided by the consenter, was cross-checked with the birth certificate for accuracy and completeness. Any missing information (i.e., doctor's first name or initials, street name, zip code) not available on the birth certificate was obtained from the American Hospital Association Guide to the Health Care Field (AHA, 1986), telephone directories, directory assistance or by calling the respondent.

Individualized letters describing the study and requesting the physicians' participation were created using data abstracted from the mothers' questionnaire and the infants' birth certificate (Appendix 25). Each letter, signed by Van Amburg and Baker, included the mother's and baby's name to assure questions were answered about the appropriate infant. The "Prenatal Care Questionnaire", labeled with the code number, infant's birthdate, and name of both the infant and the mother, a copy of the signed consent form, a number two pencil and a stamped, return envelope addressed to Van Amburg at the MDPH were sent to each physician in a white, 6.5 x 9.5 inch envelope clearly stamped "First Class".

Follow-up protocol was identical to that described for the pilot study, with a reminder note card (Appendix 16) mailed approximately ten days after the initial survey packet and a second packet mailed to non-responders one month from the initial mailing (Appendix 26). Any questionnaire returned for an insufficient or incorrect address was followed-up by searches of city and telephone directories, medical directories and Michigan Bell Directory Assistance.

Selection of the Reference Weight-For-Height Standards

Major studies on insured populations conducted in the United States and Canada in 1959 and 1979 by the Society of Actuaries and the Association of Life Insurance Medical Directors of America (Society of Actuaries, 1959, 1983) were used to develop the Metropolitan Life Insurance Reference Weight-for-Height tables (Appendix 3 and 4). The widely used 1959 reference table was replaced by the 1983 Metropolitan Reference Table when, based on findings from the 1979 Build and Blood Pressure Study of approximately 4.2 million insured men and women, it was determined that the weight associated with the greatest longevity was slightly higher than previously estimated, making the 1983 Metropolitan standard the preferred "gold standard".

Height and weight data of 20,322 individuals between the ages of six months and 72 years were collected as part of the National Health and Nutrition Examination II survey (DHHS, 1989c). An unpublished subset of this data base, the weight-for-height table for non-pregnant females between the ages of 20-34, was requested from the National Center for Health Statistics (Appendix 31a). When the median weight-for-height was

plotted against the 1959 and the 1983 Metropolitan references weight-for-height, a striking similarity between the NHANES II 50th percentile and the 1983 Metropolitan standard was noted (Appendix 31b). For that reason, only the 1959 and the 1983 Metropolitan reference standards will be used in this dissertation.

Because Rosso (1985) presented his results based on the 1959 Metropolitan Reference, the first hypothesis will be analyzed using both the 1959 and the 1983 Metropolitan Reference standards. Throughout the rest of this dissertation, however, only the 1983 Metropolitan Reference will be used in data analysis. The specific value chosen to represent a subject's desirable weight-for-height was the mean value of the medium-framed, unclothed woman without shoes in 1/2 inch height increments.

Analysis

Separate data files containing information collected from the Pregnancy Lifestyle Questionnaire and the Prenatal Care Questionnaire were created in ASCII using Wordstar 4.0 non-document mode. Birth certificate data of the 600 randomly selected subjects was downloaded onto floppy disk. The scrambled six digit code, unique to each birth certificate, was transcribed from the birth certificates, unscrambled, and matched with the subject code number. Birth weight category (LBW, MBW or OBW) and response status (responder vs non-responder) were coded on the data tape to increase efficiency of data management. The coded SQFFQs were analyzed by the Channing Laboratory in Boston and downloaded to a floppy disk in ASCII. The four data sets collected in this study (the Pregnancy Lifestyle Questionnaire, the SQFFQ, the birth certificate

data, and the Prenatal Care Questionnaire) were matched by subject code number and compiled into one data set.

The percent standard body weight attained at term were determined by comparing the women's pre-pregnant and term weight to both the 1959 and the 1983 Metropolitan Life Insurance Company's Reference Weight-for-Height (Appendix 3 and 4). A comparison of the unpublished NHANES II weight-for-height data for white American women between the ages of 20-34 (Appendix 31) indicated a close agreement between the NHANES II data and the 1983 Metropolitan reference data. Thus, the percent of one's NHANES II reference attained at term was not computed.

A MAR-12 diet quality score and an INQ-1000 nutrient density profile were calculated for each subject according to the methods of Worthington-Roberts (1989), Jenkins and Guthrie (1984) and Hansen and Wyse (1980). Because 98% of the respondents reported taking a supplement at least five times per week, all dietary data were analyzed without nutrient supplements. Caffeine and alcohol intake data were obtained from the SQFFQ. Data from any subject who reported consuming less than 600 or greater than 4,000 calories were excluded from analysis as recommended by the Willett research group at the Channing Laboratory in Boston (Sampson, personal communication, 1990). Examination of the stemleaf and normal plots indicated all extreme outliers were removed when these caloric restrictions were followed (Appendix 29-2a,b,c).

All data were analyzed using SPSS-PC 3.1 (SPSS, 1988) on a CompuAdd 286/12 microcomputer. Statistical significance was reported when the probability level attained a value of 0.05 or less with the

following exception--variables were maintained in multiple regression equations if they attained a significance level of 0.10.

Specific contrasts of interest to identify differences among groups (cases vs controls and responders vs non-responders by birth weight category and pre-pregnancy weight status) were analyzed via oneway analysis of variance and Chi-square as appropriate. Crosstabs were used to calculate the crude odds ratio and the Mantel-Haenszel summary odds ratio (the adjusted odds ratio which "corrects" for the effects of several risk factors at one time) to determine the relative risk of low birth rate for various factors measured in this survey (Kelsey et al, 1986). Both the crude odds ratios and the Mantel-Haenszel summary odds ratio were hand-calculated according to standard methods (Kelsey et al, 1986) due to the inaccessibility of an affordable computer program that could calculate these values.

Correlations, ANOVA and multiple regression analysis were used to determine the strength of relationship between the independent and dependent variables, to determine any interaction effects, to develop prediction equations and to determine which factors account for the largest portion of variance in birth weight between cases and controls. A correlational multiple regression model to predict the relationship between variables of interest and birth weight was used throughout this study. Both stepwise regression (forward inclusion) and "enter" regression procedures were used to determine the multiple regression models reported in this study (SPSS, 1989).

The following variables were recoded for the final birth weight prediction equation: 1) income level was recoded as "0" (less than 185%

of poverty) and "1" (greater than or equal to 185% of poverty), 2) sex was recoded as "0" female and "1" male and 3) the Kessner Index was recoded as "0" (not adequate) and "1" (adequate).

Factor analysis (varimax rotation) was used to determine the construct validity of the questionnaire and the number of "attitudinal constructs" measured by the questionnaire. Specific attitudinal statements which comprised the attitude scales (i.e., attitude toward weight gain, attitude toward nutrition during pregnancy) were selected if, within each construct, factor analysis indicated the correlation coefficient of the attitude statement was greater than 0.50 (Appendix 29-7). The Spearman-Brown split-half reliability measure was used to determine the reliability of the entire attitude questionnaire. Cronbach's alpha-reliability coefficient was used to determine the reliability of each of the attitude construct scales (Sims, 1981). In the field of attitude measurement, reliability coefficients of 0.70 or above are considered "desirable", although lower coefficients are tolerated (Henerson et al, 1978).

Physician's Prenatal Care Survey of Black Michigan Mothers

Subjects

Results of the pilot study suggested insufficient information would be obtained from a random sample of black infants' mothers. The only viable option for obtaining useable data about the black population within the constraints of this study was to contact the physician in attendance at birth, as noted on the birth certificate, and request the abstraction of information from the subjects' medical records. Upon approval of the Michigan Department of Public Health, the Prenatal Care Questionnaire was sent to the physician of record of 825 randomly selected black Michigan infants. These black infants, with birth weights ranging between 1000 and 4000 g, were randomly selected by a computer search of the State of Michigan birth certificates, using the same selection and exclusion criterion as the White Michigan Mothers Survey.

The mean standard deviation of birth weight for all black Michigan infants born between 1985 and 1987, weighing between 1000 and 4000 g, was 577 g. Using this value, and the method of Kraemer and Thieman (1988), 212 cases (1000-2499 g) and 212 controls (3500-4000 g) were necessary to detect a 100 gram difference in birth weight with 80% power and 95% confidence (Table 4.4). Using the method of Snedecor (1984), only 133 cases and 133 controls were needed to detect the same difference. Increasing the difference necessary to detect significance from 100 to 125 g reduced the sample size to 140 and 85 for each method, respectively.

Table 4.4 Estimated sample size of black infants needed to detect a difference with 80% power, 95% confidence and a 577 g SD.

Method	Detection Level	Cases	Controls
Kraemer and Thieman (1988)	100 g difference	212	212
	125 g difference	140	140
Snedecor (1984)	100 g difference	133	133
	125 g difference	85	85

Based on results of the pilot study, cases (LBW) and controls (OBW) were over-sampled by 267 and 192 subjects, respectively. The final sampling frame consisted of 400 cases and 325 controls (Table 4.5). Using the method of Kraemer and Thieman (1988), an estimated response rate of 53% for cases (212/400) and 52% for controls (212/325) was needed to detect a 100 g difference with 80% power and 95% confidence. Using the method of Snedecor (1984), a response rate of 33% (133/400) for cases and 41% (133/325) for controls was necessary to detect a 100 g difference at the level selected. One hundred black infants weighing between 2500 and 3499 g (medium birth weight) were included in the survey for analysis of the relation between percent reference weight-for-height attained at term and infant birth weight.

Table 4.5. Subject selection criteria for black subjects in the Physician's Prenatal Care Survey.

Birth Weight Category	Number Needed ^a	Total MI Population	% of Total Population	Time Period Surveyed
Low Birth Weight (Cases)				
1000-1999 g	33	33	100	1-11/88
	45	55	82	1-12/87
2000-2499 g	218	218	100	1-11/88
	<u>104</u>	<u>179</u>	<u>58</u>	7-12/87
Sub-Total:	400	485	82	
Moderate Birth Weight				
2500-2999 g	50	452	11	7-11/88
3000-3499 g	<u>50</u>	<u>844</u>	<u>6</u>	7-11/88
Sub-Total:	100	1296	7	
Optimal Birth Weight (Controls)				
3500-3600 g	65	150	43	7-11/88
3601-3700 g	65	103	63	7-11/88
3701-3800 g	65	105	62	7-11/88
3801-3900 g	65	167	39	7-11/88
3901-4000 g	<u>65</u>	<u>152</u>	<u>43</u>	7-11/88
Sub-Total:	325	677	48	
GRAND TOTAL:	825	2458	34	

^afor 80% power and 95% confidence to detect a 125 gram difference in birth weight estimating a 34-43% response rate.

All subjects were born between July 1, 1988 and November 30, 1988, except for 149 cases (37%) who were born between January 1, 1987 and November 30, 1988. A two-year selection period for this category was necessary due to the small population size. Because the information requested needed to be abstracted from medical records, and did not rely upon memory, recall bias was not considered a factor. Locating the

medical records and the appropriate physician, however, was a major concern.

Design, Instruments and Procedures

The design, instruments, methods and protocol of the Physicians' Prenatal Care Survey were identical to those described in the White Michigan Mothers Survey with few exceptions. The individualized letter sent to the attending physician of the black subjects (Appendix 27) differed slightly from the letter sent to the white consenters' prenatal care provider. The letter included both the mother's and baby's name, as well as the baby's birth date, to assure the physician answered the questionnaire about the appropriate infant. The second letter (Appendix 28) and survey were mailed to all non-responders approximately one month after the initial mailing.

Analysis

A data file containing responses from the Prenatal Care Questionnaire for black Michigan subjects was created in ASCII code using SPSS-Data Entry. The data from the prenatal care providers was matched and merged with each subject's birth certificate data. The same data analytical procedures and levels of statistical significance as previously reported in the White Michigan Mother's Survey were applied to this data set as appropriate.

CHAPTER V

RESULTS AND DISCUSSION

The purpose of this study was to determine factors which differ between mothers who deliver optimal and low birth weight infants. The results of both the White Michigan Mother's Study and the Physician's Survey of Black Michigan Mothers are reported and discussed in this chapter. Following the presentation of response rates and descriptive statistics, results and discussion are presented for each hypothesis.

White Michigan Mother's Study

Response Rate

Four hundred of the 600 mothers who were sent a Pregnancy Lifestyle Questionnaire (67%) responded (Table 5.1), including 171 cases (LBW) and 184 controls (OBW). Two LBW cases were dropped from subsequent analysis due to extreme weight losses of 64 and 60 pounds following major surgery for a gastric exclusion and a jejunoileal bypass, respectively. Thus data from 398 subjects, including 169 cases and 184 controls, were analyzed.

Eighty-one percent of the surveys were returned after the first mailing (n=323), 18% after the second mailing (n=72) and less than one

percent (n=3) after telephone calls to all LBW non-responders for whom a working telephone number could be obtained (n=28) (Appendix 29-1).

Current addresses could not be located by standard methods for 5% of the sampling frame (n=32), 30 of whom were mothers of LBW cases. The State of Michigan Motor Vehicle Commercial Look-Up Unit was able to provide current addresses for 11 of these 32 subjects (34%). Thus, 579 of the subjects selected for this study (96.5%) were contacted.

Seventy-one of the 400 surveys (18%) were returned without a signed consent form which allowed the subject's physician to release medical information to the researcher (Table 5.1). After a second request, 34 of the 71 non-consenters (47%) returned a signed form, resulting in a total of 363 consenters (91%).

Table 5.1. Response and consent rate to the white mother's Pregnancy Lifestyle Questionnaire.

Group	Sent	Returned (%)	Included in Study	Consenters ^a (%)
Low Birth Weight (LBW)	290	171 (60)	169	151 (88)
Moderate Birth Weight (MBW)	60	45 (75)	45	41 (91)
Optimal Birth Weight (OBW)	250	184 (74)	184	171 (93)
TOTAL:	600	400 (67)	398	363 (91)

^a Number of responders who signed a consent form allowing their physician to release medical information.

Of the 400 responders, 380 returned the Willett Semi-Quantitative Food Frequency Questionnaire (SQFFQ) with all 116 items completed (95%). Of these, 21 (5.5%) were excluded from further analysis because the subjects' caloric intake exceeded the guidelines for validity and reliability established by the Channing Laboratory (600 calories to 3,500 calories), indicating the results were unreliable and invalid (Sampson, personal communication, 1990). Because the SQFFQ had not previously been used with a pregnant population, an arbitrary, additional 500 calories were added to the upper limit to accommodate the extra caloric needs of pregnancy. To reinforce this decision, three stemleaf plots were created to determine the normality of the distribution of caloric intake dependent upon which cut-off point for exclusion was selected (Appendix 29:2a-c). Results indicated 12 extreme outliers when all the subjects' data were examined (n=380), two outliers when the arbitrary cut-off was set at 4,500 calories (n=368) and no outliers when the cut-off was set at 4,000 calories (n=359). Thus, a subject's SQFFQ was arbitrarily excluded from the study if more than 4,000 calories were consumed per day. A total of 359 SQFFQs were analyzed.

The prenatal care provider of each consentor was contacted and asked to complete the Prenatal Care Questionnaire. Of these, 281 physicians of the white subjects (77%) returned completed surveys, 72% after the first mailing and 28% after the second mailing (Table 5.2).

Table 5.2. Response rate to the Physicians' Prenatal Care Survey for white subjects.

Group	Number Sent	Response n (%)
LBW	151	113 (75)
MBW	41	32 (78)
OBW	171	136 (80)
TOTAL:	363	281 (77.4)

Few problems were encountered in locating the white subjects' prenatal care providers. Fifteen physicians could not provide the requested information due to their inability to locate records (n=4), stated refusal to participate (n=3) and no longer being employed at that location or having retired (n=8) (Appendix 29-3). Thus, although 77.4% of the physicians provided the requested information, 81.5% of the contacted physicians corresponded with the researcher.

Generalizability of Results to the Population

Sociodemographic information from the birth certificate of responders' and non-responders' infants was compared to determine the confidence with which results obtained from this sample could be generalized to the population. A comparison of the response rate of responders by geographic location throughout the state (county where the birth occurred) indicated a 69% response rate by women who delivered in

a primarily rural county and a 65% response rate by women who delivered in a primarily urban county (Appendix 32a).

There were no significant differences in infant birth weight, mother's age, number of prenatal visits, weeks gestation, number of parents named on the birth certificate, sex of the infant, Kessner Index of prenatal care, and one-minute and five-minute Apgar scores, when responders (R) and non-responders (NR) who delivered an optimal birth weight infant were compared (Appendix 29-4). Statistically significant differences were noted between the mother's years of education (13.5 R vs 12.2 NR; $p < .0001$) and month prenatal care began (2.4 R vs 2.7 NR; $p < 0.05$), although the practical significance of these differences is questionable. Results suggest a representative sample of white mothers who deliver OBW infants in Michigan was obtained.

No significant differences were noted between responders and non-responders who delivered a low birth weight infant in the following characteristics: infant birth weight, mother's age, number of previous children, weeks gestation or one-minute and five-minute Apgar scores (Appendix 29-5). However, LBW-NR had significantly fewer years of education (12.1 NR vs 12.7 R; $p < 0.049$), fewer prenatal visits (10.3 NR vs 11.7 R; $p < 0.0017$), entered prenatal care later in pregnancy (3.2 months NR vs 2.4 months R; $p < 0.001$), had a lower quality of prenatal care, as indicated by a higher Kessner Index score (1.5 NR vs 1.2 R; $p < .0005$), and had only one parent (12% NR vs 7% R), as opposed to both parents (29% NR vs 52% R), named on the birth certificate ($p < .0008$). These differences suggest any association observed between the variables of interest in this study and low birth weight will most likely under-

represent the true association, resulting in an attenuation toward the mean at the risk of a type II error (Snedecor and Cochran, 1980).

Characteristics of the Responding Sample Population

The mean responder in the White Michigan Mother's Study was 26.5 years old and had completed one year of post-high school education (Table 5.3). An estimated 40% of the responders had household incomes less than 185% of the 1988 poverty index (see Operational Definitions, Chapter 3). Twenty percent of the sample reported monthly incomes less than 100% of the poverty level. Thirty-six women (9%) received AFDC, 39 (10%) received food stamps and 69 (17%) were enrolled in WIC.

Self-reported data indicated the average responder was 5' 4 1/2" and weighed 131 lbs prior to pregnancy (range 85-255 lbs). The average weight gain during pregnancy was 29.5 lbs, ranging from a loss of 12 lbs to a gain of 71 lbs. Overall, the subjects entered pregnancy at 99% of their 1983 Metropolitan reference weight-for-height (range 68-190), and gained to 122% of their Reference Weight at term (range 69-210). Nine months after delivery, the subjects' mean weight was, on average, only three pounds higher than at conception (134 lb vs 131 lb).

Sixty-seven percent of the subjects reported consuming no alcohol during pregnancy; 62% reported they did not smoke. All but eight subjects reported taking a vitamin supplement while pregnant. As a group, the mothers initiated prenatal care during the second month of pregnancy and saw a prenatal care provider 12 times. Of the 398 infants, 206 were male (52%) and 192 were female (48%).

Table 5.3. Characteristics of the sample responders (n=398).

Characteristic	Mean $\pm$ SD ^a	Range
SOCIODEMOGRAPHIC		
Age, yrs	26.5 $\pm$ 3.8	(21-34)
Education, yrs	13.2 $\pm$ 2.0	(7-17)
Income < 185% poverty, %	40 ^b	
Income < 100% poverty, %	20	
AFDC, %	9	
WIC, %	17	
ANTHROPOMETRIC		
Height, in	64.4 $\pm$ 2.6	(57-72)
Pre-pregnant weight, lbs	131 $\pm$ 27	(85-255)
Pregnancy weight gain, lbs	29.5 $\pm$ 12	(-12-71)
Current weight, lbs	134 $\pm$ 29	(80-273)
% 1983 RW, pre-pregnant	99 $\pm$ 19	(68-190)
% 1983 RW, at term	122 $\pm$ 21	(69-210)
BEHAVIORAL		
Month prenatal care began	2.4 $\pm$ 1.2	(1-8)
Number of prenatal visits	12 $\pm$ 3	(1-24)
Took vitamin supplement, %	95	
Consumed no alcohol, %	67	
Did not smoke cigarettes, %	62	

^a except where percentage of total, as noted.

^b n=352.

Comparison of Cases and Controls by Select Descriptive Variables

A comparison of cases (mothers of LBW infants; < 2500 g) and controls (mother of OBW infants) for selected sociodemographic and anthropometric variables indicates many significant differences (Table 5.4). The impact of these differences on birth weight will be presented for each hypothesis.

Table 5.4. Comparison of white cases and controls for select descriptive variables (Means $\pm$ SD, unless noted).

Variable	LBW (n=169)	OBW (n=184)	t or χ^2	p
SOCIODEMOGRAPHIC				
Age, yrs	25.8 $\pm$ 3.8	26.9 $\pm$ 3.7	2.59	.0100
Education, yrs	12.7 $\pm$ 2.0	13.5 $\pm$ 2.0	3.85	.0001
Income < 185% poverty, %	21 ^a	18 ^b	5.9 ^c	.0529
AFDC, %	7	3	7.3 ^c	.0069
WIC, %	10	7	2.9 ^c	.0900
ANTHROPOMETRIC				
Height, in	64 $\pm$ 3	65 $\pm$ 2	5.36	.0000
Pre-pregnant wt, lbs	122 $\pm$ 25	134 $\pm$ 7	6.32	.0000
Term weight, lbs	148 $\pm$ 28	173 $\pm$ 27	8.34	.0000
Pregnancy wt gain, lbs	26 $\pm$ 12	33 $\pm$ 11	5.70	.0000
% 1983 RW, pre-pregnant	94 $\pm$ 18	104 $\pm$ 19	5.20	.0000
% 1983 RW, at term	114 $\pm$ 20	129 $\pm$ 19	4.97	.0000
% < 90% RW83, pre-pregnant	24	12	15.4 ^c	.0000
Birth weight, g	2187 $\pm$ 309	3761 $\pm$ 143	62.1	.0000
Female infants, %	58	40	3.33	.0009

^a n=148 subjects responded.^b n=169 subjects responded.^c χ^2 Comparison of Self-Reported and Medical Record Data

Maternal self-reported height, pre-pregnancy and term weights were strongly, positively correlated with the physician-recorded data (Table 5.5). The Pearson correlation coefficients, the most common procedure used to report validity (Mehrens and Lehmann, 1984), ranged from 0.94 to 0.95 (p=0.0000). It is significant to note, however, that of the 281

physicians who responded to the Michigan Mother's Survey, 20% (n=55) were unable to provide a record of the patient's height. Because of the high correlations obtained between the mother's self-reported and the physician's medical record data, and because the loss of data resulting from the inability to calculate a subject's reference weight-for-height from the physician's data would result in a significant loss of power, the mother's self-reported anthropometric data were used throughout the White Michigan Mother's Study.

Table 5.5 Comparison of mother's self-reported and physician-reported anthropometric measurements in the White Michigan Mother's Study.

Subject	Mean	SD	r	p
<u>Height, inches (n=226)</u>				
Mother	64.54	2.6	.94	.001
Medical Record	64.50	2.6		
<u>Pre-Pregnancy Weight, lbs (n=272)</u>				
Mother	131.5	25.9	.94	.001
Medical Record	132.9	26.4		
<u>Term Weight, lbs (n=279)</u>				
Mother	160.8	28.0	.95	.000
Medical Record	162.7	29.2		

Self-reports of height and weight may be subject to distortion and inaccuracy, with the validity of such data a cause for concern (Pirie et

al, 1981). No report indicating the validity of self-reported heights and weights in pregnant women was found in the literature. However, in the non-pregnant population, over-reporting of height, as well as misreporting of weight (underestimation of overweight and extreme overweight and overestimation of underweight) are common (Rowland, 1989; Stewart et al, 1987). Significant life events, however, are often clearly coded and remembered (Hewson and Bennett, 1987). Because pregnancy is a significant life event, and because pregnancy is a time when weight gain is acceptable and encouraged, it appeared that in this case the mothers had good recall about their pre-pregnancy and term pregnancy weight and provided accurate, reliable data.

RESEARCH HYPOTHESES

- HO₁-1a: A weight gain to 120% or more of one's reference weight-for-height at term is not associated with a reduced incidence of delivering a LBW infant in healthy, white women between the ages of 20 to 34.
- HO₁-1b: White women between the ages of 20-34 who gain to 120% or more of their reference weight-for-height at term do not deliver infants with significantly higher mean birth weights than those from mothers who do not meet this goal.
- HO₁-1c: A weight gain to 120% or more of one's reference weight-for-height at term is not associated with an optimal birth weight between 3500 and 4000 g, in healthy, white women between the ages of 20 to 34.
- HO₁-1d: A minimum gain of seven kilograms if a woman's pre-pregnancy weight is greater than 120% of reference does not reduce the incidence of LBW in healthy white women between the ages of 20 to 34.

Results indicated women who did not gain to 120% of their 1959 Metropolitan reference weight-for-height had almost a four-fold

increased risk of delivering a LBW infant than if they had gained to 120% or more of reference (Table 5.6). When compared with the 1983 Metropolitan standard, the estimated relative risk of not gaining to 120% of reference was associated with almost a five times greater chance of delivering a LBW infant [RR=4.63(3.0-7.3)].

Table 5.6. Estimated relative risk (RR) of delivering a LBW infant if 120% of one's reference weight was not attained at term.

Variable	Cases N	Controls N	RR (95% CI)
--1959 Metropolitan Reference Weight at Term--			
<u>Risk of LBW (n=351):</u>			
Not gaining to 120%	96	48	3.75 (2.3-5.9)
Gained to 120% or more	72	135	1.0 ^a
--1983 Metropolitan Reference Weight at Term--			
<u>Risk of LBW (n=351):</u>			
Not gaining to 120%	119	63	4.63 (3.0-7.3)
Gained to 120% or more	49	120	1.0 ^a
^a referent--baseline value associated with no risk.			

The correlation between percent 1959 Metropolitan reference weight attained at term by subjects who gained to less than 120% of reference was strongly and positively related to infant birth weight (Table 5.7). The correlation ($r=0.33$) was almost identical to that observed by Rosso (1985) in a group of racially-mixed, low income women in New York

($r=0.30$). Regression analysis indicated each one percent increase in percent of reference weight gained in this group was associated with a 30 g increase in birth weight. Once subjects attained to 120% or more of reference, however, the correlation between infant birth weight and percent reference attained became non-significant ($r=0.12$, $p=0.07$). Again, these results concur with those obtained by Rosso (1985), who concluded maximal fetal growth occurred only in the women who had attained a "critical" body mass equivalent to 120% of their non-pregnant standard weight.

Table 5.7. Correlation between percent 1959 Metropolitan reference weight attained at term (less than 120% or greater than 120%) and infant birth weight.

Subjects	< 120% RW at Term	$\geq$ 120% RW at Term
--1959 Reference--		
<u>All Responders (n=398):</u>		
R	.33	.12
adjusted R^2	.10	.01
Beta	30.1	4.8
Standard Error-Beta	6.9	2.6
F	19.0	3.4
p	.0000	.07
n	160	238

The relationship between percent of the 1959 Metropolitan reference attained at term and infant birth weight can be seen in the graph in Figure 5.1. The 30 g increase in birth weight per each

incremental increase in percent standard body weight until 120-130% of standard is demonstrated by the rising slope.

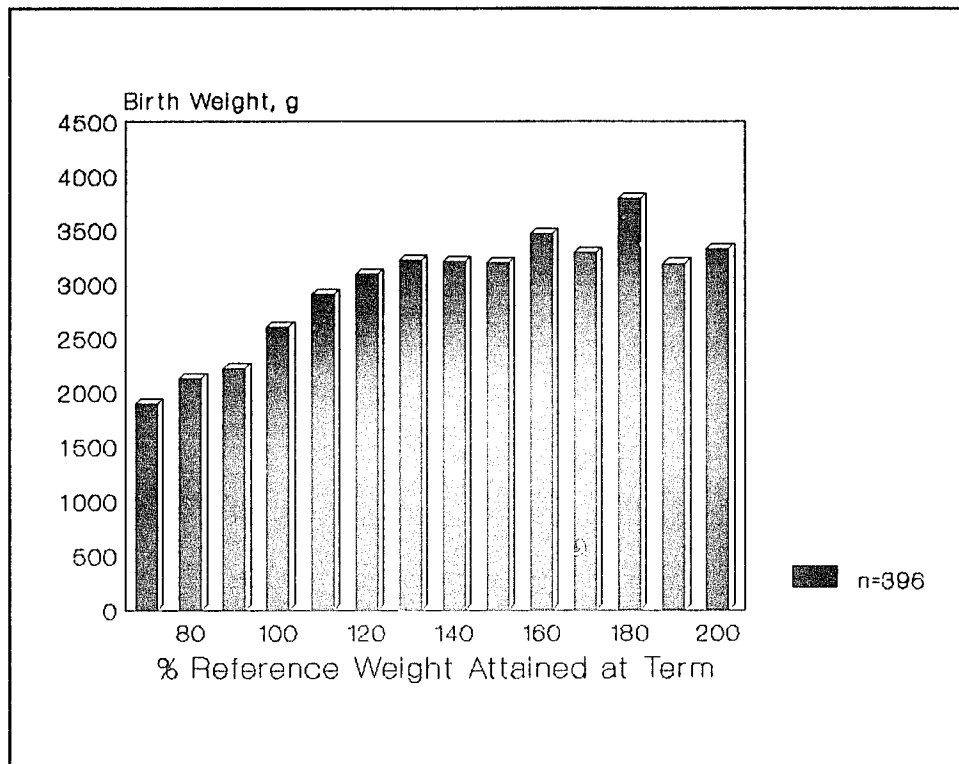


Figure 5.1. Relationship between percent of 1959 reference weight attained at term with birth weight.

When the 1983 Metropolitan reference was used as the standard for "reference weight" (Table 5.8), the correlation between infant birth weight and percent reference weight attained at term in women who gained to less than 120% of reference was slightly higher ($r=0.35$), explaining 12% of the variance in birth weight. Once a gain to 120% or more of the 1983 reference was attained, however, the regression slope became non-significant ($r=0.06$, $p=0.41$), indicating only a minimal increase in infant birth weight (2.5 g for each percent increase). These results

suggest attaining to 120% of the 1983 reference, rather than the 1959 reference, correlates more strongly with birth weight and is a better predictor of the critical body mass a woman should attain near term.

Table 5.8. Correlation between percent 1983 Metropolitan reference weight attained at term (less than 120% or greater than 120%) and birth weight.

Subjects	< 120% RW at Term	≥ 120% RW at Term
--1983 Reference--		
<u>All Responders (n=398):</u>		
R	.35	.06
adjusted R ²	.12	-.002
Beta	30.4	2.5
SE-Beta	5.8	3.0
F	27.7	0.68
p	.0000	.41
n	206	192

The relationship between percent of the 1983 Metropolitan reference standard weight attained at term and infant birth weight can be seen graphically in Figure 5.2. The 30.4 g increase in birth weight associated with each incremental increase in percent reference attained is denoted by the incline in the slope up to 120-130% of reference. Once this weight level is attained during pregnancy, the additional benefit to infant birth weight is minimal, as demonstrated by the plateau effect in the regression slope.

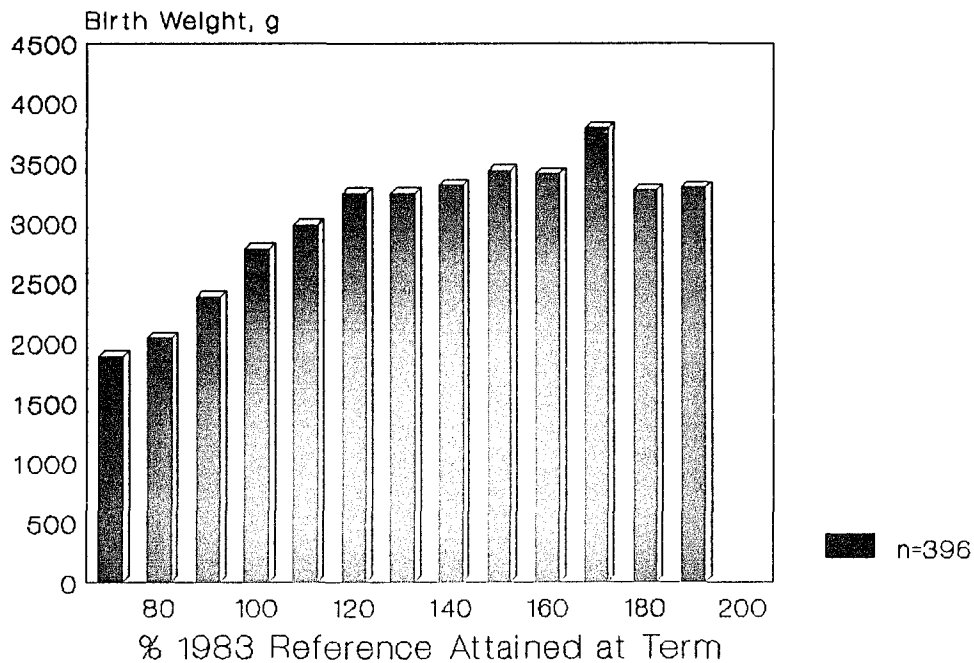


Figure 5.2. Relationship between percent of 1983 reference weight attained at term with birth weight

Because Rosso (1985) tested his hypothesis on a group of non-smoking "healthy" women, a subset of non-smoking women who weighed less than 120% prior to conception was formed. Despite the reduction in power from the smaller sample size, the relative risk of gaining to less than 120% of reference at term and subsequently delivering a low birth weight infant indicated an estimated 4.5-fold increased, and a 3.5-fold increased, risk based on the 1959 and the 1983 reference standards, respectively.

Table 5.9. Estimated relative risk of delivering a LBW infant if 120% of reference weight was not attained at term: smokers and overweight subjects excluded.

Variable	Cases N	Controls N	RR (95% CI)
--1959 Metropolitan Reference--			
<u>Risk of LBW (n=154):</u>			
Not gaining to 120%	34	37	4.53 (2.16-9.49)
Gained to 120%	14	69	1.0 ^a
--1983 Metropolitan Reference--			
<u>Risk of LBW (n=161)^b:</u>			
Not gaining to 120%	37	50	3.47 (1.9-6.4)
Gained to 120%	13	61	1.0 ^a

^areferent

^bn differs due to higher weight cut-off for 1983 reference

The removal of smokers and overweight women increased the correlation between percent 1959 reference and birth weight in women who gained to less than 120% of reference at term from $r=0.33$ to $r=0.39$, despite the reduction in sample size from 160 to 81 (Table 5.10). Each increase in percent standard weight attained was associated with a 38 g increase in birth weight. Gaining to more than 120% of reference, however, was not associated with a significantly higher infant birth weight, as the correlation between the two variables was reduced to $r=0.04$.

Table 5.10. Correlation between percent 1959 Metropolitan reference weight attained at term (less than 120% or greater than 120%) and birth weight with smokers and overweight women (pre-pregnant wt $\geq$ 120%) excluded.

Subjects	< 120% RW at Term	$\geq$ 120% RW at Term
--1959 Reference--		
<u>PPW < 120% RW-59 and Non-Smoker (n=177):</u>		
R	.39	.04
adjusted R ²	.14	-.009
Beta	38.4	-2.3
Standard Error-Beta	10.2	6.6
F	14.1	0.12
p	.0003	.729
n	81	96

When compared to the 1983 reference standard, an even larger increase in birth weight (44 g increase vs a 30.4 g increase in the entire sample) was observed in the same subset of underweight and normal weight (pre-pregnant), non-smoking women (Table 5.11). A weight gain to higher than 120% of standard, however, did not increase, or decrease, infant birth weight significantly.

Table 5.11. Correlation between percent 1983 Metropolitan reference weight attained at term (less than 120% or greater than 120%) and birth weight with smokers and overweight women ($\geq 120\%$ pre-pregnant wt) excluded.

Subjects	< 120% RW at Term	$\geq 120\%$ RW at Term
--1983 Reference--		
<u>PPW < 120% RW-83 and Non-Smoker (n=187):</u>		
R	.49	.004
adjusted R^2	.23	-.012
Beta	43.9	-.302
SE-Beta	7.8	7.8
F	31.7	.002
p	.0000	.969
n	102	85

The mean birth weight of infants born to women who attained to 120% of their 1959 reference at term was 3,206 g (Table 5.12). Women who did not gain to 120% of the 1959 reference delivered infants who weighed, on average, 486 g lower ($t=6.32$; $p=0.0000$). When the 1983 Metropolitan reference was used as the standard, the mean birth weight of infants born to women who attained to 120% of their reference at term was 3,289 g. Women who did not gain to 120% of their reference delivered infants who weighed, on average, 537 g lower ($t=7.23$; $p=0.0000$).

Table 5.12. Mean birth weight of infants born to women who did and did not attain to 120% of their Metropolitan reference weight at term.

Variable	Gained to < 120% at Term (N)	Gained to 120% or More at Term (N)	t	p
1959 Metropolitan Reference Weight	2720 $\pm$ 746 (159)	3206 $\pm$ 750 (237)	6.32	.0000
1983 Metropolitan Reference Weight	2752 $\pm$ 754 (205)	3289 $\pm$ 721 (191)	7.23	.0000

These results support the observation of Rosso (1985) that women who attained to 120% of their 1959 Metropolitan reference standard weight delivered infants with significantly higher mean birth weights than those from mothers who did not meet this goal. However, even though a weight gain to 120 percent of either the 1959 or the 1983 Metropolitan reference weight was associated with a decreased incidence of LBW, and higher mean birth weights, this gain did not correspond to Brown's (1988) definition of an "optimal" birth weight of 3,500 g to 4,000 g in this study. The mean birth weight of infants born to women who gained to 120% or more of the 1983 standard (3,289 $\pm$ 721 g) was 173 g lower than the 3,462 $\pm$ 482 observed by Rosso (1985) in the group of 262 non-smoking, racially mixed low-income women, and 126 g lower than the mean birth weight of white Michigan infants in 1987 of 3,415 g (MDPH, 1989). It must be noted, however, that the present sample is not a homogeneous sample representative of all possible birth weights, as was true for

both Rosso's sample and the Michigan figures. Rather, this sample consisted primarily of LBW and OBW infants. The effect of this sampling decision is indicated by the large standard deviation in birth weight. Whether or not a gain to 120% of reference in a homogeneous population representative of all birth weights would be associated with an optimal birth weight cannot be answered with the present study design.

Of the 56 women who weighed more than 120% of their 1959 reference at conception, only 10 gained less than 7 kg at term (Table 5.13). Of these, five delivered a LBW infant and five delivered an OBW infant. Of the 40 women who weighed more than 120% of their 1983 reference prior to pregnancy, only eight gained less than 7 kg at term. Of these, three delivered a LBW infant and five delivered an OBW infant. The estimated relative risk of delivering a LBW infant when pre-pregnancy weight was 120% or more of reference and less than 7 kg were gained was not significantly different when using either the 1959 or the 1983 Metropolitan reference.

Table 5.13. Estimated relative risk (RR) of delivering a LBW infant if a woman enters pregnancy at or above 120% of reference and gains less than seven kg.

Variable	Cases	Controls	RR (95% CI)
<u>If > 120% 1959 Pre-Pregnant(n=56):</u>			
	N	N	
Gained less than 7 kg	5	5	2.54 (0.63-12.26)
Gained 7 kg or more	13	33	1 ^a
<u>If > 120% 1983 Pre-Pregnant(n=40):</u>			
Gained less than 7 kg	3	5	1.53 (0.30-7.78)
Gained 7 kg or more	9	23	1 ^a

^areferent

Overweight (120% or more of reference) women often deliver larger-than-average infants even when their gestational weight gain is less than the recommended 24 lbs or 11 kg (Eastman and Jackson, 1968; Niswander et al, 1969; Simpson et al, 1975). For that reason, a minimal weight gain of 15 lbs (7 kg), equivalent to the weight of the products of conception, has been recommended for overweight women (Niswander et al, 1969; Eastman and Jackson, 1968). Results of the Michigan Mother's Study, however, did not equate a weight gain of less than 7 kg with an increased incidence of LBW among women who were overweight or obese prior to pregnancy. The sample size, however, was quite small.

Based on these results, the null hypotheses $H_{0,1a}$ and $H_{0,1b}$ are refuted. A weight gain to 120% of reference, whether the 1959 or the 1983 reference, is associated with a reduction in the incidence of LBW, and higher mean birth weights. A weight gain to 120% of the 1983 Reference was associated with a higher mean birth weight than a gain to 120% of the 1959 reference. These data validate the hypothesis of Rosso (1985) in white women, and indicate the 1983 Metropolitan reference standard should be the reference tool of choice.

The null hypothesis $H_{0,1c}$ cannot be refuted. A weight gain to 120% of reference was not associated with the delivery of an "optimal" birth weight of 3,500-4,000 g. Rather, a gain to 120% or more of reference was associated with a mean birth weight of $3,206 \pm 750$ g ($n=237$) when the 1959 reference standard was used, and 3289 ± 721 g ($n=191$) when the 1983 Metropolitan reference standard was used. These birth weights are lower than the $3,462 \pm 482$ reported by Rosso (1985) in a group of 262 black and Hispanic non-smoking, non-drinking pregnant women.

Although not considered "optimal" by Brown's (1988) definition, these weights have been associated in Michigan with an infant mortality rate of approximately 3.6 deaths/1000 live births within the first year of life (Appendix 30a), well below the 9/1000 deaths set as a Year 2000 Health Objective for the Nation (DHHS, 1989a). Thus, although not "optimal" by Brown's definition, the birth weight of infants born to mothers who gained to 120% or more of reference can be considered a "healthy" birth weight, if the corresponding Michigan infant mortality rates and the Year 2000 Objective are used as the standard.

Based on results presented here, the null hypothesis H_{0_1} -1d must be retained. There was no significant difference in the estimated risk of delivering a LBW infant in women who gained less than 7 kg (15.5 lbs) at term if overweight prior to pregnancy. The small sample size (only ten women obese prior to pregnancy gained less than 7 kg at term) resulted in a reduction in power and an attenuation of the measure toward its null value (Kelsey et al, 1986).

H_{0_2} -1a: Maternal birth weight (MBW) does not differ between mothers who deliver optimal and low birth weight infants and cannot be used to predict birth weight.

Eighty-seven percent of the responders to the White Michigan Mother's Survey (n=348) provided an estimate of their own birth weight, 144 of whom subsequently delivered a LBW infant and 166 of whom delivered an OBW infant. On average, the maternal birth weight (MBW) of women who delivered a LBW infant was 381 g less than the MBW of women who delivered an OBW infant (Table 5.14).

Table 5.14. Mean self-reported maternal birth weight of women who delivered a LBW or an OBW infant.

	Delivered LBW Baby	Delivered OBW Baby	t	p
Maternal Birth Weight	3009±603	3390±543	5.87	.0000
N	144	166		

The crude odds ratio indicated a woman whose own birth weight was less than 2,500 g had a three-fold increased risk of delivering a LBW infant as compared to a woman whose MBW was greater than 2,500 g (Table 5.15). Low birth weight women had a nine-times greater risk of delivering a LBW infant than did women whose birth weight was "optimal" (3,500 to 4,000 g).

Table 5.15 Estimated relative risk (RR) of delivering a LBW infant by self-reported maternal birth weight (MBW) categories.

Variable	LBW Infant	OBW Infant	RR (95% CI)
Maternal Birth Weight	N	N	
Optimal (3,500-4,000 g)	20	75	1.0 ^a
LBW (< 2,500 g)	27	11	9.2 (3.9-21.7)
Maternal Birth Weight			
≥ 2,500 g	117	155	1.0 ^a
< 2,500 g	27	11	3.3 (1.6-6.8)

^a reference group

The overall correlation between maternal birth weight (MBW) and infant birth weight (IBW) was highly significant ($r=0.32$, $p < 0.0000$), explaining 10% of the variance in birth weight. When subjects were categorized by pre-pregnant reference weight (Table 5.16), results indicated the correlation between MBW and IBW was highest for subjects who entered pregnancy underweight (weighing less than 90% of their 1983 reference weight; $r=0.37$) or at their desirable weight (between 90 and 119% of their 1983 reference weight; $r=0.28$), accounting for 14% and 8% of the variance in infant birth weight, respectively. The correlation between MBW and IBW was not significant for subjects who entered pregnancy weighing 120% or more of their 1983 reference standard. This was likely due to the small numbers and the large variance observed.

Table 5.16 Correlation between infant birth weight (IBW) and maternal birth weight (MBW) by pre-pregnant 1983 Metropolitan reference weight.

Pre-Pregnant Weight	N	R	R ²	B	SE-B	Constant	F	p
All Mothers	348	.32	.10	.42	.07	1696	38.3	.0000
< 90% RW	118	.37	.13	.46	.11	1253	18.0	.0000
90-119% RW	187	.28	.08	.37	.09	1992	15.8	.0001
120-149% RW	33	.26	.07	.29	.20	2314	2.2	.1449
≥ 150% RW	10	.31	.01	.39	.42	2106	0.8	.3584

As indicated in Table 5.17, there were no statistically significant differences in maternal birth weight between any of the four pre-pregnant weight categories within the infant birth weight groups (LBW, $p=0.96$; OBW, $p=0.48$). However, mothers who weighed less than 90% of their 1983 Reference Weight at conception, and who subsequently delivered a LBW infant, had lower maternal birth weights than underweight mothers who delivered an OBW infant (MBW=2,958 vs 3,501, $p=0.000$). Similarly, mothers who weighed between 90-119% of their 1983 Reference Weight at conception, and who delivered a LBW infant, had lower maternal birth weights than desirable-weight mothers who delivered an OBW infant (MBW=3,034 g vs 3,347 g, $p=0.009$). There were no differences in MBW between women who delivered LBW or OBW infants if subjects weighed greater than 120% of reference prior to conception.

Table 5.17 Maternal birth weight of women who delivered a LBW or OBW infant by their pre-pregnant 1983 Metropolitan reference weight category.

Pre-Pregnant Weight Category	Delivered LBW Baby	N	Delivered OBW Baby	N	t	p
<u>Maternal Birth Weights</u>						
< 90% RW	2985±583	75	3501±491	36	4.58	.000
90-119% RW	3034±626	57	3347±520	103	3.38	.001
120-149% RW	3018±765	9	3391±644	20	1.38	.184
≥ 150% RW	3100±603	3	3276±666	7	0.45	.675
F-prob, within group	0.96		0.48			

Because a woman's pre-pregnancy weight status and the amount of weight gained during pregnancy has been shown to account for the largest percent of variance in term infant's birth weight (Brown, 1986; Taffel, 1984), subjects in this study were categorized by percent of pre-pregnant reference weight attained at term to account for these factors (Table 5.18). Results indicate mothers who delivered LBW infants had lower maternal birth weights than mothers who delivered OBW infants, despite gaining to the same reference weight at term. These results suggest maternal birth weight impacts infant birth weight independent of pre-pregnant weight status and amount of weight gained during pregnancy.

Table 5.18 Maternal birth weight of women who delivered a LBW or OBW infant by the percent 1983 Metropolitan reference weight attained at term.

Reference Weight Attained at Term	Delivered LBW Baby	N	Delivered OBW Baby	N	t	p
<u>Maternal Birth Weights</u>						
< 90% RW	2782±579	7	-	-	-	-
90-119% RW	2990±555	95	3408±576	56	4.42	.000
120-149% RW	3072±716	36	3378±457	88	2.85	.005
≥ 150% RW	3199±682	6	3336±726	21	0.45	.683
MEAN:	3009±603	144	3390±543	166	5.87	.000
F-prob within groups	.56		.86			

Nonetheless, for the 38 women who reported weighing less than 2,500 g at birth, the crude odds ratio (Table 5.19) indicated a protective effect against the delivery of a LBW infant if the women gained to 120% or more of the 1983 reference weight at term [RR=0.19, (0.04-0.88)]. These results suggest prenatal care providers should be encouraged to determine a patient's own birth weight, and if LBW, the provider should encourage the woman to gain to a minimum of 120% of standard at term as a safeguard against the delivery of a low birth weight infant.

Table 5.19. Estimated relative risk (RR) of a LBW mother delivering a LBW infant if the mother did not gain to 120% of her reference weight at term.

Risk of LBW	LBW (N)	OBW (N)	RR (95% CI)
<u>If MBW < 2,500 g and:</u>			
Gained to $\geq$ 120% RW at term	9	8	0.19 (0.04-0.88)
Gained to < 120% RW at term	18	3	1 ^a

^a reference group

Based upon these results, the null hypothesis H_{02-1a} is rejected. In women who were not overweight or obese at conception, maternal birth weight clearly impacted infant birth weight, independent of pre-pregnancy weight status and percent standard weight attained at term.

Although birth weight undoubtedly is the result of the interaction between many factors, these results indicate a possible genetic influence on birth weight which accounted for approximately 10% of the variance in birth weight among women who were not obese prior to pregnancy. These results suggest a stronger relationship than observed by Hackman et al (1983) who reported the simple correlation between maternal birth weight and infant birth weight was $r=0.11$, accounting for approximately 1% of the variance in birth weight. The present sample, however, is not homogenous in birth weight and is "loaded" with low birth weight infants, the group in which Hackman et al suggested the strongest relationship between MBW and IBW existed. Results are also slightly higher than those observed by Klebanoff and Yip (1987) who reported an association of $r=0.20$ for whites and $r=0.18$ for blacks, explaining 4% and 3.2% of the variance in birth weight, respectively.

In light of the potential impact LBW could have on the birth weight of the next generation of babies, and in view of the increasing number of LBW and very low birth weight infants who are surviving today, these results provide added impetus to strengthen research efforts to identify medical, environmental and behavioral factors associated with poor fetal outcome and to develop educational and public assistance programs to help women modulate those risk behaviors. In addition, LBW women should be identified early in prenatal care and their weight gain monitored closely, as, in this study, underweight and normal weight women who themselves were LBW reduced their risk of delivering a LBW infant by gaining to at least 120% of reference weight at term.

H0₂-1b: Maternal percent prepregnant weight-for-height (1983 Metropolitan Reference) does not differ between mothers who deliver OBW and LBW infants and cannot be used to predict birth weight.

On average, mothers who subsequently delivered a LBW infant entered pregnancy at 94% of their 1983 Metropolitan reference weight-for-height (Table 5.20). Mothers of controls weighed, on average, 104% of reference.

Table 5.20 Mean percent prepregnant weight-for-height (PPW) for mothers of LBW and OBW infants.

Variable	LBW	OBW	t	p
% 1983 PPW	93.5 ± 17.8	103.9 ± 19.4	5.19	.0000
Range, %	(68-190)	(71-187)		
n	168	184		

Thirty-five percent (n=140) of all responders to this survey reported entering pregnancy at a weight less than 90% of their 1983 reference weight. Of these, 85 subsequently delivered a LBW infant and 41 delivered an OBW infant. The crude odds ratio indicated women who entered pregnancy at less than 90% of reference had a 333% increased risk of delivering a LBW infant than a mother who entered pregnancy at 90-119% of reference (Table 5.21). Entering pregnancy above 119% of reference (i.e., overweight or obese) was not associated with either an increased, or a decreased, risk of delivering a LBW infant.

Table 5.21 Estimated relative risk of delivering a LBW infant dependent upon maternal prepregnant reference weight-for-height.

Variable	Cases N	Controls N	RR (95% CI)
<u>Prepregnant Reference Weight:</u>			
< 90%	85	41	3.33 (2.07-5.36)
90-119%	71	114	1.0 ^a
120-149%	9	21	0.69 (0.30-1.59)
150% or more	3	7	0.69 (0.17-2.76)
^a referent			

When percent prepregnant reference weight was regressed against birth weight, the correlation ($r=0.266$; $F=30.0$) was statistically significant, explaining 7% of the variance in birth weight. When subjects' percent prepregnant reference weight and pregnancy weight gain were both regressed against birth weight, the amount of explained variance in birth weight increased to 16% ($r=0.40$). The partial regression coefficients indicated "weight gain" and "pregnate weight status" accounted for 52% and 48% of the explained variance in birth weight, respectively (Table 5.22).

Table 5.22 Multiple regression analysis of prepregnant weight status (% PPW) and weight gain on birth weight.

Variable	B	SE-B	Partial r	t	Sig t
Weight gain	20.16	3.10	0.301	6.51	.0000
% PPW	11.47	1.87	0.284	6.14	.0000
Constant	1277	215		5.95	.0000
Multiple R	0.40				
R ²	0.16				
F	37.8				
DF	(2,393)				
p	.000				

When subjects were classified by percent prepregnant reference weight as underweight (< 90% RW), normal weight (90-119% RW), overweight (120-149% RW) or very overweight (150% RW or more), the corresponding percent reference weight attained at term and infant birth weight were highly correlated (Table 5.23). For the underweight, normal weight and moderately overweight women, each percent increase in reference weight attained at term was associated with a 33.7 g ($p=0.000$), 14.6 g ($p=0.009$) and 26.8 g ($p=0.0106$) increase in birth weight, respectively. In the very overweight category, the slope of the regression line did not differ from zero and was therefore not statistically significant.

Table 5.23. Regression of percent 1983 reference weight attained at term on infant birth weight by pre-pregnant weight classification.

	<u>Pre-Pregnant Weight Classification</u>			
	Underweight ($< 90\%$)	Normal Weight ($90-119\%$)	Overweight ($120-149\%$)	Obese ($\geq 150\%$)
r	0.43	0.23	0.43	-0.49
adj r^2	0.18	0.05	0.16	-0.16
B	33.7	14.6	26.8	-20.5
SE-B	6.0	4.3	9.9	12.0
F	31.2	11.3	7.3	2.9
n	140	212	36	12
p	0.0000	0.0009	0.0106	0.1224

This relationship of increasing infant birth weight by an increased weight gain in women who entered pregnancy underweight women is seen graphically in Figure 5.3. These results reinforce the importance of a weight gain to 120-130% of one's standard weight at term for optimal birth weight. The decrease observed in infant birth weight as women in this study gained to more than 150% of reference at term is not unlike that which has been previously reported in the literature (Abrams and Laros, 1986). The sample size of very overweight women in this study, however, is quite small ($n=12$).

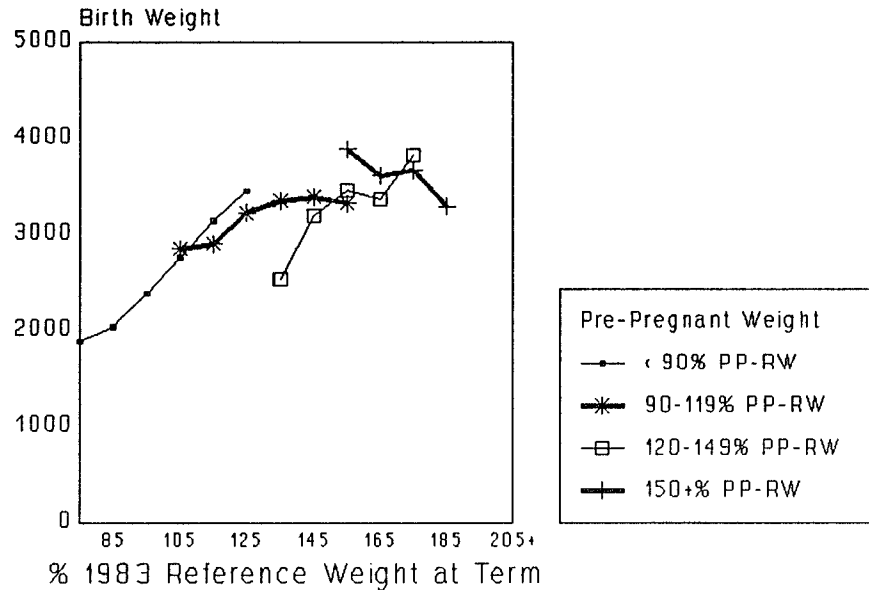


Figure 5.3. Birth weight by percent reference weight at term according to a subject's prepregnancy weight classification.

Responders' height, independent of weight, was associated with birth weight ($r=0.24$; $F=24.59$), accounting for 6% of the variance in birth weight (Appendix 29-5a). When subjects were categorized by maternal stature as being short (≤ 62 "), medium (62.5-65.6") or tall (≥ 66 "), the corresponding infant birth weights were 2729 g, 3017 g and 3191 g, respectively ($F=10.49$; $p=0.0000$). The impact of increasing maternal height on infant birth weight, within each of the four categories of percent reference weight attained at term, is seen graphically in Figure 5.4.

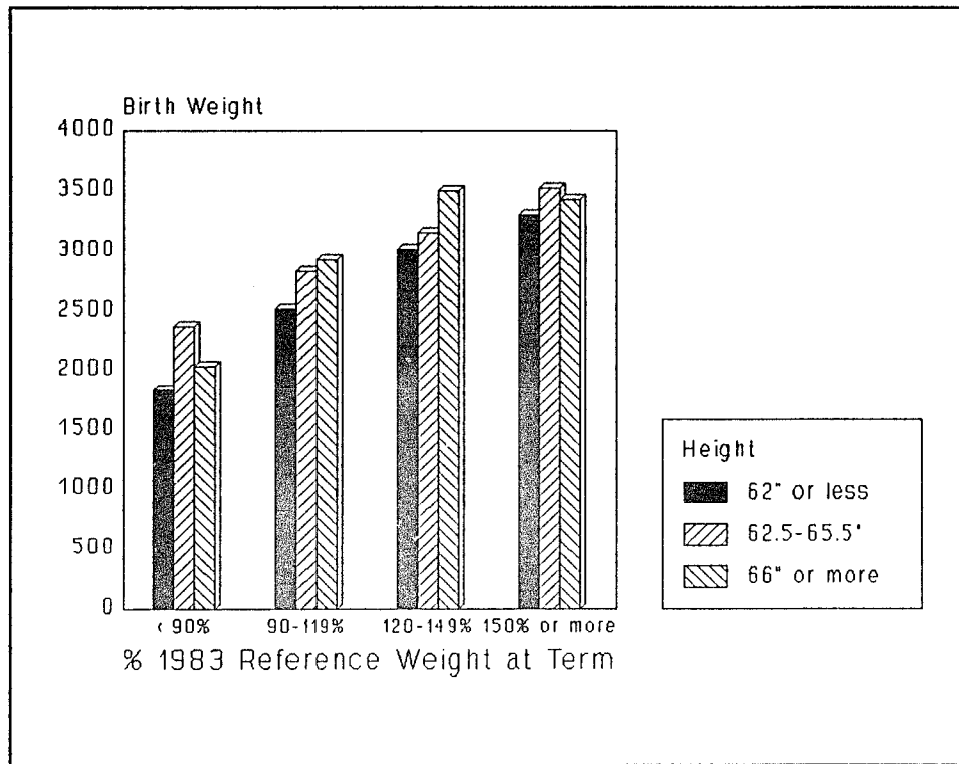


Figure 5.4. Effect of increasing maternal height on infant birth weight by percent 1983 Metropolitan Reference weight at term.

Results presented here contribute to the body of literature which indicated women who enter pregnancy below their reference weight-for-height are at increased risk for delivering a low birth weight infant (Naeye, 1979; NCHS, 1980; Simpson et al, 1975; Brown et al, 1981). Metcalf et al (1981) suggested that, after gestational age, pregravid weight status and antenatal weight gain have the greatest impact on birth weight, each accounting for approximately eight and six percent of the variance in birth weight, respectively. Results of this study are consistent with this observation. In this group of term infants,

prepregnant weight status accounted for seven percent of the variance in birth weight. When both weight gain and percent prepregnant weight status were regressed against birth weight, 16% of the variance was explained, with weight gain explaining slightly more than half.

Abrams and Laros (1986) stratified 2946 women who delivered live, term infants into four prepregnancy weight-for-height categories based on the 1959 Metropolitan reference. These researchers observed that, for the underweight (< 90%), normal weight (90-120%) and moderately overweight (121-135%) subjects, each kilogram of maternal weight gain increased birth weight by 25.9, 28.3 and 17.8 g, respectively. Although the reference standard and category cut-offs differed in this study, results presented here indicate a similar trend. The birth weight of infants born to women who entered pregnancy underweight increased almost 34 g for each one percent increase in reference weight at term. Corresponding increases in birth weight of infants born to women entering pregnancy at a normal weight or overweight were 14.6 g and 26.8 g for each one percent increase in percent reference weight attained at term. Results of this study concur with the observation of Abrams and Laros (1986) that very overweight women did not benefit their infant by high weight gains. The present sample size of very overweight women, however, was quite small.

Luke et al (1984) reported mean infant birth weight paralleled increasing maternal delivery weight in short, medium and tall women. These researchers reported a 10% increase in weight associated with increases of 127 g, 74 g and 87 g in mean birth weight for short, medium and tall women, respectively. Results of this study indicated short

women delivered infants weighing, on average, 462 g less than infants born to tall women. Women of medium height delivered infants weighing, on average, 174 g less than tall women. Within each category of percent reference weight attained at term the observation is more striking. In general, as percent reference weight at term increased up to 150% of reference, infant birth weight increased. As stature increased within each of the term reference weight categories up to 150% of reference, infant birth weight increased.

Results presented here support the hypothesis of Rosso (1985) that a weight gain to 120% of one's reference weight at term is associated with increased infant birth weight. Results presented in Figure 5.3 and Figure 5.4 demonstrated the leveling-off effect on birth weight as subjects gained to between 120-130% of their 1983 reference weight. Results also provide modest support for Rosso's observation that very overweight women may not need to gain the same amount of weight as women who enter pregnancy weighing less than 120% of reference. Results presented in Table 5.23 indicated no significant increase in birth weight with increasing weight gain in very overweight women.

Based on these results the null hypotheses are refuted. Maternal pre-pregnant weight (percent of 1983 Metropolitan reference weight-for-height) clearly differed between mothers who delivered LBW and OBW infants. Women who entered pregnancy underweight had a three-fold increased risk of delivering a LBW infant. Maternal stature, independent of prepregnancy weight, was predictive of infant birth weight. Even within each category of percent reference weight attained at term, taller women delivered heavier infants.

Results indicated maternal percent prepregnant weight can be used as a predictor of birth weight. By itself, a subject's prepregnant weight status accounted for 7% of the variance in birth weight. When prepregnant weight status was combined with weight gain, both variables together explained 16% of the variance in infant birth weight.

Taken together, these data suggest underweight women can reduce their risk of delivering a LBW infant by establishing a higher prepregnancy weight and/or by gaining extra weight during the prenatal period. These results underscore the importance of determining a woman's prepregnant weight status so an appropriate, individual weight gain recommendation can be made. In this study, however, 20% of the prenatal care providers were unable to provide their patient's height. Prenatal care providers should be urged to determine a patient's pre-pregnant weight-for-height status and make weight gain recommendations accordingly. The present sample size of very overweight women was too small to provide stable evidence of a deleterious effect on birth weight with increasing weight gain in obese women. Further research, however, is warranted.

H0₂-2a: Maternal weight gain does not differ between mothers who deliver OBW and LBW infants and cannot be used to predict birth weight.

As a group, responders to the White Michigan Mother's Survey gained 29.5 pounds (n=396). Women who delivered LBW infants gained, on average, seven pounds less than mothers who delivered OBW infants (Table 5.24).

Table 5.24. Mean weight gain of white mothers who delivered LBW and OBW infants.

Variable	LBW	OBW	F	p
Weight gain, lbs	26.4 ± 11.6	33.2 ± 10.7	5.70	0.0000

Seventy four percent of the responders indicated their prenatal care provider had made a specific weight gain recommendation. On average, the weight gain of LBW subjects was almost identical to that recommended by these subjects' prenatal care provider (27 lbs). Women who delivered OBW infants gained, on average, six pounds more than their prenatal care provider had recommended (28 lbs).

The crude odds ratio indicated women who gained less than 22 pounds were not at an increased risk of delivering a LBW infant compared to mothers who gained the currently recommended 22-27 pounds (Table 5.25). However, women who gained less than 22 pounds had a 540% increased risk of delivering a LBW infant than mothers who gained 28 pounds or more.

Table 5.25. Estimated relative risk of delivering a LBW infant dependent on amount of pregnancy weight gain (n=351).

Variable	LBW	OBW	RR (95% CI)
<u>Weight gain, lbs:</u>	N	N	
< 22 lbs	59	22	1.83 (0.93-3.59)
22-27 lbs	44	30	1 ^a
> 27 lbs	65	131	0.34 (0.19-0.59)
< 22 vs > 27 lbs			5.40 (3.05-9.58)

^areferent

When subjects were categorized according to their pre-pregnant percent reference weight (<90%, 90-119%, 120-149% 150% or more), underweight and normal weight women who subsequently delivered OBW infants gained significantly more weight than women who delivered LBW infants (Table 5.26). Similarly, overweight women who delivered OBW infants gained more than overweight women who delivered LBW infants, however the difference was not statistically significant (31 ± 14 vs 20 ± 14 ; $t=1.90$). Very overweight women who delivered OBW infants gained less weight than very overweight mothers of LBW infants, but again the difference was not statistically significant due to the sample size and the variance observed in the measure (19.5 ± 15 vs 31 ± 8 ; $t=1.30$).

Table 5.26. Amount of weight gained during pregnancy by mothers of OBW and LBW infants when subjects were categorized according to their 1983 Metropolitan pre-pregnancy reference weight.

Pre-Pregnant Weight Classification	LBW (n)	OBW (n)	t	p
< 90%	25 ± 10 (85)	34 ± 8 (41)	4.82	.0000
90-119%	29 ± 13 (71)	34 ± 10 (114)	3.29	.0012
120-149%	20 ± 14 (9)	31 ± 14 (21)	1.90	.0667
150% or more	31 ± 8 (3)	19 ± 15 (7)	1.30	.2336

Regression analysis indicated weight gain was highly correlated with birth weight (Table 5.27), explaining 8% of the variance. The correlation between birth weight and weight gain was higher among women who weighed less than 120% of their 1983 Metropolitan reference prior to pregnancy ($r=0.31$; $F=35.1$). Each pound of weight gained by underweight and normal weight women was associated with a 48.8 g increase in birth weight. A smaller gain in birth weight (32.3 g/pound weight gain) was noted among women who entered pregnancy overweight or obese.

Table 5.27. Regression of weight gain on birth weight by white subject's pre-pregnant percent of reference weight.

Statistic	< 120% Pre-Pregnant	120% or more Pre-Pregnant	All Subjects
r	0.31	0.28	0.284
r ²	0.10	0.08	0.08
B	48.8	32.3	41.9
SE-B	8.2	13.6	7.1
F	35.1	5.7	34.6
p	0.00	0.02	0.00
n	330	66	396

Results of the Michigan Mother's Study presented here reinforce the position of Brown (1983) and Rosso (1985) that weight gain recommendations should be individualized. Results of this study indicated women who entered pregnancy underweight needed to gain more than the 22-27 pounds currently recommended by the American College of Obstetricians and Gynecologists (ACOG, 1982), as well as by these subjects' prenatal care providers.

Previous research has indicated each pound of weight gained during pregnancy was associated with a 44-50 g increase in birth weight (Eastman and Jackson, 1968; Niswander et al, 1969; Simpson et al, 1974; Abrams and Laros, 1986). Results of this study concur with this observation, as each pound of weight gain among underweight and normal weight women was associated with a 48.8 g increase in birth weight. A smaller increase was seen among women who entered pregnancy overweight or very overweight. Metcalf et al (1981b) indicated the correlation

coefficients between weight gain and birth weight in most surveys are usually around 0.20 to 0.30. Again, results of the present study support this observation, as the correlation coefficient between weight gain and birth weight among all subjects was 0.28. When overweight and very overweight subjects were removed from the sample population, the correlation between weight gain and birth weight increased to 0.31, explaining 10% of the variance in birth weight.

Naeye (1979) noted optimal infant outcome was associated with a weight gain of 30 pounds for underweight women. Brown (1986) reported a weight gain of 33 pounds was associated with an optimal birth weight of 3,000 to 4,000 g if the mother was underweight prior to pregnancy. Results of this study indicated a weight gain of 34 pounds by underweight women was associated with an optimal birth weight of 3,500 to 4,000 g. This same weight gain was associated with optimal birth weight among women who entered pregnancy at or near their desirable reference weight. No specific weight gain recommendation can be made for women who entered pregnancy overweight from this study due to the small sample size and high variance observed.

Based on results presented here, the null hypotheses are refuted. There was a significant difference in amount of weight gained by mothers of LBW and OBW infants. It must be noted that the amount of weight gained by mothers of LBW infants was not, on average, less than the highest weight gain recommended by the subjects' prenatal care providers. Thus, a 27 pound weight gain recommendation was clearly not high enough for these subjects. The estimated relative risk of delivering a LBW infant also supports the fact that a 22-27 pound weight

gain was insufficient. In fact, the relative risk of delivering a LBW infant was not significantly different between women who gained either 22-27 pounds or less than 22 pounds. A weight gain greater than 27 pounds, in contrast, significantly reduced the incidence of LBW.

HO₂-2b: Maternal hemoglobin values during pregnancy do not differ between mothers who deliver optimal and low birth weight infants and cannot be used to predict birth weight.

The highest and lowest hemoglobin levels recorded during pregnancy were provided by the prenatal care provider of 230 cases and controls. If only one value was recorded during pregnancy (n=68), it was coded as the "highest" value. No statistically significant differences were observed in either the highest or the lowest hemoglobin values recorded during pregnancy between mothers who delivered optimal or low birth weight infants (Table 5.28).

Table 5.28. Mean high and low hemoglobin values recorded during pregnancy between cases and controls.

Variable	LBW	(n)	OBW	(n)	t	p
Highest Hb, g/dl	13.2 ± 1.1	(108)	13.1 ± 0.8	(122)	0.91	.37
Lowest Hb, g/dl	12.0 ± 1.1	(69)	11.8 ± 1.0	(93)	0.64	.52

The correlation between the lowest hemoglobin value recorded during pregnancy and birth weight was not significant ($r=0.07$; $F_p=0.36$).

Likewise, the correlation between the highest hemoglobin value and birth weight was not significant ($r=0.06$; $F_p=0.32$). When the hemoglobin values were categorized according to the levels recommended by Murphy et al (1986), the odds ratio did not indicate a statistically significant increased risk of delivering a LBW infant if the highest hemoglobin value recorded during pregnancy was greater than 13.2 g/dl (Table 5.29).

Table 5.29 Estimated relative risk of delivering a LBW infant dependent upon maternal hemoglobin levels recorded during pregnancy.

Variable	Cases N	Controls N	RR (95% CI)
Highest Hb recorded (n=230)			
< 10.4 g/dl	2	0	-
10.4-13.2 g/dl	53	76	1.0 ^a
> 13.2 g/dl	53	46	1.65 (0.98-2.80)

^a referent

This observation does not support that of Murphy et al (1986) who reported hemoglobin levels greater than 13.2 g/dl in pregnant women were associated with an increased incidence of perinatal mortality, preterm delivery and low birth weight as compared to infants of women with intermediate hemoglobin levels (10.4-13.2 g/dl). These researchers had suggested the high hemoglobin levels reflected some failure in plasma volume expansion, resulting in decreased uteroplacental circulation and a concomitant decreased birth weight due to a reduced supply of nutrients to the fetus. Naeye (1977) had also hypothesized high

hemoglobin values contributed to the formation of placental infarcts, again resulting in decreased uteroplacental flow, decreased nutrient transfer and decreased infant size.

Based upon these results, the null hypothesis is retained. There were no significant differences in the mean hematologic values between groups, nor was there a significant correlation between birth weight and either the highest or lowest hemoglobin values recorded during pregnancy. In addition, the crude odds ratio did not indicate an elevated risk of delivering a LBW infant if the maternal hemoglobin value was higher than 13.2 g/dl at some point during pregnancy.

H0₂-2c: Highest and lowest maternal diastolic blood pressure values recorded during pregnancy do not differ between mothers who deliver optimal and low birth weight infants and cannot be used to predict birth weight.

Highest and lowest diastolic blood pressure readings were provided by the prenatal care provider of 229 cases and controls. Results indicated no statistically significant difference in either the mean high or low diastolic blood pressure readings between mothers who delivered optimal or low birth weight infants (Table 5.30).

Table 5.30. Mean high and low diastolic blood pressure (DBP) readings during pregnancy between cases and controls.

Variable	LBW (n=105)	OBW (n=124)	t	p
Highest DBP, mm HG	79 ± 13	77 ± 9	1.92	.057
Lowest DBP, mm HG	59 ± 9	59 ± 8	0.01	.351

The correlation between the lowest recorded diastolic blood pressure reading during pregnancy and birth weight was not significant (Table 5.31). However, the correlation between the highest recorded blood pressure reading during pregnancy and birth weight was statistically significant, with each incremental increase in diastolic blood pressure associated with a 10.5 g decrease in infant birth weight.

Table 5.31. Correlation between highest and lowest diastolic blood pressure readings recorded during pregnancy and infant birth weight.

Variable	Lowest DBP	Highest DBP
R	-.03	-.15
adjusted R ²	.00	.02
Beta	-2.9	-10.5
Standard Error-Beta	5.7	4.3
Constant	3207	3854
F	.2516	5.9
p	.6164	.0158
n	256	256

Highest and lowest diastolic blood pressure values were categorized based on the observations of Grunberger et al (1979) and Naeye (1979), who independently observed that diastolic blood pressure readings of less than 65 mm Hg or greater than 99 mm Hg were associated with a decreased infant birth weight. The crude odds ratios indicated that, although there was no association between a diastolic blood pressure of less than 65 mm Hg and low birth weight, there was a statistically significant increased risk of delivering a LBW infant if the highest diastolic blood pressure reading during pregnancy was greater than 99 mm Hg (Table 5.32).

Table 5.32. Estimated relative risk of delivering a LBW infant dependent upon highest and lowest maternal diastolic blood pressure readings during pregnancy.

Variable	Cases N	Controls N	RR (95% CI)
<u>Highest DBP recorded (n=213):</u>			
< 65 mmHg	0	0	-
65-89 mmHg	77	107	1 ^a
90-99 mmHg	6	9	0.92 (0.31-2.69)
> 99 mmHg	13	1	18.0 (2.3-141.0)
<u>Lowest DBP recorded (n=229):</u>			
< 65 mmHg	81	102	0.73 (0.38-1.39)
65-89 mmHg	24	22	1 ^a
90-99 mmHg	-	-	-
> 99 mmHg	-	-	-

^a referent

These results do not support the observation of Grunberger et al (1979) that a diastolic blood pressure lower than 65 mmHg reduces uteroplacental perfusion, decreasing transfer of nutrients to the fetus and resulting in a smaller infant. These results are, however, consistent with the observation of Naeye (1979) that a peak diastolic blood pressure greater than 99 mm Hg during pregnancy is associated with a reduced infant birth weight. Naeye suggested this high diastolic blood pressure represents an overshoot of the normal, homeostatic, hemodynamic mechanisms, reducing the supply of nutrients to the fetus and resulting in a smaller than expected infant.

Results presented herein suggest that, while low maternal diastolic blood pressure values do not differ between mothers who deliver optimal and low birth weight infants, high diastolic blood pressures do differ between mothers of cases and controls, and can be used to predict infant birth weight. A high diastolic blood pressure greater than 99 mmHg at some time during pregnancy was associated with an 18-fold increased risk for delivering a LBW infant. Based upon these results, the null hypothesis that low diastolic blood pressure readings do not differ between mothers of LBW and OBW mothers is retained. However, the null hypothesis that highest recorded diastolic blood pressures do not differ between mothers of LBW and OBW infants is cautiously refuted, with a diastolic blood pressure greater than 99 mmHg associated with an increased risk for delivering a LBW infant.

Caution is warranted in interpreting these results. Peak diastolic blood pressure values for 16 subjects were discarded during data entry

due to what appeared to be an apparent misinterpretation of the question by respondents. Data were discarded if the peak diastolic reading was reported to be 120 mm Hg or greater with no mention made of a diagnosis of hypertension or toxemia. (REMINDER: Subjects were excluded from the sampling frame if, according to the birth certificate, the physician had diagnosed the patient as having hypertension, pre-eclampsia or toxemia during pregnancy). It appeared to this researcher that some respondents had provided the subject's systolic and diastolic blood pressures, rather than the high and low diastolic pressures. This observation was especially noticeable when a medical records assistant had completed the survey. Thus, it appears bias has been introduced into this question.

HO₂-3a: The mean number of cigarettes consumed per day does not differ between mothers who deliver optimal and low birth weight infants and cannot be used to predict birth weight, regardless of percent 1983 reference weight at term or number of calories consumed.

Self-reported smoking behavior prior to and during pregnancy was provided by 395 respondents to the Michigan Mother's Survey. Fifty-four percent of the women (n=214) indicated they did not smoke prior to pregnancy. An estimated eight percent quit smoking while pregnant, bringing the number of non-smokers to 62% of the sample (n=245). Thirty percent (n=54) of the women who smoked before pregnancy reported they did not reduce their consumption of cigarettes during pregnancy.

In this study, mothers who delivered LBW infants consumed significantly more cigarettes, both prior to and during pregnancy, as

compared to women who delivered OBW infants (Table 5.33). On average, both groups reduced their cigarette consumption during pregnancy by half.

Table 5.33. Mean number of cigarettes consumed per day prior to and during pregnancy as reported by mothers of cases and controls.

Variable	LBW (n=167)	OBW (n=184)	t	p
<u># Cigarettes/day</u>				
Before pregnancy	13.4 ± 12.2	5.4 ± 9.9	6.75	.0000
During pregnancy	7.8 ± 10.2	2.7 ± 6.6	5.71	.0000

The crude odds ratio indicated women who reported smoking during pregnancy had almost a 5-fold increased risk of delivering a LBW infant as compared to non-smokers (Table 5.34). Women who reported consuming 20 or more cigarettes per day during pregnancy were at highest risk for delivery of a LBW infant [RR=5.6 (2.6-11.8)]. After adjusting for the confounding risk factor of not gaining to 120% of 1983 Metropolitan reference weight at term, the Mantel Haenszel adjusted odds ratio indicated smoking more than one cigarette per day during pregnancy was still associated with an increased risk for delivery of a LBW infant [RR=4.73 (3.47-6.46)].

Table 5.34. Estimated relative risk of delivering a LBW infant associated with number of cigarettes consumed per day during pregnancy.

Variable	Cases N	Controls N	RR (95% CI)
<u># Cigarettes/day:</u>			
Non-smoker	70	143	1 ^a
Smoker	97	41	4.8 (3.0-7.7)
1-9	29	17	3.5 (1.8-6.8)
10-19	38	13	6.0 (3.0-11.9)
20 or more	30	11	5.6 (2.6-11.8)

^a referent

Simple regression indicated the number of cigarettes consumed per day during pregnancy was negatively associated with infant birth weight ($r = -0.25$). Each cigarette consumed per day was associated with a 22.3 g decrease in infant birth weight (Table 5.35).

Table 5.35. Simple regression of number of cigarettes consumed per day during pregnancy on birth weight (n=395).

Statistics	Value
R	-0.25
adjusted R ²	0.06
Beta	-22.3
Standard Error-Beta	4.3
Constant	3127
F	26.7
DF	(1,394)
p	.0000

When both the percent of 1983 reference weight attained at term and number of cigarettes consumed per day during pregnancy were regressed against infant birth weight, both factors independently entered the equation (Table 5.36). Together these two variables explained 17% of the variance in birth weight ($r=0.41$). After correcting for percent 1983 reference weight attained at term, each cigarette consumed per day was associated with an 18.3 g decrease in infant birth weight. Thus, smoking one-half pack of cigarettes per day was associated with a 183 g decrease in infant birth weight. Smoking a pack or more per day during pregnancy was associated with a 363 g decrease in birth weight in this study.

Table 5.36. Regression analysis indicating the relationship between number of cigarettes consumed per day, percent 1983 reference weight attained at term and birth weight.

Variable	B	SE-B	Regression Coefficient	T	Sig T
% 1983 Reference Weight at Term	12.36	1.75	0.328	7.05	.0000
# Cigarettes/day	-18.28	4.11	-0.207	-4.45	.0000
Constant, g	1603	220		7.29	.0000
Multiple R	.410				
R ²	.168				
F	39.55				
DF	(2,391)				
p	.0000				

The decrease in birth weight with increasing number of cigarettes consumed per day can be seen graphically in Figure 5.5. The slight increase in birth weight associated with the consumption of 20 or more cigarettes per day, as compared to the consumption of 10-19 cigarettes per day, was unexpected. Possible explanations include: 1) mothers who reported consuming 10-19 cigarettes under-reported, thus their infant's birth weights are lower than one would have expected, 2) several women who delivered optimal birth weight infants, in fact, smoked 20 or more cigarettes per day causing a regression of birth weight toward the mean or 3) this could be a statistical artifact.

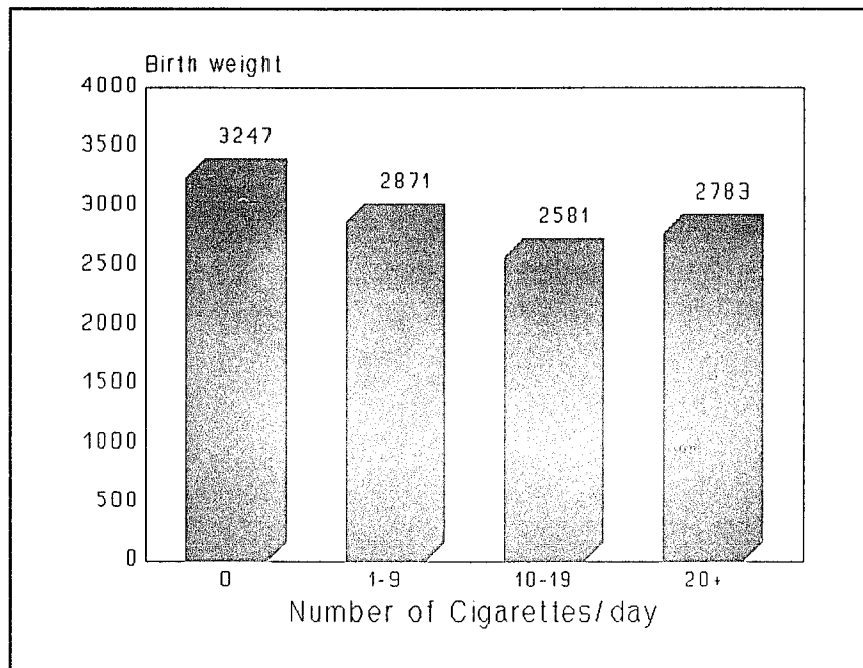


Figure 5.5. Effect of increasing cigarette consumption on birth weight.

When the subjects were classified as either being a smoker (smoked one or more cigarettes per day) or a non-smoker (abstained from smoking throughout pregnancy), smokers delivered infants who weighed, on average, 556 g less than infants born to women who indicated they did not smoke (2670 ± 752 vs 3226 ± 728 ; $t=7.28$). Interestingly, the average weight gain of smokers was not significantly different from that of non-smokers, nor was there a significant difference in the estimated number of calories consumed per day (Table 5.37). Non-smokers were significantly older than smokers by one year ($t=3.71$; $p=.0002$).

Table 5.37. Comparison of infant birth weight, weight gain and calories consumed per day between smokers vs non-smokers (n=395).

Variable	Non-Smokers (n=244)	Smokers (n=244)	t	p
Birth weight, g	3226 $\pm$ 728	2670 $\pm$ 753	7.28	.0000
Weight gain, lbs	30 $\pm$ 12	29 $\pm$ 12	1.25	.2111
Calories/day	2312 $\pm$ 669	2317 $\pm$ 727	0.08	.9399
Age, years	27 $\pm$ 4	26 $\pm$ 4	3.71	.0002

Data from the National Natality Survey indicated an estimated 25% of married white women over the age of 20 smoke (Kleinman and Kopstein (1987). Of these, an estimated 17% of women quit smoking, and 40% cut down on the number of cigarettes consumed per day during pregnancy.

Results of the White Michigan Mother's Study indicated a much higher incidence of smoking (46%) among the white respondents between 20-34 years of age at delivery and a much lower number of respondents who quit smoking during pregnancy (8%). Only the percentage of subjects who cut down on cigarette usage during pregnancy in this study was compatible with the national survey data (37% vs 40%).

A review of the literature indicated cigarette smoking has consistently been associated with a 150 to 250 g decrease in birth weight (Abel, 1980). Results of the White Michigan Mother's Study indicated smokers delivered infants who weighed, on average, 556 g less than infants of non-smokers. This large difference found must be regarded in context with the sample design chosen for this study. Because 43% of the subjects in this study weighed less than 2,500 g at birth (cases), and 46% weighed 3,500 to 4,000 g at birth (controls), the magnitude of the difference in birth weight would be expected to be large if the prevalence of smoking was higher in one group than the other. Because more cases than controls smoked, this large difference is not surprising.

Metcoff et al (1981b) reported cigarette smoking typically accounts for 3-6% of the variance in birth weight. Results presented here concur with this statement, as regression analysis indicated cigarette smoking accounted for 4-6% of the variance in birth weight. The estimated relative risk of delivering a LBW infant if a mother smoked during pregnancy was higher than any value previously reported in the literature. Again, the present study design contributes to the magnitude of the difference. LBW infants are compared to optimal birth

weight infants, rather than to infants who weigh 2,500 g or more.

Few studies have reported the effect of both smoking and diet on birth weight. Picone et al (1982a, 1982b), based on results of five 24-hour diet recalls obtained throughout pregnancy, reported smokers consumed significantly more calories than non-smokers. Hayworth et al (1980) and Higgins (1976) also reported smokers consumed significantly more calories per day than non-smokers. The estimated daily caloric intake during pregnancy in this study, as determined by the Willett SQFFQ, was not significantly different between smokers and non-smokers.

Based on these results, the null hypothesis of no difference in the number of cigarettes consumed per day between mothers who deliver optimal and low birth weight infants is refuted. Results indicate mothers of LBW infants consumed significantly more cigarettes per day. In addition, mothers who smoked at all during pregnancy had a five-fold increased risk of delivering a LBW infant.

Regression analysis indicated that the number of cigarettes smoked per day during pregnancy was highly, negatively associated with infant birth weight. Each cigarette smoked per day was associated with an estimated 18 gram decrease in birth weight, after accounting for percent standard weight attained at term. Simple regression indicated smoking accounted for 6% of the variance in birth weight, a value consistent with that reported in the literature. Based on these results, the second clause of the null hypothesis is refuted. Results presented herein indicate the number of cigarettes consumed per day can be used to predict infant birth weight.

H0₂-3b: Mean daily alcohol intake does not differ between mothers who deliver optimal and low birth weight infants and cannot be used to predict birth weight.

Results of the Pregnancy Lifestyle Questionnaire indicated 92% of respondents either reduced or eliminated their consumption of alcohol during pregnancy. Eighty-nine percent of the women (n=355) reported consuming less than one drink per month. Only six respondents reported consuming three to five drinks or more per week. When the Willett semi-quantitative food frequency questionnaire (SQFFQ) was used to estimate alcohol intake, 17 subjects reported consuming five or more drinks per week. Which figure is most accurate cannot be determined in this retrospective study. Data obtained from the SQFFQ was analyzed to determine the relation of self-reported alcohol intake to birth weight.

An estimate of the mean alcohol intake (g/day) during pregnancy was obtained for 359 responders to the White Michigan Mother's Survey. Results indicated mothers of cases consumed, on average, twice as much alcohol per day as mothers of controls (Table 5.38). The variance within each group, however, was quite large.

Table 5.38. Mean daily alcohol intake as reported by mothers of cases and controls on the SQFFQ instrument.

Variable	LBW (n=144)	OBW (n=166)	t	p
Daily alcohol intake, g	1.4 ± 3.3	0.7 ± 2.2	2.26	.0245

Subjects were categorized by mean daily alcohol intake into the following four groups according to the method of Wright et al (1983): abstainer (no alcohol during pregnancy), light drinkers (1-49 g/week or at least one drink per month but less than five per week), moderate drinkers (50-99 g/week or five or more, but less than 10, per week) and heavy drinkers (100 or more g/week or 10 or more drinks per week). The crude odds ratio indicated a significant increase in the risk of delivering a LBW infant only when subjects consumed more than 100 g of alcohol per week (Table 5.39).

Table 5.39. Estimated relative risk of delivering a LBW infant associated with maternal consumption of alcohol during pregnancy as reported on the Willett SQFFQ (n=310).

Variable	Cases N	Controls N	RR (95% CI)
<u>Alcohol Consumption, g/week:</u>			
Abstainer	102	136	1.0 ^a
< 50 g	31	34	1.22 (0.70-2.12)
50-99 g	10	5	2.67 (0.88-8.04)
100+ g	1	1	1.33 (1.03-1.72)
Consumers vs abstainers	42	40	1.4 (0.85-2.32)
Consumed > 50 g/week vs abstainers	11	6	2.34 (0.84-2.32)

^a referent

Simple regression between mean daily alcohol intake and infant birth weight was significantly and negatively correlated ($r = -0.13$; $F = 9.86$). Each gram of alcohol consumed per day during pregnancy was

associated with a 38 g decrease in birth weight. The correlation between the alcohol consumption and number of cigarettes smoked per day was significant ($r=0.23$; $F_p=19.6$), indicating a potential confounding effect. When alcohol, number of cigarettes and an alcohol x cigarette interaction term were regressed against birth weight (Table 5.40), the interaction term provided only modest evidence of an impact of alcohol dependent on the number of cigarettes smoked per day ($t=1.48$, $p=0.14$). Analysis of the partial regression coefficients indicated both alcohol intake and the number of cigarettes independently impacted birth weight. Together they explained 6.6% of the variance in birth weight ($r=0.257$; $F=8.35$). Of the 6.6% of variance explained, the partial regression coefficients indicated alcohol intake explained approximately 28%, smoking 50% and the interaction between the two approximately 23% of the variance in birth weight.

Table 5.40. Regression analysis of alcohol consumption per day, number of cigarettes smoked and the interaction between these variables on birth weight.

Variables	B	SE-B	Regression Coefficient	t	Sig t
Alcohol/day, g	-43.5	20.7	-0.15	-2.43	.0362
Cigarettes/day	-23.3	5.5	-0.26	-4.25	.0000
Alcohol x cigarettes	2.0	1.4	0.12	1.48	.1386
Constant	3195	48.66		65.66	.0000
Multiple R	-0.257				
R ²	0.066				
F	8.35				
DF	(3,353)				
p	0.0000				

Results presented here are consistent with the observation of Brooke et al (1989) who reported a trend toward reduced birth weight with increasing consumption of alcohol. After controlling for effects of smoking, however, no additional alcohol-effect on birth weight was noted except among smokers who drank heavily. Because only two subjects in this study reported consuming more than 100 g alcohol per week (Brooke's definition of "heavy"), multiple regression analysis could not test this hypothesis in the White Michigan Mother's Study.

Although only two women reported consuming 100 g or more alcohol per week in this study, the crude odds ratio did indicate an increased risk of delivering a LBW infant when 100 g or more alcohol were consumed per day [RR=1.33 (1.03-1.72)]. This same observation was reported by Wright et al (1983) who, after adjusting for smoking, detected an increased risk of low birth weight among women who drank more than 100 g/week during pregnancy [RR=2.27(1.36-3.86)].

Based on these results, the null hypotheses are refuted. There was a statistically significant difference in the amount of self-reported alcohol consumed per day between mothers who delivered optimal and low birth weight infants. The crude odds ratio indicated an alcohol intake of 100 g or more per week was associated with an increased risk of delivering a LBW infant. Although statistically significant, the sample size was quite small, with the mother of only one case and one control reported consuming more than 100 g alcohol (10 or more drinks) per week.

Simple regression indicated a significant, negative relationship between alcohol and birth weight. After controlling for the effect of

cigarette consumption, the partial regression coefficient still indicated a significant, negative effect of alcohol on birth weight. Holding cigarette consumption constant, each gram of alcohol consumed per day was associated with a 43.5 g decrease in infant birth weight. Considering the mean daily intake of alcohol was only 1.4 and 0.7 g/day for mothers of LBW and OBW infants, respectively, one can see that the effect of alcohol as a risk factor for low birth weight in this study was marginal at best.

H0₂-3c: Self-reported intake of caffeine during pregnancy does not differ between mothers who deliver optimal and low birth weight infants and cannot be used to predict birth weight.

Data from the Willett semi-quantitative food frequency questionnaire (SQFFQ) provided an estimated mean daily intake of caffeine during pregnancy for 359 subjects. Oneway ANOVA indicated a significant difference in estimated mean daily intake of caffeine between mothers of cases and controls (Table 5.41).

Table 5.41. Self-reported estimated daily intake of caffeine between mothers of cases and controls.

Variable	LBW	OBW	t	p
Caffeine, mg	168 ± 209	97 ± 152	3.52	.0005
N	(144)	(176)		

When caffeine intake was classified according to the method of Martin and Bracken (1987), the odds ratio indicated a three-fold increased relative risk of delivering a LBW infant when more than 300 mg of caffeine, the amount in two cups of coffee, was consumed per day during pregnancy (Table 5.42). There was no increased risk of LBW associated with the consumption of less than 300 mg caffeine per day.

Table 5.42. Estimated relative risk (RR) of low birth weight by self-reported caffeine intake during pregnancy.^a

Variable	Cases N	Controls N	RR (95% CI)
<u>Caffeine consumption:</u>			
< 50 mg/day	53	90	1.0 ^b
50-149 mg/day	31	37	1.42 (0.76-2.56)
150-299 mg/day	20	17	2.00 (0.96-4.15)
300+ mg/day	33	18	3.11 (1.60-6.07)

^a data from the Willett SQFFQ

^b referent

The impact of caffeine intake on birth weight can be seen graphically in Figure 5.6. Results indicated women who estimated their daily caffeine intake to be between 0-149 mg caffeine (n=232) were delivered of infants who weighed, on average, 3173 ± 755 g. In contrast, women who estimated their caffeine intake to be 300 mg/day or more (n=58) delivered infants who weighed, on average, 2782 ± 933 g. This difference was statistically significant ($t=2.41$, $p=0.0033$).

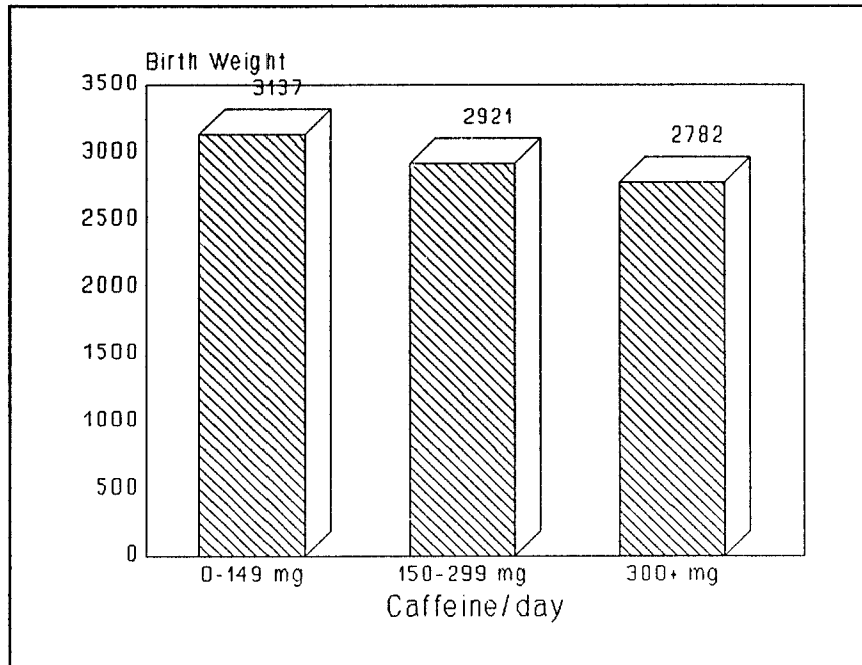


Figure 5.6. Impact of caffeine intake on birth weight.

Multiple regression analysis (Table 5.43) indicated a statistically significant, negative relationship between caffeine intake and infant birth weight ($r=-0.16$). The correlation between number of cigarettes smoked and caffeine intake per day was statistically significant ($r=0.45$). Each cigarette smoked per day was associated with an additional 10 mg increase in caffeine consumption.

Table 5.43. Simple regression of caffeine intake on birth weight and caffeine intake on number of cigarettes smoked per day during pregnancy.

	Caffeine & Birth Weight	Caffeine & Cigarettes
r	-0.16	0.45
adjusted r^2	0.03	0.20
Beta	-0.67	9.56
SE-Beta	0.21	1.01
Constant	3147	84
F	9.86	89.10
p	.0018	.0000
n	358	358

The interactive effect of number of cigarettes smoked per day and mean daily caffeine intake on birth weight was determined and regressed against birth weight. A caffeine x cigarette interaction term and a non-linear smoking term were both statistically significant (Table 5.44).

Table 5.44. Multiple regression analysis of caffeine and cigarettes on birth weight.

Variable	B	SE-B	Partial r	t	Sig t
Caffeine	-0.68	0.34	-0.166	-2.00	.0465
# Cigarettes	-44.94	9.69	-0.509	-4.64	.0000
Smoking x smoking	0.52	0.23	0.225	2.24	.0254
Caffeine x Cigarettes	0.04	0.02	0.217	2.00	.0458
Constant	3257	54.83		59.4	.0000
Multiple R	0.30				
R^2	0.09				
F	8.68				
DF	(4,352)				
Fp	0.000				

These results indicate four variables contributed significantly to the variance in birth weight, suggesting both an independent and an interactive effect of caffeine and smoking on birth weight. The partial regression coefficients indicated daily caffeine intake and number of cigarettes smoked per day during pregnancy independently reduced birth weight. While holding cigarette smoking constant, each 100 mg of caffeine was associated with a 68 g decrease in birth weight.

The caffeine-cigarette interaction can be seen graphically in Figure 5.7. For sake of clarity, caffeine consumption was categorized as less than 300 mg/day or 300+ mg/day and subjects were classified as either being smokers or non-smokers. The mean birth weight of infants born to smokers who consumed less than 300 mg caffeine per day (n=86), appeared not to be depressed any further by the consumption of 300 mg or more caffeine/day (n=46) than they already were depressed from smoking. However, the consumption of 300 mg or more caffeine/day among non-smokers (n=12) was associated with a 551 g decrease in birth weight as compared to infants born to women who did not smoke and also consumed less than 300 mg caffeine/day (n=213). Although this apparent caffeine-effect on the birth weight of infants born to non-smokers is striking, the reader is cautioned that the number of subjects within this category was quite small (n=12).

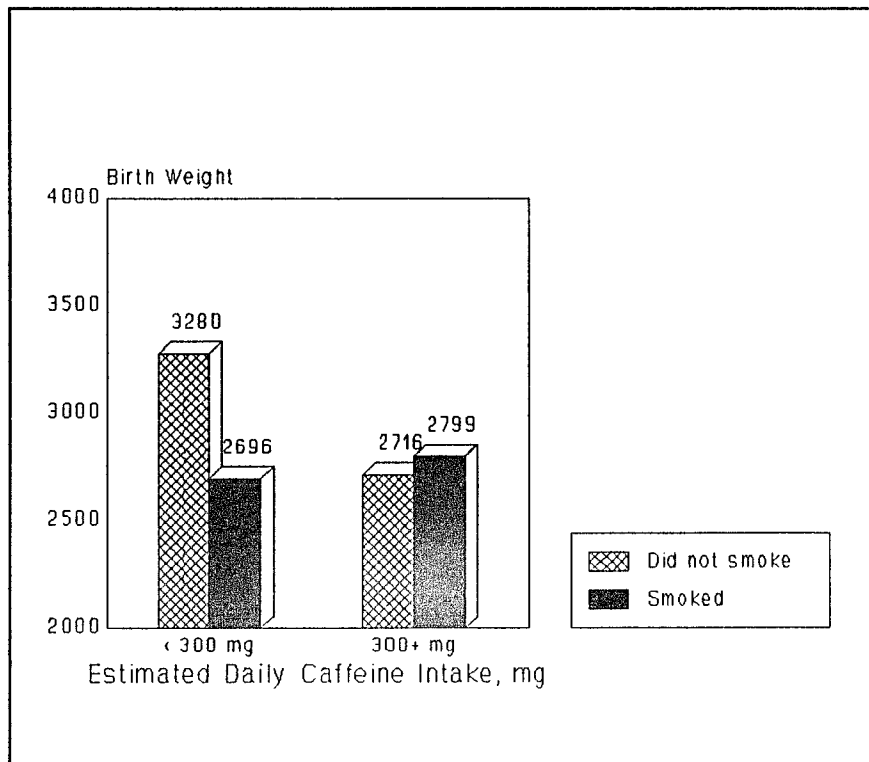


Figure 5.7. Interactive effect of caffeine intake and smoking on infant birth weight.

Based on these observations, the first condition of the null hypothesis is refuted. There is a statistically significant difference in the estimated daily intake of caffeine between mothers of cases and controls. The consumption of 300 mg or more caffeine per day was associated with a three-fold increased risk of delivering a LBW infant. Regression analysis indicated both an independent and an interactive effect of caffeine on birth weight. There did not appear to be an additional caffeine-effect on the birth weight of infants born to smokers. In contrast, non-smoker who consumed more than 300 mg/day delivered infants who had significantly reduced birth weights as

compared to infants of non-smokers who consumed less than 300 mg caffeine/day.

Beaulac-Baillargeon and Desrosiers (1987) indicated consumption of 300 mg or more caffeine per day was associated with decreased birth weight. They noted 206 g decrease in birth weight in infants born to mothers who both smoked 15 or more cigarettes per day and consumed 300 mg or more caffeine, as opposed to mothers who only smoked. These researchers also observed a reduced placental weight in women who both smoked and consumed 300 mg or more caffeine as compared to women who only smoked. The authors concluded the concomitant consumption of caffeine and cigarettes constituted a high risk for the developing fetus.

Results of this study, do not support this conclusion of Beaulac-Baillargeon and Desrosiers (1987). There was no additional decrement in the birth weight of infants born to smokers that could be attributed to caffeine. Rather, results of this study suggest a caffeine effect among non-smokers who consumed more than 300 mg caffeine/day.

Martin and Bracken (1987) observed an increased relative risk of low birth weight among mothers who consumed 151-300 mg [2.3(1.1-5.2)], and 300 mg or more caffeine per day [4.6(2.0-10.5)]. Results presented here only indicated an increased relative risk of LBW among women who consumed 300 mg caffeine or more per day [RR=3.1 (1.6-6.0)]. Martin and Bracken (1987) detected a decrease in birth weight of 31 g and 105 g among women who consumed 151-300 mg and more than 300 mg caffeine per day, respectively, as compared to women who did not consume caffeine. Cigarette smoking was only associated with a 137 g decrease in birth

weight. Results of the Michigan Mother's Study presented here indicated a much higher decrease in infant birth weight among women who consumed 150-299 g and 300 g or more caffeine per day (216 g and 355 g, respectively). In addition, a much higher reduction in birth weight (464 g) was observed in the present study when the birth weight of infants whose mother did not smoke at all were compared to infants born to mothers who reported smoking 20 or more cigarettes per day. These large differences are most likely due to the birth weight distribution of the sampling frame in the White Michigan Mother's Survey.

Linn et al (1982) reported low birth weight occurred more frequently among 12,205 non-diabetic women who drank four or more cups of coffee per day (approximately 500 mg caffeine). The LBW rate of women who consumed no tea or coffee during pregnancy was 7.4/100. The LBW rate rose to 10.4/100 among women who consumed more than four cups of coffee or tea per day. Upon further analysis, these researchers stated that, independent of smoking, there was no increase LBW infants born to women who were heavy coffee drinkers.

Results presented here do not support this conclusion. In this study, partial regression coefficients indicated both an independent and an interactive effect of caffeine and cigarettes on birth weight. Differences in the caffeine database could possibly account for the lack of congruity between these two studies. Linn et al only used intake of coffee and tea to quantify the exposure variable. The caffeine database in the White Michigan Mother's Study was much more comprehensive. It included not only caffeinated and decaffeinated coffee, tea, and diet and regular soda pop, but also cocoa, brownies, ice cream sundaes and

chocolate candy, resulting in a more accurate account of the true exposure variable.

Based on these results, the null hypotheses are refuted. A significant difference was observed in the mean intake of caffeine between mothers of cases and mothers of controls. An intake of 300 mg caffeine or more per day in this study was associated with an increased risk of delivering a LBW infant. Lastly, multiple regression analysis indicated both an independent, and an interactive, effect of caffeine on birth weight.

These data provide additional support for the inclusion of estimated daily caffeine intake to the list of risk factors associated with a reduced birth weight. Prenatal care providers should be encouraged to determine the caffeine intake of their patients and discuss with them its potential deleterious effects on birth weight.

H0₂-3d: Quality of the diet during pregnancy does not differ between mothers who deliver optimal and low birth weight infants and cannot be used to predict birth weight.

Overall, the 398 responders to the White Michigan Mother's Survey rated the quality of their diet during pregnancy (1=poor, 10=excellent) higher than the quality of their diet before pregnancy. Seventy-nine percent (n=315) of the subjects indicated they consumed a higher quality diet, 18% (n=71) consumed the same quality and only 3% (n=12) reported consuming a poorer quality diet during pregnancy. The Mann-Whitney test indicated no difference in either of the two diet quality ratings when responses of mothers who delivered LBW and OBW infants were compared

(mean rank before=174 vs 180, $p=0.5382$; mean rank after=173 vs 181; $p=0.4214$). Both groups reported significant increases in the quality of their diet during pregnancy (Table 5.45).

Table 5.45. Self-reported rating of diet quality (1=poor, 10=excellent) prior to and during pregnancy by mothers of cases and controls.

Diet Quality Rating	LBW (n=169)	OBW (n=184)	Z	Sig Z
Before Pregnancy	5.2 $\pm$ 1.8	5.3 $\pm$ 1.8	-0.62	.5382
During Pregnancy	7.5 $\pm$ 1.8	7.7 $\pm$ 1.6	-0.80	.4214
Mean ranks within groups		58.3		71.1
Z, within groups	-9.4	-10.6		
Sig Z	.000	.000		

Dietary data for 144 cases and 176 controls were analyzed. Overall, mothers of OBW infants consumed a slightly higher quantity of all nutrients than mothers of LBW infants. The magnitude of the difference between groups, however, was quite small (Table 5.46). The estimated energy intake between cases and controls differed by only 83 calories. The difference in protein intake between cases and controls, although statistically significant ($t=5.67$; $p=0.0178$), was only 9 g/day. Analysis of the individual micronutrient content of the diet indicated controls consumed significantly more iron, zinc, thiamin, pyridoxine and folacin than did controls (Appendix 29-6a).

Table 5.46. Daily macronutrient intake between cases and controls as estimated by the Willett SQFFQ.

Nutrient	LBW	OBW	t	Sig t
Calories	2258 ± 718	2341 ± 648	1.08	.2810
Protein, g	96 ± 32	105 ± 32	2.38	.0178
Carbohydrate, g	284 ± 104	294 ± 95	0.98	.3738
Saturated fat, g	35 ± 15	35 ± 12	0.00	.9970
Monounsatur. fat, g	30 ± 11	31 ± 11	0.77	.4418
Polyunsatur. fat, g	13 ± 6	14 ± 5	1.22	.2247
Cholesterol, mg	357 ± 154	361 ± 128	0.24	.8093

In general, when nutrient intakes were compared to the 1989 Recommended Dietary Allowances for pregnant adult women (NRC-RDA, 1989), mothers of both cases and controls appeared to consume adequate diets. The mothers of OBW infants consistently reported consuming a higher percent of the RDA for every nutrient, despite consuming only a estimated 87 calories per day more than mothers of cases (Table 5.47). Statistically significant differences were noted in the percent of the RDA consumed for thiamin, pyridoxine, folic acid, iron, zinc and protein. Iron was the only nutrient for which both groups consumed less than two-thirds of the RDA.

Table 5.47. Estimated percent of the 1989 Recommended Dietary Allowance (RDA) consumed per day during pregnancy between mothers of cases and controls, without supplements.

Nutrient	LBW (n=144)	OBW (n=176)	t	Sig t
<u>% 1989 RDA</u>				
Calories	90 ± 29	94 ± 26	1.08	.281
Protein	160 ± 53	174 ± 53	2.38	.018
Vitamin A	67 ± 61	72 ± 66	0.67	.500
Vitamin D	88 ± 49	98 ± 48	1.94	.053
Vitamin E	81 ± 54	92 ± 57	1.69	.090
Ascorbic Acid	256 ± 175	275 ± 166	0.95	.340
Thiamin	104 ± 39	116 ± 38	2.74	.006
Riboflavin	154 ± 63	166 ± 60	1.77	.080
Pyridoxine	99 ± 38	111 ± 43	2.52	.012
Folacin	76 ± 35	84 ± 35	2.04	.042
B ₁₂	442 ± 350	464 ± 348	0.57	.566
Calcium	107 ± 50	116 ± 46	1.58	.115
Iron	47 ± 21	53 ± 22	2.28	.023
Zinc	96 ± 35	105 ± 37	2.35	.020

A comparison of the mean MAR-12 scores for mothers of cases and controls indicated mothers who delivered OBW infants consumed diets of

significantly higher nutritional quality than mothers who delivered LBW infants (Table 5.48). This finding means that, after removing the weighting effect contributed by subjects who consumed more than 100% of the RDA for any or all nutrients, the mothers of OBW infants consumed a higher percent of the RDA than did mothers of LBW infants.

Table 5.48. Mean diet quality scores (MAR-12) between mothers of cases and controls, without supplements.

Variable	LBW	OBW	t	p
MAR-12	73 ± 13	77 ± 11	2.75	.0063

The same observation was noted when subjects were categorized as being smokers or non-smokers. The MAR-12 of non-smokers was significantly higher than the MAR-12 of smokers (76.9 ± 11 vs 73.6 ± 13 ; $t=2.64$; $p=0.0086$), despite consuming the same number of calories (2303 ± 674 vs 2327 ± 711 ; $t=0.32$; $p=0.7474$). Because the caloric intake between mothers of cases and controls, and between smokers and non-smokers, was not different, the higher MAR-12 scores indicates mothers of OBW infants and non-smoking mothers selected more nutrient-dense diets for the number of calories consumed.

A comparison of the Index of Nutritional Quality (INQ), the amount of a nutrient consumed per 1000 calories, indicated mothers of OBW infants consumed ten nutrients with an INQ score of 1.0 or more. Mothers of LBW infants, in comparison, consumed eight nutrients with an INQ of

1.0 or more (Appendix 29-6b). The INQ-12 score did not differ between cases and controls (LBW=1.62 $\pm$ 0.6 vs OBW=1.70 $\pm$ 0.6; t=0.96). Likewise, no difference was noted when the INQ-4 score, based on Jenkins and Guthrie's (1984) four indicator nutrients (A, B-6, iron and calcium), were compared (0.90 $\pm$ 0.28 vs 0.94 $\pm$ 0.30; t=0.45).

Regression analysis indicated the only nutrition indicators which correlated significantly with birth weight in this study were protein intake and the MAR-12 score (Table 5.49). Although both were statistically significant, neither of these two variables explained more than one to two percent of the variance in infant birth weight.

Table 5.49. Simple regression of calories, protein and diet quality scores with birth weight (n=359).

Statistic	Calories	Protein	MAR-12	INQ-12	INQ-4
R	0.04	0.11	0.13	0.06	0.09
R ²	0.001	0.01	0.02	0.004	0.007
Beta	0.04	2.7	8.6	142	229
SE-Beta	0.06	1.3	3.4	74	142
Constant	2964	2791	2406	2914	2847
F	0.48	2.07	6.41	1.40	2.62
p	0.49	0.04	0.01	0.24	0.11

A protein intake equivalent to 20% or more of one's caloric intake has been associated with decreased birth weight (Rush et al, 1980; Picone and Allen, 1984). Results of this study indicated there was no increased risk of delivering a LBW infant if the diet contained more

than 20% of its calories from protein (Table 5.50). Likewise, the consumption of less than 10% of one's calories from protein was not associated with an increased risk of delivering a LBW infant.

Table 5.50. Estimated relative risk of delivering a LBW infant dependent upon percent of calories from dietary protein.

Variable	Cases N	Controls N	RR (95% CI)
<u>% Calories from Protein:</u>			
10% or less	3	2	1.71 (0.3-10.4)
11-19%	121	138	1.0 ^a
20% or more	20	36	0.63 (0.35-1.15)

^a referent

The limited associations found between dietary intake and birth weight were not entirely unexpected. Because of the complexity of the physiologic relationships during pregnancy, the problems with collection and use of dietary data, and the confounding of the diet/pregnancy relationship by behavioral and sociodemographic factors, remarkably few studies have found associations between dietary intake and pregnancy outcome, particularly when the population was not specifically selected a priori as being "high risk". In addition, these results must be tempered by the realization that the Willett SQFFQ has not previously been used with a pregnant population. Therefore, the validity and reliability of these data must be considered conditional.

Animal and human studies have both indicated a decrease in birth weight with severe caloric restriction (Wallace, 1945; Chow and Lee, 1964; Smith, 1947) and severe protein restriction (Winick and Noble, 1965; Antonov, 1947). On average, subjects in this study consumed 92% of the RDA for calories during pregnancy. If the recently published data, indicating only 100 additional calories are needed per day to meet the energy cost of pregnancy, are validated (Durnin, 1987a,b), mothers of OBW and LBW infants in this study would have consumed approximately 100% of the recommended 2300 calories. Thus, it is not surprising that caloric intake in this study was not associated with a decreased birth weight. Even if a subject consumed fewer calories than recommended, data from the 5-country study (Durnin, 1987a,b) indicated the human body has a tremendous capacity to adapt physiologically to a reduced energy intake by reducing the resting metabolic rate. This enables an underfed pregnant woman to sustain adequate fetal growth and development, even in the face of limited energy stores.

The only additional macronutrient associated with birth weight for which even a modest body of literature exists is protein (Rush, 1981; Lechtig et al, 1975). Subjects in this study consumed, on average, 160 to 174% of the RDA for protein. Because both protein and calories were consumed in more than adequate amounts by responders to the Michigan Mother's Study, any reduction in birth weight associated with a reduced protein and/or calorie intake would not be expected in this population.

Meta-analysis of several human studies had suggested a diet containing more than 20% of its calories from protein was associated with retarded fetal growth (Rush, Stein and Susser, 1980). Results of

the present study do not support this conclusion. The odds ratio indicated no significant increase, or decrease, in birth weight when 20% or more of a subject's calories were from protein.

Dietary zinc and folic acid intakes were significantly higher in mothers of OBW infants. Zinc and folic acid both play a critical role in rapidly growing tissues, with a deficiency of both associated with a reduced synthesis of DNA, RNA and cellular proteins (Solomons, 1988). It has been well established, however, that dietary intake does not serve as a valid indicator of the amount of a nutrient that is physiologically functioning (Apgar, 1985; Lazebnik et al, 1988). Without any biochemical indices of the zinc or folacin status of the mother or fetus, no relationship between these nutrient intake levels and birth weight can be, or should be, suggested.

Brown (1989) indicated one of the most pressing, unresolved issues in the field of nutrition is quantification of the impact of total diet quality on infant birth weight. To that end, the correlation between the MAR-12 score and birth weight observed in this study is encouraging. Only two studies which examined the effect of a total diet quality score and birth weight, as opposed to the relationship between individual nutrient intakes and birth weight, were identified in the literature.

Burke et al (1943a) reported an "excellent" diet, one which contained 100% or more of the 1941 RDA for eight nutrients, was associated with a birth weight of 3,856 g. In contrast, a "very poor diet", one which contained less than 50% of the RDA for the same eight nutrients, was associated with a birth weight of 2,637 g. Phillips and Johnson (1977) reported a MAR-12 score was positively correlated with

birth weight ($r=0.30$; $p < 0.05$). When included in a series of multiple regression equations, the MAR-12 score remained significantly associated with birth weight, accounting for approximately 6-7% of the variance.

Although not correlated as highly as that observed by Phillips and Johnson (1977), the MAR-12 score was positively associated with birth weight ($r=0.13$). The amount of variance in birth weight explained by the diet quality score, however, was minimal ($CV=1\%$). The MAR-12 score was significantly higher in mothers of OBW infants than mothers of LBW infants, and mothers who did not smoke. This was true despite no differences in caloric intake between these groups.

These results provide modest support for the premise that diet quality is associated with increased birth weight. There were no statistically significant associations between caloric intake, the INQ-12 or the INQ-4 diet quality score and birth weight. No differences were noted between mothers of OBW and LBW in the mean intake of calories or the INQ-12 and INQ-4 scores. However, protein intake and the MAR-12 score differed between mothers of cases and controls, and between smokers and non-smokers, and were statistically correlated with birth weight. For these reasons, the null hypothesis is cautiously refuted. Protein intake and a MAR-12 score appear to be modestly associated with birth weight. Whether these variables acted as a proxy for socioeconomic status, or whether these results are spurious, will require additional investigation. Nonetheless, these results suggest prenatal care advisors would do well to recommend nutrition counseling for smokers to help increase the nutrient density of their food choices during pregnancy.

H0₂-3e: Maternal attitude toward weight gain, nutrition, and being pregnant do not differ between mothers who deliver optimal and low birth weight infants and cannot be used to predict birth weight.

Factor analysis indicated 11 attitude questions from the Pregnancy Lifestyle Questionnaire loaded to three distinct attitude constructs: 1) attitude toward weight gain during pregnancy, 2) attitude toward the importance of good nutrition during pregnancy and 3) attitude toward being pregnant at that time (Appendix 29-7). The Spearman-Brown split-half reliability of the entire questionnaire was $r=0.73$. Cronbach's alpha reliability coefficient for the three individual attitude constructs were 0.73, 0.67 and 0.28 for the weight factor, nutrition factor and pregnancy factor scores, respectively. Based on these results, the "attitude toward being pregnant" factor was dropped from further analysis due to its apparent poor reliability. The weight factor score and the nutrition factor score, however, were quite acceptable. Each of these two attitude constructs will be discussed separately.

Attitude Toward Nutrition

Oneway ANOVA indicated the nutrition attitude score (1=negative, 5=positive) was not significantly different between mothers who delivered LBW and OBW infants (4.45 ± 0.5 vs 4.51 ± 0.5 ; $t=-1.38$). Pearson's correlation indicated a nonsignificant relationship between subject's nutrition attitude score and infant birth weight ($r=0.04$; NS). Based on these results, the null hypothesis is retained. A subject's nutrition attitude score is not different between mothers of cases and controls, and the nutrition factor score is not predictive of birth weight.

Further analysis indicated the nutrition factor score, although not associated with birth weight, was positively correlated with a subject's self-reported diet quality during pregnancy. Regression analysis indicated a positive relationship between nutrition attitude score and MAR-12 diet quality score ($r=0.23$; $F=19.8$), protein intake ($r=0.14$; $F=6.63$) and INQ-12 score ($r=0.14$; $F=6.64$). The nutrition attitude score, however, was not associated with either caloric intake ($r=0.07$; $F=1.82$) or pregnancy weight gain ($r=0.03$; $F=0.28$). These results suggest that, although not predictive of birth weight or pregnancy weight gain, the nutrition attitude score was predictive of self-reported nutrition behavior. Subjects in this study who reported a positive attitude toward nutrition during pregnancy also reported eating a more nutrient dense diet.

Attitude Toward Weight Gain

Results indicated a significant difference in the mean "attitude toward weight gain" score between mothers of cases and controls (Table 5.51). Women who delivered LBW infants reported a more positive attitude toward weight gain during pregnancy than women who delivered OBW infants, despite having gained less weight.

Table 5.51. Weight gain attitude scores and actual weight gained between mothers of cases and controls (1=negative, 5=positive).

Variable	LBW (169)	OBW (184)	t	p
Weight attitude score	3.75 $\pm$ 0.68	3.45 $\pm$ 0.73	1.98	.0000
Weight gain, lbs	26 $\pm$ 11	33 $\pm$ 11	5.70	.0000

When subjects were categorized according to their pre-pregnant 1983 reference weight, two observations were striking. When scores were compared by weight categories, women who entered pregnancy underweight had significantly more positive attitudes about weight gain than did women who entered pregnancy at or near their desirable weight (Table 5.52). No difference in attitude was detected between underweight and overweight women. In fact, both underweight and overweight women expressed a more positive attitude toward weight gain than did normal weight women.

Table 5.52. Weight gain attitude score of women who entered pregnancy underweight, normal weight and overweight.

Weight Category	N	Mean	SD	F	p
< 90%	139	3.82 ^a	0.70	11.38	.0000
90-119%	211	3.46 ^a	0.74		
120% or more	46	3.66	0.61		

^asignificantly different from each other, $t=4.74$, $p=0.0000$

The second observation was even more striking. Within each pre-pregnant weight category, underweight and normal weight women who delivered LBW infants reported a more positive attitude toward weight gain than women who delivered OBW infants (Table 5.53).

Table 5.53. Weight factor attitude score of mothers of cases and controls categorized by 1983 pre-pregnant weight (1=negative, 5=positive).

Weight Category	LBW	n	OBW	n	F	p
< 90%	4.04 ± 0.67	85	3.75 ± 0.83	41	4.28	.0406
90-119%	3.70 ± 0.74	71	3.42 ± 0.78	114	5.83	.0167
120% +	3.63 ± 0.78	12	3.76 ± 0.61	28	0.33	.5696

Mean weight gains dependent upon a subject's weight gain attitude score were compared. Results indicated subjects who expressed a more positive attitude gained fewer pounds, both within and between groups (Table 5.54).

Table 5.54. Weight gain of women who delivered LBW and OBW infants categorized by their weight gain attitude score.

Weight Attitude Score	LBW	n	OBW	n
Weight Gain, lbs				
1 (negative)	-	-	42	(3)
2	31	(21)	38	(35)
3	27	(59)	32	(80)
4	24	(74)	31	(58)
5 (positive)	26	(14)	30	(7)
F, within	2.0		3.63	
F prob	0.115		0.0071	

The fact that mothers of OBW infants gained, on average, seven pounds more weight than was recommended by their physician, and that mothers of LBW infants gained, on average, exactly what their physician had recommended, does suggest a possible link between the two factors. If true, the implication of this finding is that prenatal care providers should be encouraged to foster in their patients a healthier, guilt-free attitude toward a reasonable weight gain during pregnancy. Pomerance et al (1980) indicated 88% of pregnant women indicated they thought their physician would be more concerned if they gained "too much", as compared to "too little", weight. In this study, women who gained more weight had a more negative attitude about the weight gain, but the result of their gain appeared to be an infant of optimal birth weight.

Regression analysis indicated the weight gain attitude score was significantly and negatively related to both birth weight ($r = -0.2266$; $p < 0.001$) and actual weight gained ($r = -0.207$; $F = 17.66$). Each one unit increase in the weight gain attitude score was associated with a three pound decrement in actual weight gain, on average.

Few researchers have examined the relationship between women's attitudes during pregnancy and subsequent pregnancy outcome. Palmer et al (1985) observed a significant, positive relationship between a weight gain attitude score and actual weight ($p < 0.025$). Data analysis in this study, however, was done with Chi square after categorizing the subjects as having a "positive" attitude or a "negative" attitude based on whether the subjects score fell above or below the median score of the sample. In addition, Palmer et al only examined the attitudes of 29 white, middle-class subjects.

Results presented here appear to be unique in the attitude literature. Based on these observations, the null hypothesis is refuted. Subject's weight gain attitude scores differed between mothers of cases and controls, in an unexpected direction. Results indicated mothers of LBW infants had a more positive attitude toward weight gain than mothers of OBW infants who gained more weight. In addition, regression analysis indicated the weight gain attitude score was predictive of birth weight, as well as weight gain, but again in an unexpected direction. In this study, a more positive attitude toward weight gain was associated with a lower birth weight and a lower actual weight gain. The study design only allows speculation as to the cause of this less positive attitude. Future research must be done to validate these results and to determine possible causal paths. However, if one's attitudes or beliefs influence behavior, as indicated in the White Michigan Mother's Study, then identification of individuals with inappropriate behavioral intentions or attitudes is critical to design and target appropriate prenatal intervention strategies.

H0₂-4a: The quality of prenatal care, as measured by the Kessner Index, does not differ between mothers who deliver optimal and low birth weight infants and cannot be used to predict birth weight.

Results of this study indicated 86% of the mothers of LBW infants, and 90% of the mothers of OBW infants who responded to the survey, began prenatal care in the first trimester. This percentage exceeds the 1986 U.S. average (76%) and, in the OBW mothers, the health objective for the year 2000, which is to increase to at least 90% the proportion of all

pregnant women who receive prenatal care in the first trimester of pregnancy (DHHS, 1989).

The Kessner Index indicated 78% of the cases and 85% of controls who responded to this survey obtained adequate prenatal care during their pregnancies. The percent of women receiving adequate care in this survey was higher than the state of Michigan as a whole when, in 1987, adequate prenatal care was obtained by 75.7% of the mothers of live born white infants (MDPH, 1989). Within this sample, Chi Square analysis indicated no significant difference in the Kessner Index between mothers of cases and controls (Table 5.55).

Table 5.55. Kessner Index classification of prenatal care obtained by mothers of cases and controls.

Kessner Index Classification	LBW (n=169)	OBW (n=184)	χ^2	p
Adequate Care	132	156	3.97	.1374
Intermediate	33	22		
Inadequate	4	6		

When the Kessner Index was dissected into its component parts (weeks gestation, number of prenatal visits and month prenatal care began), the number of prenatal visits (11.7 ± 3.4 vs 12.3 ± 2.8 ; $p=0.0469$) and the estimated weeks of gestation (38.6 ± 1.4 vs 40.0 ± 1.3 ; $p=0.000$) were significantly lower among cases than controls. When these three individual components and the Kessner Index were regressed against birth weight, 19% of the variance in infant birth weight was explained (Table

5.56). Of these variables, only "estimated weeks gestation" was statistically significant, with each additional week of gestation associated with a 216 g increase in birth weight. No other prenatal care variable contributed significantly to the variance in birth weight in this sample.

Table 5.56 Regression analysis of the Kessner Index, number of prenatal visits, month prenatal care began and estimated weeks gestation with birth weight.

Variables	B	SE-B	Regression Coefficient	T	Sig T
Kessner Index	165.8	128	.082	1.29	.1964
Weeks gestation	215.6	24	.419	8.92	.0000
# Prenatal visits	1.3	14	.005	0.093	.9258
Month care began	-6.6	41	-.009	-0.161	.8719
Constant	-5598	926		-6.047	.0000
R	0.43				
R ²	0.187				
F	22.4				
DF	(4,389)				
p	.0000				

Early, high quality prenatal care has been correlated with healthier pregnancies and the prevention of poor pregnancy outcome (DHHS, 1989b). Results of the present study, however, do not indicate any significant differences in the quality of care, as defined by the Kessner Index, between mothers of cases and controls. For that reason,

the null hypothesis must be retained: the Kessner Index, in this study, is not different between mothers of cases and controls, and cannot be used to predict infant birth weight.

However, all infants in the present study were selected because they were "term infants". Results obtained herein suggest the selection criteria of "term infants", and the bias that resulted from responders of cases having had significantly higher Kessner Index scores than non-responders, appeared to force the sample population into having a Kessner Index which was not significantly different between groups. Thus, in this study, the Kessner Index does not function as a discriminating independent variable to predict birth weight.

Conceptual Framework: A Model for Predicting Birth Weight

The conceptual model used to drive this study theoretically and operationally was presented at the end of Chapter II. Analysis of data indicated the following model (Figure 5.8) was predictive of infant birth weight. The multiple regression equations from which the partial regression coefficients used in the model were derived can be found in Appendix 29-8.

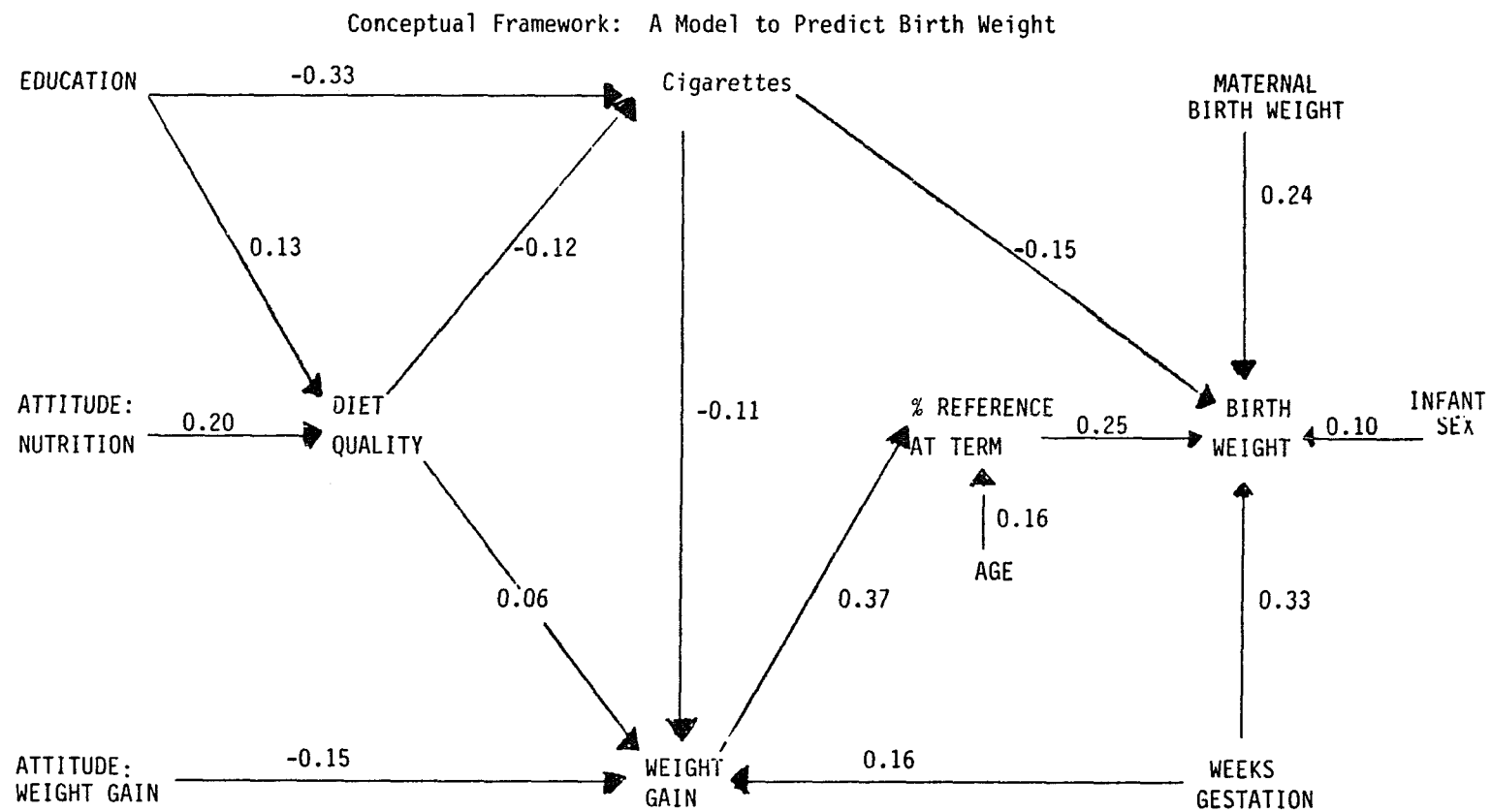


Figure 5.8. Model indicating the correlation between selected maternal characteristics, attitudes and behaviors as they influence birth weight (values = partial regression coefficients ($R=0.594$; $R^2 = 35\%$)).

This causal model accounted for approximately 35% of the variation in infant birth weight ($r=0.59$; $F=36.92$). Whether or not this percent of explained variation is in concordance with the literature cannot be determined, because no similar study design was identified. The strong association of maternal birth weight on infant birth weight ($r=0.24$) is presented here in a multiple regression equation for only the second time (Anderson et al, 1984). The strong influence of percent standard weight attained at term on birth weight ($r=0.25$), which in turn was influenced by pregnancy weight gain ($r=0.37$), indicated the importance of determining a target weight gain based on an individual's prepregnant reference weight. Maternal age was independently associated with percent reference weight attained at term ($r=0.16$). Maternal smoking, associated with a decreased weight gain ($r=-0.11$), a less positive attitude toward nutrition during pregnancy ($r=-0.12$) and fewer years of education ($r=-0.33$) had a direct, negative effect on birth weight ($r=-0.15$). High diet quality, associated with a higher level of education ($r=0.13$) and a more positive attitude toward the importance of nutrition during pregnancy ($r=0.20$), impacted weight gain minimally ($r=0.06$). A less positive attitude toward weight gain during pregnancy was associated in this study with women who gained the most weight ($r=-0.15$) and delivered optimal birth weight infants. Despite designing this study to include only term infants (37 to 40 weeks gestation), each additional week of gestation within this four-week span was associated with both an increased maternal weight gain ($r=0.16$) and infant birth weight ($r=0.33$). In general, males weighed more than females ($r=0.10$). This observation is consistent with figures reported by the State of

Michigan's Office of the Registrar where, in 1988, 54% of all LBW white infants were female. In comparison, 55% of all optimal birth weight infants (3,500-4,000 g) were male.

Multiple Regression Analysis to Predict Birth Weight

Two multiple regression equations to predict birth weight (one="stepwise", two="enter"), based on a sample consisting primarily of LBW and OBW infants, accounted for 38% of the variance in birth weight (Table 5.57). Due to the case-control design of this study, these equations are unique to the literature and cannot be directly compared. In general, however, for infants born at all gestational ages, about 40% of the variation in birth weight has been accounted for by weeks of gestation, prenatal weight gain, prepregnancy weight status and smoking during pregnancy (Anderson et al, 1984; Burke et al, 1943; Burke et al, 1949; Metcalf et al, 1981b), with weeks gestation accounting for the largest proportion of variance in each study. Thus, the multiple R and the percent of variance explained by the two equations presented here appear to be in the realm of values reported in the literature.

Table 5.57 Two multiple regression equations to predict birth weight.

Variable	Equation #1: Method=Stepwise				Equation #2: Method=Enter			
	B	b	t	Sig t	B	b	t	Sig t
Weeks gestation	173	0.34	7.21	.0000	170	0.33	7.46	.0000
Maternal birth weight	0.31	0.24	5.25	.0000	0.31	0.238	5.45	.0000
% 1983 reference weight at term	7.69	0.20	4.29	.0000	8.50	0.226	5.043	.0000
Number cigarettes/day	-12.3	-0.14	-3.02	.0028	-11.5	-0.13	-2.917	.0038
Weight gain attitude score	-123	-0.12	-2.61	.0095	-106	-0.10	-2.35	.0193
Mother's age	21.9	0.11	2.32	.0211				NS
Male infant	143	0.09	1.99	.0476	136	0.09	1.99	.0473
Received Public Asst (AFDC, Food Stamps)				NS	-172	-0.09	-2.14	.0038
Kessner Index				NS				NS
Mother's education				NS				NS
Weight gain				NS				NS
Nutrition attitude score				NS				NS
Diet Quality MAR-12 score				NS				NS
Calories/day				NS				NS
Protein/day, g				NS				NS
Caffeine/day, mg				NS				NS
Alcohol/day, g				NS				NS
Constant	-5858		-5.73	.0000	-5279		-5.65	.0000
R	0.617				0.615			
R ² , %	38				38			
SE-B	624 g				625 g			
DF	(7,307)				(7,338)			
F	26.89				29.30			
p	.0000				.0000			

In both equations, estimated weeks gestation accounted for the largest proportion of variance explained in this study (33-34%), explaining 11% of the total variance in birth weight. Maternal birth

weight accounted for the next largest proportion of explained variance in birth weight (24% of explained, 6% of the total variance in birth weight). Each kg of maternal birth weight was associated with an increased 310 g increase in infant birth weight. The only study located in the literature which included maternal birth weight in a regression equation ($B=0.118$, $r^2=0.014$) indicated each kg of maternal birth weight was associated with a 107 gm increase in infant birth weight (Anderson et al, 1984).

The percent of reference weight at term accounted for between 20-22% of the explained variance (5% of the total variance in birth weight). The high correlation between prepregnant weight status and term reference weight ($r=0.86$) required the elimination of one of these two variables to avoid multicollinearity (Snedecor, 1981). Adding weight gain did not improve the amount of explained variance. These results suggest term reference weight is an adequate substitute for prepregnant weight and weight gain, two variables shown in previous studies to explain approximately 6-8% of the variance in birth weight (Metcoff et al, 1981b).

Cigarettes consumption in this study was associated with an 11.5-12.3 g decrease in birth weight for every cigarette smoked per day, explaining 2% of the variance in total birth weight. A woman who smoked a pack of cigarettes could expect to deliver an infant weight 230-250 g less than if she did not smoke. These results are consistent with the decrease of -12.5 g/cigarette reported by Anderson et al (1984) and the -11.0 reported by Philipps and Johnson (1977). Metcoff et al (1981b)

reported cigarette smoking typically contributes three to six percent of the variance in birth weight.

The inclusion of a "weight gain attitude score" is reported here for the first time. Women who expressed a more neutral or negative attitude toward gaining weight during pregnancy did, on average, actually gain more weight and deliver babies who weighed more than women who expressed a very positive attitude toward weight gain.

Maternal age and education have been reported to account for as much as eight percent of the variance in birth weight (Metcoff et al, 1981b). Anderson et al (1984) reported a 7.1 g increase in birth weight for each year of maternal age ($R^2=0.003$). In this study, increasing maternal age was associated with an 11 g increase in birth weight for each year in the stepwise equation. When all variables were entered into the regression equation, whether or not public assistance was received (AFDC, Food Stamps, WIC) was more strongly correlated with birth weight than was age. The correlation between these two variables, however, was high ($r=-0.295$), with younger mothers receiving more public assistance than older mothers, within the 20-34 year age range of the subjects in this study.

Lastly, previous research has indicated female infants weigh 171 g (Anderson et al, 1984) and 118 g (Dougherty and Jones, 1982) less than males. In the present study, being female was associated with a reduction of 136-143 g as compared to males.

In summary, these prediction equations, including the unique variables of "percent reference weight at term" as a substitute for prepregnancy weight status and weight gain, "maternal birth weight" and

"attitude toward weight gain score", are not outside the realm of previously published equations and make a unique contribution to the field.

Summary: White Michigan Mother's Study

Infant birth weight is the primary predictor of infant viability, accounting for the vast majority of variation in infant mortality and morbidity (Shapiro et al, 1980). Improving infant birth weight has been identified as the critical issue if declines in the infant mortality rate in the United States are to occur (McCormick, 1985; Shapiro, 1985). Such improvements will, in part, depend upon identification and improvement of modifiable factors that influence birth weight.

Results of the White Michigan Mother's Survey, a study of 398 Michigan residents between the ages of 20-34 who were delivered of either their first or second child between June 1, 1988 and November 30, 1988, identified several modifiable risk factors for the delivery of a low birth weight infant. In addition to the known LBW risk factors of low income level, fewer years of maternal education, number of weeks gestation and infant sex, results indicated the following risk factors differed between mothers who delivered LBW and OBW infants and could be used to predict birth weight:

- 1) A weight gain to less than 120% of one's 1983 Metropolitan reference weight at term. A gain to less than 120% was associated with a 463% higher risk of LBW.

- 2) Maternal birth weight. A maternal birth weight of less than 2,500 g was associated with a 9-fold increased risk of delivering a LBW, rather than an OBW, infant.
- 3) Prepregnant weight-for-height. A weight-for-height less than 90% of reference was associated with a 333% increased risk of delivering a LBW, rather than an OBW, infant.
- 4) Pregnancy weight gain. A weight gain less than 22 lbs was associated with a five-fold increased risk of LBW as compared to a woman who gained more than 27 lbs.
- 5) Diastolic blood pressure. A diastolic blood pressure reading of 100 mg Hg or more at some point in pregnancy associated with an 18-fold increased risk of delivering a LBW infant.
- 6) Cigarette consumption. Each cigarette consumed per day was associated with approximately an 11-12 g decrement in birth weight.
- 7) Alcohol intake. The consumption of greater than 100 g/week was associated with a 1.3-fold risk of LBW in this study.
- 8) Caffeine intake. The consumption of more than 300 mg/day was associated with a three-fold increased risk of delivering a LBW infant.
- 9) Diet quality. A more nutrient-dense diet, as indicated by a MAR-12 score, was associated with a decreased risk of delivering a LBW infant.
- 10) Attitude toward weight gain. The delivery of OBW infants was associated with women who reported a less positive attitude toward their weight gain than mothers of LBW infants.

Several factors hypothesized to be associated with LBW were not found to be associated with an increased risk of LBW in this study. These factors included a minimal weight gain of 7 kg if one's prepregnancy weight was 120% or more of reference, either low or high maternal hemoglobin levels, a diastolic blood pressure less than 60 mm Hg, caloric intake, attitude toward nutrition during pregnancy and the Kessner Index of prenatal care.

Several results of this study can be used in program planning at the local, state and national level to target specific sub-populations at risk for low birth weight. Prenatal care providers must be made aware of the increasing body of literature which supports the association between a higher weight gain during pregnancy and a more "optimal" birth weight of at least 3,300 g or more. Evidence indicates a woman's target weight gain during pregnancy should be based on her prepregnancy reference weight-for-height status, with the target equivalent to a minimum of 120% of one's 1983 Metropolitan reference weight. Results of this study clearly indicated a weight gain of 22-27 pounds was not adequate protection against the delivery of a LBW infant, particularly if the woman entered pregnancy underweight. Physician's should be urged to record both the subject's height and weight during the first prenatal visit in order to calculate the percent of reference weight. The blanket recommendation of 22-27 pounds, while an improvement over earlier pregnancy weight recommendations, should be individualized. Associated risk factors of cigarette smoking, caffeine intake, alcohol consumption and a low nutrient-dense diet should be emphasized. Through improved

patient education, and concomitant patient compliance, an increase in the mean infant birth weight, and reduction in infant mortality and morbidity associated with LBW, should occur.

Physician's Prenatal Care Survey of Black Michigan Mothers

Response Rate

Three hundred and one surveys (36.5%) sent to the physician of record of the 825 randomly selected black Michigan mothers were returned (Table 5.58). Of these, 136 (45%) referred to mothers of LBW infants and 124 (41%) referred to mothers of OBW infants. Fifty-nine percent (n=177) of the returned surveys were received after the first mailing and 41% (n=124) after the second mailing.

Table 5.58. Response rate to the Physician's Prenatal Care Survey of black Michigan mothers.

Group	Number Sent	First Mailing		Second Mailing		Response Rate (%)	
	n	n	(%)	n	(%)	n	(%)
Low Birth Weight (LBW)	400	83	(61)	53	(39)	136	(34)
Moderate Birth Weight (MBW)	100	27	(66)	14	(34)	41	(41)
Optimal Birth Weight (OBW)	325	67	(55)	57	(45)	124	(38)
TOTAL:	825	177	(59)	124	(41)	301	(37)

One hundred and eighty-one (22%) black subjects were lost to follow-up. Primary reasons for this loss included: 1) many physicians delivered the infants as residents or interns, but subsequently moved out of state or to a different hospital and did not have access to the record, 2) many physicians delivered the subject's baby but were not involved in their prenatal care and thus could not provide the requested information, 3) inability to locate the patient's prenatal records and 4) physician refusal due to lack of signed consent by the patient (n=3).

Generalizability of Results to the Population

Sociodemographic information from the birth certificate of responders' and non-responders' infants was compared to determine the confidence with which results obtained from this sample could be generalized to the population of black Michigan mothers. Response rate by county indicated, in general, a much lower response from large, urban centers such as Kent, Oakland, Wayne and Washtenaw counties (33%) as compared to primarily rural counties (66%), indicating response bias (Appendix 32b).

When responders (R) and non-responders (NR) who had delivered an optimal birth weight infant were compared (Appendix 29-9a,b), there were no significant differences in infant birth weight, maternal age, month prenatal care began, number of prenatal visits, weeks gestation, father's age, father's education, number of parents named on the birth certificate, sex of the infant, concurrent illnesses or complications,

Kessner Index of prenatal care, and one-minute and five-minute Apgar scores. The only statistically significant difference was noted between maternal years of education (13.5 R vs 12.8 NR; $p < .0005$), although the practical significance of this difference is questionable. Results suggest a representative sample of black mothers who deliver OBW infants in Michigan was obtained.

No significant differences were noted between responders and non-responders who had delivered low birth weight infants in the following characteristics: infant birth weight, mother's age, month prenatal care began, number of prenatal visits, weeks gestation, father's age, father's education, infant's sex, complications or pregnancy or delivery, Kessner Index of prenatal care, or one-minute and five-minute Apgar scores (Appendix 29-9c,d). However, LBW-NR had significantly fewer years of education (12.3 NR vs 12.7 R; $p < 0.042$), a higher frequency of drug abuse during their pregnancy as reported on the birth certificate (15 vs 0), and had only one parent (184 NR vs 77 R), as opposed to both parents (82 NR vs 56 R), named on the birth certificate ($X^2=4.50$; $p=0.0339$). These differences suggest associations observed between the variables of interest in this study and LBW could under-represent the true association. If true, this attenuation toward the mean could result in a type II error, causing the null hypothesis to be retained when, in truth, it should be refuted (Snedecor and Cochran, 1980).

Characteristics of the Responding Sample Population

Information obtained from the birth certificates indicated the average subject in this study was 25.1 years old and had completed one

year of post-high school education (Table 5.59). All subjects were black. According to the subject's medical records, the average responder was 5' 4" and weighed 143 lbs prior to pregnancy (range 90-375 lbs). The average weight gain during pregnancy was 31 lbs, ranging from a loss of 29 lbs to a gain of 83 lbs. Overall, the subjects entered pregnancy at 109% of their 1983 Metropolitan Reference Weight-for-Height (range 74-273), and gained to 133% of their 1983 Reference Weight at term (range 78-292). As a group, the mothers initiated prenatal care during the end of the second month of pregnancy and saw a prenatal care provider approximately 12 times.

Table 5.59. Characteristics of the sample responders (n=301).

Characteristic	Mean $\pm$ SD	n	Range
SOCIODEMOGRAPHIC			
Age, yrs	25.1 $\pm$ 4.1	301	(20-34)
Education, yrs	13.1 $\pm$ 1.7	301	(8-17)
ANTHROPOMETRIC			
Height, in	64.3 $\pm$ 2.8	230	(59-71)
Pre-pregnant weight, lbs	143 $\pm$ 37	263	(90-375)
Pregnancy weight gain, lbs	31 $\pm$ 15	262	(-29-83)
% 1983 RW, pre-pregnant	109 $\pm$ 27	220	(74-273)
% 1983 RW, at term	133 $\pm$ 29	220	(78-292)
BEHAVIORAL			
Month prenatal care began	2.8 $\pm$ 1.5	301	(1-9)
Number of prenatal visits	12 $\pm$ 4	301	(0-35)

Comparison of Cases and Controls by Select Descriptive Variables

A comparison of cases (mothers of LBW infants; < 2500 g) and controls (mother of OBW infants; 3,500-4,000 g) for selected sociodemographic and anthropometric variables indicated many significant differences (Table 5.60). Only maternal age, percent of 1983 prepregnant reference weight and number of subjects entering pregnancy at less than 90% of their 1983 Metropolitan reference weight were not significantly different between groups.

Table 5.60. Comparison of cases and controls for select descriptive variables (Means $\pm$ SD, unless noted).

Variable	LBW	n	OBW	n	t or χ^2	p
SOCIODEMOGRAPHIC						
Age, yrs	25.1 $\pm$ 4.1	134	25.6 $\pm$ 4.2	122	1.02	.3060
Education, yrs	12.7 $\pm$ 1.7	134	13.5 $\pm$ 1.7	122	3.77	.0000
Had prenatal care, %	88	134	97	122	6.32 ^a	.0120
Two parents named, %	42	134	57	122	4.76 ^a	.0292
ANTHROPOMETRIC						
Height, in	64 $\pm$ 3	98	65 $\pm$ 3	101	3.48	.0001
Pre-pregnant wt, lbs	139 $\pm$ 39	112	150 $\pm$ 36	110	2.34	.0200
Term weight, lbs	163 $\pm$ 40	116	189 $\pm$ 37	120	5.31	.0000
Preg. wt gain, lbs	25 $\pm$ 15	111	39 $\pm$ 14	110	7.33	.0000
% 1983 RW, pre-preg.	108 $\pm$ 28	94	112 $\pm$ 27	95	1.11	.2670
% 1983 RW, at term	127 $\pm$ 29	96	141 $\pm$ 27	101	3.66	.0000
% < 90% RW83, PPW	11	20	8	15	2.50 ^a	.2860
Birth weight, g	2295 $\pm$ 284	134	3753 $\pm$ 137	122	52.8	.0000
Percent female infants	58	134	42	122	6.23 ^a	.0125

^a χ^2

RESEARCH HYPOTHESES

- H0₃-1a: A weight gain to 120% or more of one's reference weight-for-height at term is not associated with a reduced incidence of delivering a LBW infant in healthy, black women between the ages of 20 to 34.
- H0₃-1b: Black women between the ages of 20-34 who gain to 120% or more of their reference weight-for-height at term do not deliver infants with significantly higher mean birth weights than infants of mothers who do not meet this goal.
- H0₃-1c: A weight gain to 120% or more of one's reference weight-for-height at term is not associated with an optimal birth weight between 3500 and 4000 g in healthy, black women between the ages of 20 to 34.
- H0₃-1d: If a woman's pre-pregnancy weight is greater than 120% of reference, a minimum gain of seven kilograms will not reduce the incidence of LBW in healthy black women between the ages of 20 to 34.

Responders were unable to provide the following anthropometric measurements for several subjects: height (n=71), prepregnant weight (n=38) and term weight (n=38). Only 220 black subjects had data for all three variables necessary to answer hypotheses H0₃-1. Of these, 96 were cases and 101 were controls.

Results of the Physician's Prenatal Care Survey of Black Michigan Mother's indicated women who did not gain to 120% of their 1959 Metropolitan reference weight-for-height had a 243% increased risk of delivering a LBW infant than if they had gained to 120% or more of reference (Table 5.61). When compared with the 1983 Metropolitan standard, the estimated relative risk of not gaining to 120% of

reference was associated with a 275% greater chance of delivering a LBW infant [RR=2.75(1.49-5.09)].

Table 5.61. Estimated relative risk (RR) of delivering a LBW infant if 120% of one's reference weight was not attained at term among black Michigan mothers.

Variable	Cases N	Controls N	RR (95% CI)
--1959 Metropolitan Reference Weight at Term--			
<u>Risk of LBW (n=197):</u>			
Not gaining to 120%	27	14	2.43 (1.18-4.99)
Gained to 120% or more	69	87	1.0 ^a
--1983 Metropolitan Reference Weight at Term--			
<u>Risk of LBW (n=197):</u>			
Not gaining to 120%	43	23	2.75 (1.49-5.09)
Gained to 120% or more	53	78	1.0 ^a

^areferent--baseline value associated with no risk.

The correlation between percent 1959 Metropolitan reference weight attained at term by subjects who gained to less than 120% of reference, however, was not linearly related to infant birth weight (Table 5.62). The correlation between infant birth weight and percent reference attained when subjects gained to 120% or more of reference was, likewise, not significant ($r=0.10$, $p=0.10$).

Table 5.62. Correlation between percent 1959 Metropolitan reference weight attained at term (less than 120% or greater than 120%) and birth weight among black subjects.

Subjects	< 120% RW at Term	≥ 120% RW at Term
--1959 Reference--		
<u>All Responders (n=230):</u>		
R	.24	.12
adjusted R ²	.04	.01
Beta	18.6	3.4
Standard Error-Beta	10.7	2.1
F	3.04	2.66
p	.0873	.1047
n	52	178

The relationship between percent of the 1959 Metropolitan reference attained at term and infant birth weight can be seen in the graph in Figure 5.9. The inconsistent increase in birth weight with each 10% increase in reference weight attained at term is demonstrated by the rising and falling slope.

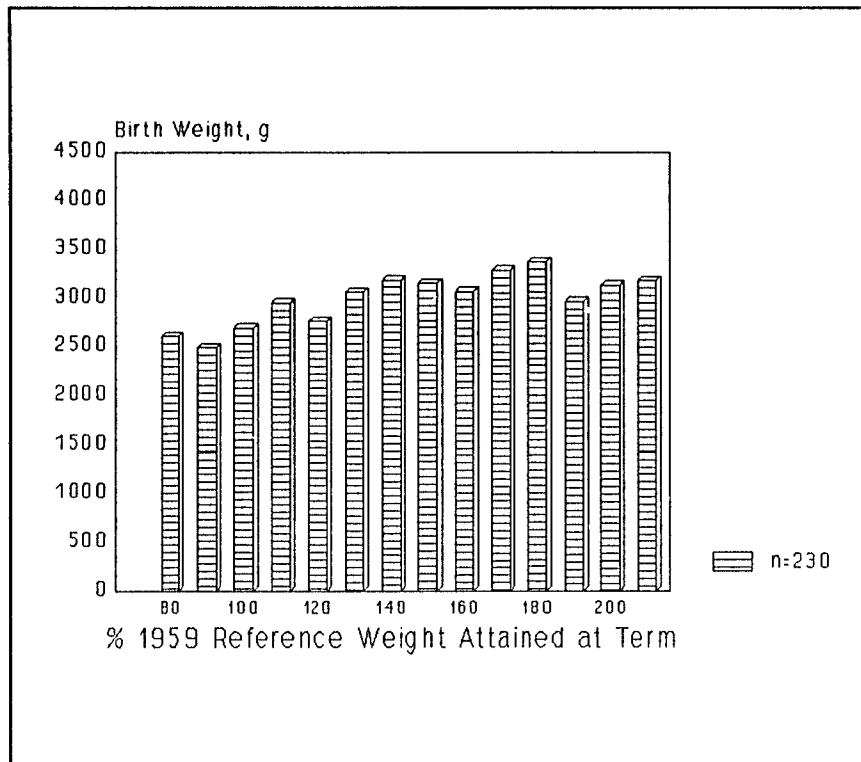


Figure 5.9. Relationship between percent of 1959 reference weight attained at term with birth weight among black subjects.

When the 1983 Metropolitan reference was used as the gold standard for "reference weight" (Table 5.63), the correlation between infant birth weight and percent reference weight attained at term in women who gained to less than 120% of reference was still not statistically significant ($r=0.20$; $p=0.08$), explaining only 3% of the variance in birth weight. The regression slope between birth weight and a weight gain to 120% or more of one's 1983 reference standard was not significantly different than zero ($r=0.10$, $p=0.21$).

Table 5.63. Correlation between percent 1983 Metropolitan reference weight attained at term (less than 120% or greater than 120%) and birth weight among black women.

Subjects	< 120% RW at Term	$\geq$ 120% RW at Term
--1983 Reference--		
<u>All Responders (n=230):</u>		
R	.20	.10
adjusted R ²	.03	.004
Beta	14.9	2.93
SE-Beta	8.3	2.3
F	3.2	1.57
p	.0756	.2118
n	80	154

The relationship between percent of the 1983 Metropolitan reference standard weight attained at term and infant birth weight can be seen graphically in Figure 5.10. The non-significant increase in birth weight associated with each incremental increase in percent reference attained is denoted by the rising and falling slope. In general, a gain to between 140-149% of reference (1983) was associated with the heaviest babies for the largest number of subjects (3325 g; n=32). The peak birth weight of 3912 observed between 180-189% of reference was associated with only one subject.

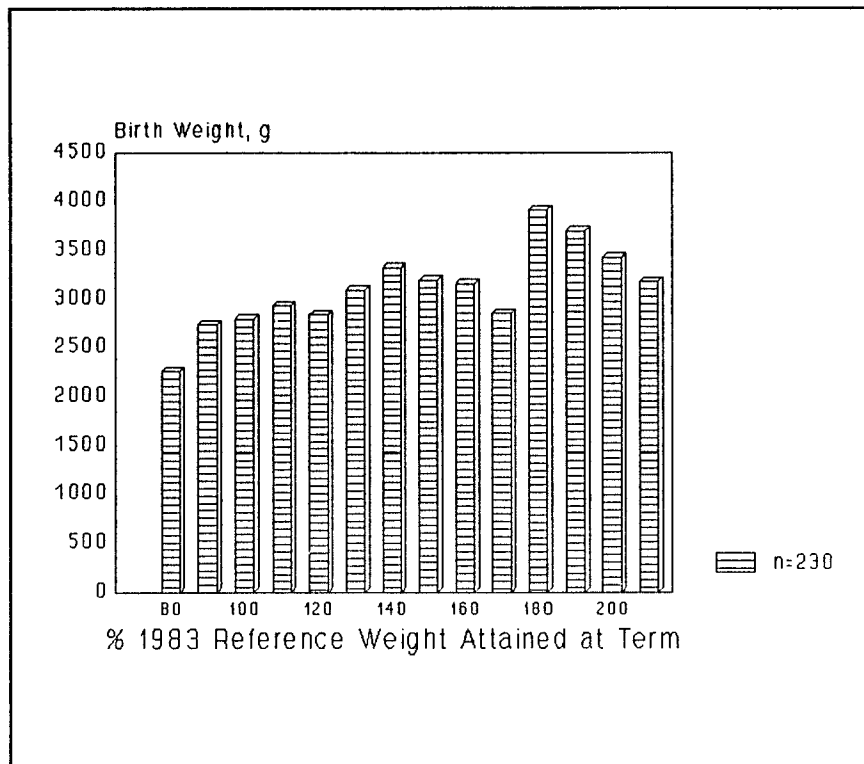


Figure 5.10. Relationship between percent of 1983 reference weight attained at term with birth weight among black women.

The mean birth weight of infants born to women who attained to 120% of their 1959 reference at term was 3,066 g (Table 5.64). Women who did not gain to 120% of the 1959 reference delivered infants who weighed, on average, 249 g lower ($p=0.024$). When the 1983 Metropolitan reference was used as the gold standard, the mean birth weight of infants born to women who attained to 120% of their reference at term was 3,105 g. Women who did not gain to 120% of their reference delivered infants who weighed, on average, 281 g lower ($p=0.005$).

Table 5.64. Mean birth weight of infants born to black women who did and did not attain to 120% of their Metropolitan reference weight at term (Mean $\pm$ SE).

Variable	Gained to < 120% at Term (N)	Gained to 120% or More at Term (N)	t	p
Birth Weight, g				
1959 Metropolitan Reference Weight	2817 $\pm$ 93 (51)	3066 $\pm$ 57 (177)	2.30	.024
1983 Metropolitan Reference Weight	2824 $\pm$ 79 (205)	3105 $\pm$ 61 (191)	2.82	.005

Even though a weight gain to 120 percent of either the 1959 or the 1983 Metropolitan reference weight was associated with a decreased incidence of LBW, and higher mean birth weights, this gain did not correspond to Brown's (1988) definition of an "optimal" birth weight of 3,500 g to 4,000 g in this study. The mean birth weight of infants born to women who gained to 120% or more of the 1983 standard (3,105 $\pm$ 61 g) was 357 g lower than the 3,462 $\pm$ 482 observed by Rosso (1985) in the group of 262 non-smoking, racially mixed low-income women, yet 28 g higher than the mean birth weight of white Michigan infants in 1987 of 3,077 g (MDPH, 1989). It must be noted that the present sample is not a homogeneous sample of all possible birth weights. Rather, this sample consisted primarily of LBW and OBW infants. In addition, this population may or may not be "healthy" by Rosso's definition, because information

about smoking was not collected. Whether or not a gain to 120% of reference in a homogeneous non-smoking, black Michigan population representative of all birth weights would be associated with an optimal birth weight cannot be answered with the present study design.

Of the 69 women who weighed more than 120% of their 1959 reference at conception, only 9 gained less than 7 kg (15.5 lbs) at term (Table 5.65). Of these, seven delivered a LBW infant and two delivered an OBW infant. The estimated relative risk of delivering a LBW infant when pre-pregnancy weight was 120% or more of reference and pregnancy weight gain was less than 7 kg, was six-fold higher than among women who gained more than 7 kg [RR=6.22 (1.17-33.18)]. Of the 48 women who weighed more than 120% of their 1983 reference prior to pregnancy, only nine gained less than 7 kg at term. Of these, seven delivered a LBW infant and two delivered an OBW infant. Again, the estimated relative risk of delivering a LBW infant when pre-pregnancy weight was 120% or more of one's 1983 reference and less than 7 kg were gained was significantly different, indicating an eight-fold higher increased risk of LBW than black women who gained more than 7 kg.

Table 5.65. Estimated relative risk (RR) of delivering a LBW infant if a woman enters pregnancy at or above 120% of reference and gains less than seven kg according to the black subjects medical records.

Variable	Cases	Controls	RR (95% CI)
<u>If > 120% 1959 Pre-Pregnant(n=59):</u>	N	N	
Gained less than 7 kg	7	2	6.22 (1.17-33.18) 1 ^a
Gained 7 kg or more	18	32	
<u>If > 120% 1983 Pre-Pregnant(n=42):</u>			
Gained less than 7 kg	7	2	8.05 (1.42-45.77) 1 ^a
Gained 7 kg or more	10	23	
^a referent			

Results presented here concur, for the most part, with the observations of Rosso (1985) that a weight gain to 120% of one's 1959 Metropolitan reference was associated with infants of significantly higher mean birth weights than mothers who did not attain to this level. Regression analysis indicated a gain to approximately 140% of one's 1959 or 1983 reference weight appeared to be associated with the highest mean birth weight in this population.

The crude odds ratio indicated slightly more than a two-fold increased risk of delivering a LBW infant if 120% of reference was not attained. The student's t-test indicated women who gained to 120% or more of either the 1983 or 1959 Metropolitan references delivered significantly heavier babies who weighed, on average, 249-281 g more than mother's who did not attain this level. A gain to 120% of reference

was not, however, associated with the delivery of an "optimal birth weight" as defined by Brown (1988).

The correlation between percent reference weight attained at term and birth weight was not statistically significant. Rosso (1985) reported that the correlation between birth weight and percent reference weight attained at term (up to 120% of reference) among a group of healthy, non-smoking, low-income black and Hispanic women was $r=0.30$. After attaining to 120% of reference, Rosso reported no additional increase in infant birth weight. In the present study, however, the correlation between birth weight and percent standard weight attained at term (up to 120%) was lower ($r=0.24$, 1959; $r=0.20$, 1983) and not statistically significant. Because information about the smoking habits of these subjects was not collected, a "healthy" sub-population, similar to Rosso's, could not be derived from this population. However, data from the Missouri Center for Health Statistics, collected between 1981-1983, indicated approximately 35.5% of black women smoked during pregnancy (Malloy et al, 1989). If this were true in Michigan, a significant effect of smoking, associated with a reduction in birth weight, could be expected.

Because overweight (120% or more of reference) women often deliver larger-than-average infants, even when their gestational weight gain is less than the recommended 24 lbs or 11 kg, a minimal weight gain of 15 lbs (7 kg) has been recommended for overweight women (Niswander et al, 1969; Eastman and Jackson, 1968). Results of the Physician's Prenatal Care Survey of Black Michigan Mothers support this recommendation. In this study, black women who entered pregnancy overweight or obese

(greater than 120% of reference) and who did not gain a minimum 7 kg, had a six-fold to an eight-fold increased risk of delivering a LBW infant, as compared to overweight and obese mothers who gained more than 7 kg. The confidence intervals were wide due to the small sample size.

Based on these results, the null hypotheses H_{03-1a} and H_{03-1b} are refuted. Although the correlations between birth weight and percent of reference attained at term were not significant, a weight gain to 120% of either the 1959 or 1983 reference was associated with a reduction in the incidence of LBW, and higher mean birth weights. A weight gain to 120% of the 1983 Reference was associated with a 39 g higher mean birth weight than a gain to 120% of the 1959 Reference. These data repeat the previously reported findings of Rosso (1985) in black women. Because a higher birth weight was associated with a gain to 120% of the 1983 Metropolitan reference, this researcher recommends the 1983 standard be the reference tool of choice.

The null hypothesis H_{03-1c} cannot be refuted. A weight gain to 120% of reference was not associated with the delivery of an "optimal" birth weight of 3,500-4,000 g. Rather, a gain to 120% or more of the 1959 and 1983 reference was associated with a mean birth weight of $3,066 \pm 57$ g ($n=177$) and $3,105 \pm 61$ g ($n=151$), respectively. These birth weights are lower than the $3,462 \pm 482$ reported by Rosso (1985) in a group of 262 black and Hispanic non-smoking, non-drinking pregnant women. The Rosso study and the Black Michigan Mother's study cannot be directly compared for two reasons: 1) the mean birth weight among only the black subjects was not reported, and 2) historically, Hispanic women deliver

heavier infants than black women (Shiono et al, 1986). For these reasons, the mean birth weight reported by Rosso may be inflated.

Although not considered "optimal" by Brown's (1988) definition, the mean birth weights from this study have been associated with a black infant mortality rate of approximately 5.8 deaths/1000 live births within the first year of life in Michigan (Appendix 30b), below the 9/1000 deaths set as a Year 2000 Health Objective for the Nation (DHHS, 1989a) and well below the current Michigan black IMR of 22.0/1000 live births (MDPH, 1989). Thus, although not "optimal" by Brown's definition, the birth weight of infants born to mothers who gained to 120% or more of reference can be considered a "healthy" birth weight, if the corresponding Michigan IMR and the Year 2000 Objective are used as the reference guide.

Based on results presented here, the null hypothesis H_{03-1d} is refuted. Overweight and obese women who did not gain a minimum 7 kg in this study had between a six-fold to eight-fold increased risk of delivering a LBW infant as compared to overweight and obese women who gained more than this amount. Thus, results of this study suggest a minimum weight gain of 7 kg (15.5 lbs) should be recommended for black women who enter pregnancy overweight or obese.

H0₄-1: Maternal percent prepregnant weight-for-height (1983 Metropolitan Reference) does not differ between black mothers who deliver OBW and LBW infants and cannot be used to predict birth weight.

On average, mothers who subsequently delivered a LBW infant entered pregnancy at 108% of their 1983 Metropolitan Reference weight-for-height (Table 5.66). Mothers of controls weighed, on average, 112% of reference. This difference was not statistically significant. The range within both groups was very large (142-200%).

Table 5.66 Mean percent prepregnant weight-for-height (PPW) for black mothers of LBW and OBW infants.

Variable	LBW	OBW	t	p
% 1983 PPW	108 ± 28	112 ± 27	1.08	0.2670
Range, %	(74-274)	(74-216)		
n	94	95		

Nineteen percent (n=35) of black mothers who delivered cases and controls in this survey entered pregnancy at less than 90% of their 1983 reference weight. Of these, 20 subsequently delivered LBW infants and 15 delivered OBW infants. The crude odds ratio indicated women who entered pregnancy at less than 90% of reference, or 120% of reference or more, were not at an increased risk of delivering a LBW infant as compared to mothers who entered pregnancy at 90-119% of reference (Table 5.67).

Table 5.67 Estimated relative risk of delivering a LBW infant dependent upon maternal prepregnant reference weight-for-height among black subjects.

Variable	Cases N	Controls N	RR (95% CI)
<u>Prepregnant Reference Weight (n=189):</u>			
< 90%	20	15	1.29 (0.60-2.78)
90-119%	57	55	1.0 ^a
120-149%	9	17	0.51 (0.21-1.24)
150% or more	8	8	0.96 (0.34-2.74)

^a referent

When percent prepregnant reference weight was regressed against birth weight, the correlation ($r=0.049$; $F=0.52$) was not statistically significant. However, when subjects' percent prepregnant reference weight and pregnancy weight gain were both regressed against birth weight, the amount of explained variance in birth weight increased significantly to 16% ($r=0.40$). The partial regression coefficients indicated only "weight gain" accounted for any of the explained variance in birth weight (Table 5.68). Results indicated pre-pregnant status was not indicative of pregnancy outcome among this sample of black Michigan women.

Table 5.69 Multiple regression analysis of prepregnant weight status (% PPW) and weight gain on birth weight among black subjects.

Variable	B	SE-B	Partial r	t	Sig t
Weight gain	18.86	2.97	0.40	6.34	.0000
% PPW	1.83	1.70	0.07	1.08	.2835
Constant	2224	216		10.31	.0000
Multiple R	0.40				
R ²	0.16				
F	20.4				
DF	(2,216)				
p	.000				

When subjects were classified by percent prepregnant reference weight as being underweight (< 90% RW), at their desirable weight (90-119% RW), overweight (120-149% RW) or very overweight (150% RW or more), the corresponding percent reference weight attained at term and birth weight was only statistically correlated in the desirable weight group (Table 5.69). In this group, each percent increase in reference weight attained at term was associated with a 20.3 g ($p=0.000$) increase in birth weight. In the underweight, overweight and very overweight categories, the slope of the regression lines did not differ from zero and were not statistically significant.

Table 5.68. Regression of percent 1983 reference weight attained at term on infant birth weight by pre-pregnant weight classification among black Michigan mothers.

<u>Pre-Pregnant Weight Classification</u>				
Statistic	Underweight (< 90%)	Normal Weight (90-119%)	Overweight (120-149%)	Obese (≥150%)
% Term Reference Weight with Birth Weight				
r	0.28	0.37	0.24	0.20
adj r ²	0.06	0.13	0.02	-0.02
B	17.9	20.3	13.9	4.30
SE-B	9.4	4.5	10.6	5.57
F	3.64	30.37	1.73	0.61
n	45	128	32	18
p	0.063	0.000	0.199	0.446

The lack of a relationship between infant birth weight and percent of 1983 reference attained at term can be seen in Figure 5.11. A positive association between birth weight and percent reference weight attained at term was observed only among the group of women who entered pregnancy at or near their desirable 1983 reference weight.

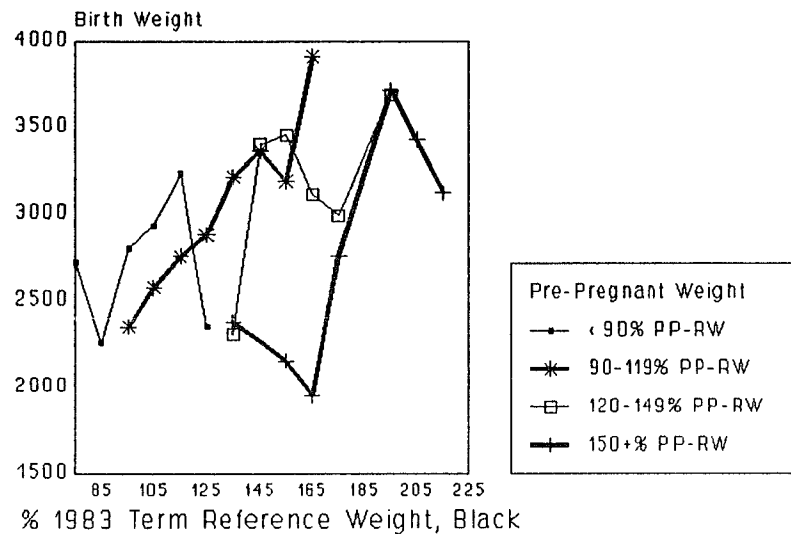


Figure 5.11. Birth weight by percent reference weight at term according to prepregnancy weight classification among black Michigan mothers.

Weight gain during pregnancy and prepregnant weight have been shown to be the two strongest determinants of infant birth weight with the exception of gestational age (Philipps and Johnson, 1977; Brown, 1988). Edwards et al (1979) suggested underweight status prior to pregnancy was a more important determinant for the delivery of LBW infants than weight gain in pregnancy. These researchers observed a two-fold increase in the delivery of LBW infants among underweight women despite adequate total weight gains (22-27 lbs). In contrast, Niswander and Jackson (1974) used data from the Perinatal Collaborative Study to

rank 32 conditions in hierarchy of importance as birth weight predictors. They found that, in both black and white women, weight gain during pregnancy was the strongest predictor of birth weight, with prepregnant weight (not % of reference) ranking second.

Results obtained in the present study suggest maternal weight gain had the greatest impact on the birth weight of black Michigan infants. Neither prepregnant percent of reference weight nor percent of reference weight attained at term were statistically associated with birth weight in this sample. This lack of relationship is in contrast to that reported by Rosso (1986), Brown (1981) and Abrams and Laros (1986) who all reported a stronger association between birth weight and percent reference weight at term, particularly among women who entered pregnancy underweight. The reasons for the observed results can only be speculated. Without information regarding cigarette, drug, caffeine and alcohol use, dietary intake and socioeconomic status, to name but a few factors, a concrete explanation can not be attempted.

Based on these results the null hypotheses must be retained. Maternal pre-pregnant weight (percent of 1983 Metropolitan Reference weight-for-height) did not differ between black mothers who delivered LBW and OBW infants. Women who entered pregnancy underweight were not at an increased risk of delivering a LBW infant. Prepregnant percent reference weight was not predictive of infant birth weight. When subjects were classified according to their prepregnant weight, the correlation between percent of reference weight attained at term and birth weight was significant only among women who entered pregnancy at their ideal weight. There was a trend toward significance among

underweight mothers ($p=0.0634$). These results suggest that, among this sample, the amount of weight a woman gained was more important than the percent of reference weight-for-height.

H0₄-2a: Maternal weight gain does not differ between black mothers who deliver OBW and LBW infants and cannot be used to predict birth weight.

As a group, subjects in the Physician's Prenatal Care Survey of Black Michigan Mothers gained 31 pounds ($n=262$). The range of weight gains was quite high. When mothers of cases and controls were compared, women who delivered LBW infants gained, on average, almost 14 pounds less than mothers who delivered OBW infants (Table 5.70).

Table 5.70. Mean weight gain of black mothers who delivered LBW and OBW infants.

Variable	LBW ($n=223$)	OBW ($n=110$)	t	p
Weight gain, lbs	25.0 $\pm$ 14.9	38.6 $\pm$ 14.0	6.95	0.0000
Range	(-29-73)	(8-83)		
n	111	110		

Seventy four percent of the prenatal care providers indicated they had made a specific weight gain recommendation to the subjects in question. The mean recommendation was 27 lbs (range 12-40). On average,

the weight gain of LBW subjects was two pounds less than that recommended by these subjects' prenatal care provider (27 lbs, n=93). Women who delivered OBW infants gained, on average, 11.6 pounds more than their prenatal care provider had recommended (27 lbs; n=99).

The crude odds ratio indicated women who gained less than 22 pounds had a three-fold increased risk of delivering a LBW infant than mothers who gained the currently recommended 22-27 pounds (Table 5.71). Gaining more than the recommended 22-27 pounds protected against the delivery of a LBW infant [RR=0.36 (0.17-0.780)]. Stated another way, women in this study who gained the recommended 22-27 pounds were at a 279% increased risk of delivering a LBW infant as compared to women who gained more than 27 pounds. When women who gained less than 22 pounds were compared to women who gained 28 pounds or more, a 919% increased risk of delivering a LBW infant was observed.

Table 5.71. Estimated relative risk of delivering a LBW infant dependent on amount of pregnancy weight gain by black women (n=221).

Variable	LBW	OBW	RR (95% CI)
<u>Weight gain, lbs:</u>	N	N	
< 22 lbs	47	10	3.29 (1.25-8.64)
22-27 lbs	20	14	1 ^a
> 27 lbs	44	86	0.36 (0.17-0.78)
22-27 lbs vs > 27 lbs			2.79 (1.29-6.05)
< 22 lbs vs > 27 lbs			9.19 (4.24-19.91)

^areferent

When subjects were categorized according to their pre-pregnant percent reference weight (<90%, 90-119%, 120-149% 150% or more), within each group, underweight, normal weight and overweight women who delivered OBW infants gained significantly more weight than women who delivered LBW infants (Table 5.72). Very overweight women who delivered OBW infants, as compared to LBW infants, gained more weight, but the difference was not statistically significant due to the sample size and the very large variance observed in the measure (33 ± 17 vs 16 ± 29 ; $t=1.47$).

Table 5.72. Amount of weight gained during pregnancy by black mothers of OBW and LBW infants when subjects were categorized according to their 1983 Metropolitan pre-pregnancy reference weight.

Pre-Pregnant Weight Classification	LBW (n)	OBW (n)	t	p
< 90%	26 $\pm$ 13 (20)	34 $\pm$ 9 (15)	2.11	.041
90-119%	26 $\pm$ 13 (56)	40 $\pm$ 14 (55)	5.75	.000
120-149%	24 $\pm$ 18 (9)	37 $\pm$ 14 (17)	2.06	.049
150% or more	16 $\pm$ 29 (8)	33 $\pm$ 17 (8)	1.47	.165
F, within	1.13	1.36		
F prob	0.3408	0.2601		

Regression analysis indicated weight gain was highly correlated with birth weight (Table 5.73), explaining 16% of the variance. The

correlation between birth weight and weight gain was almost identical among women who weighed less than 120% of their 1983 Metropolitan reference prior to pregnancy ($r=0.41$; $F=33.1$), as compared to women who gained to more than 120% of reference ($r=0.39$; $F=8.30$). Each pound of weight gained by underweight and normal weight women was associated with a 20.5 g increase in birth weight. A smaller gain in birth weight (15.7 g/lb weight gain) was noted among women who entered pregnancy overweight or obese.

Table 5.73. Regression of weight gain on birth weight by black subject's pre-pregnant percent of reference weight.

Statistic	< 120% Pre-Pregnant	120% or more Pre-Pregnant	All Subjects
r	0.40	0.39	0.40
r ²	0.16	0.15	0.16
B	20.5	15.7	19.2
SE-B	3.6	5.5	2.7
F	33.1	8.30	50.3
p	0.000	0.006	0.000
n	172	49	260

Results of the Physician's Prenatal Care Survey of Black Michigan Mothers presented here do not reinforce the position of Brown (1983) and Rosso (1985) that weight gain recommendations should be individualized dependent upon prepregnant weight status. In general, results of this study indicated the delivery of an optimal birth weight infant: 1) was independent of the subject's prepregnant weight status and 2) was associated with a weight gain much higher than the 22-27 pounds

currently recommended by the American College of Obstetricians and Gynecologists (ACOG, 1982) and these subjects' prenatal care providers.

Previous research has indicated each pound of weight gained during pregnancy was associated with a 44-50 g increase in birth weight (Eastman and Jackson, 1968; Niswander et al, 1969; Simpson et al, 1974; Abrams and Laros, 1986). Results of the present study indicated that, in women who weighed less than 120% of reference prior to pregnant, each pound of weight gain was associated with a 20.5 ± 3.6 g increase in birth weight. This is less than half the corresponding increase in birth weight seen in white Michigan infants (see Michigan Mother's Survey). In women who entered pregnancy overweight or obese, each pound of weight gained during pregnancy was associated with a 15.7 ± 5.5 g increase in birth weight.

Metcoff et al (1981b) indicated the correlation coefficients between weight gain and birth weight in most surveys are usually around 0.20 to 0.30. Niswander and Jackson (1974) noted that the simple correlation between birth weight and weight gain among the 6,012 black subjects in the Collaborative Perinatal Study was $r=0.22$. In the present study, the correlation between these two variables was much higher ($r=0.40$), even though the corresponding beta weights (i.e., 20.5 g and 15.7 g) were much lower than those usually seen.

Naeye (1979) noted optimal infant outcome was associated with a weight gain of 30 pounds for underweight women. Brown (1986) reported a weight gain of 33 pounds was associated with an optimal birth weight of 3,000 to 4,000 g if the mother was underweight prior to pregnancy. Results of this study indicated a weight gain of 34 ± 9 pounds by

underweight women (n=15) was associated with an optimal birth weight of 3,500 to 4,000 g. A much higher weight gain (40 ± 14 lbs) was associated with optimal birth weight among women who entered pregnancy at or near their desirable reference weight (n=55). The delivery of an OBW infant by women who entered pregnancy overweight (n=17) or obese (n=8) was associated with weight gains of 37 ± 14 and 33 ± 17 lbs, respectively.

Based on results presented here, the null hypotheses are refuted. There was a significant difference in amount of weight gained by mothers of LBW and OBW infants. The amount of weight gained by mothers of LBW infants was, on average, two pounds less than the mean weight gain recommended by the subjects' prenatal care providers. The estimated relative risk of delivering a LBW infant indicated a 22-27 pound weight gain was insufficient to support the delivery of an OBW infant. A weight gain greater than 27 pounds, as compared to the generally recommended 22-27 pounds, significantly reduced the incidence of LBW.

Results indicated the amount of weight a woman gained could be used to predict birth weight. The correlation between these variables was significant and highly positive, explaining approximately 16% of the variance in birth weight. Surprisingly, this relationship did not vary among women who entered pregnancy either underweight, at their desirable weight, overweight or obese.

In sum, results of this study indicated a 22-27 pound weight gain during pregnancy was insufficient to support the development of a fetus who weighs 3,000 to 4,000 g at term for women in all prepregnant weight categories. If significant progress is to be made in decreasing the LBW and IMR rates in this country, these results the medical community must

reconsider the present pregnancy weight gain recommendation of 22 to 27 pounds for all women, regardless of pre-pregnancy weight status.

HO₄-3a: Maternal hemoglobin values during pregnancy do not differ between black mothers who deliver optimal and low birth weight infants and cannot be used to predict birth weight.

The highest and lowest hemoglobin levels recorded during pregnancy were provided by the prenatal care provider of 216 cases and controls. If only one value was recorded during pregnancy (n=88), it was coded as the "highest" value. No statistically significant difference in the highest hemoglobin values recorded during pregnancy was noted between mothers who delivered optimal or low birth weight infants (Table 5.74). A statistically significant difference between the lowest hemoglobin reading was observed. Mothers of OBW infants had lower hemoglobin levels (11.1 g/dl vs 11.6 g/dl).

Table 5.74. Mean high and low hemoglobin values recorded during pregnancy between black mothers of cases and controls.

Variable	LBW (n)	OBW (n)	t	p
Highest Hb, g/dl	12.3 ± 1.1 (110)	12.2 ± 1.1 (106)	0.38	.7037
Lowest Hb, g/dl	11.6 ± 1.2 (73)	11.1 ± 1.0 (74)	2.58	.0109

Similarly, the correlation between the lowest hemoglobin value recorded during pregnancy and birth weight was significant ($r=0.18$; $F_p=5.96$). In contrast, the correlation between the highest hemoglobin value and birth weight was not significant ($r=0.04$; $F_p=0.45$). When the hemoglobin values were categorized (Murphy et al, 1986), the odds ratio did not indicate a statistically significant increased or decreased risk of delivering a LBW infant if the highest hemoglobin values recorded were greater than 13.2 g/dl or less than 10.4 g/dl (Table 5.75).

Table 5.75 Estimated relative risk of delivering a LBW infant dependent upon maternal hemoglobin levels recorded during pregnancy among black subjects.

Variable	Cases N	Controls N	RR (95% CI)
Highest Hb recorded (n=216)			
< 10.4 g/dl	5	3	1.69 (0.39-7.28)
10.4-13.2 g/dl	85	86	1.0 ^a
> 13.2 g/dl	20	17	1.19 (0.58-2.43)

^a referent

This observation does not support that of Murphy et al (1986) who reported hemoglobin levels greater than 13.2 g/dl in pregnant women were associated with an increased incidence of perinatal mortality, preterm delivery and low birth weight as compared to infants of women with intermediate hemoglobin levels (10.4-13.2 g/dl). These researchers had suggested the high hemoglobin levels reflected some failure in plasma

volume expansion, resulting in decreased uteroplacental circulation and a concomitant decreased birth weight due to a reduced supply of nutrients to the fetus. Naeye (1977) had also hypothesized high hemoglobin values contributed to the formation of placental infarcts, which resulted in decreased uteroplacental flow, decreased nutrient transfer and decreased infant size.

Several studies have indicated the size of the increase in plasma volume correlates positively with the birth weight (Hytten and Paintin, 1963; Pirani et al, 1973; Duffus et al, 1971). It is possible that in this group of black Michigan mothers the low hemoglobin value was actually a reflection of a higher maternal plasma volume which contributed to the infant's size.

Based upon these results, the null hypotheses are refuted. There was a significant difference in the mean hematologic values, with mother's of OBW infants having a lower "lowest" hemoglobin readings. In addition, there was a statistically significant correlation between birth weight and the lowest hemoglobin values recorded during pregnancy. The practical physiological difference between a hemoglobin value of 11.1 vs 11.6 g/dl, however, must be questioned.

H0₄-3b: Highest and lowest maternal diastolic blood pressure values recorded during pregnancy do not differ between black mothers who deliver optimal and low birth weight infants and cannot be used to predict birth weight.

Highest and lowest diastolic blood pressure recordings were provided by the prenatal care provider of 229 cases and controls. Results indicated a statistically significant difference between the mean highest, but not lowest, diastolic blood pressure readings between mothers who delivered optimal or low birth weight infants (Table 5.76).

Table 5.76. Mean high and low diastolic blood pressure (DBP) readings during pregnancy between black mothers of cases and controls.

Variable	LBW (n=101)	OBW (n=110)	t	p
Highest DBP, mm HG	78.6 ± 10	75.5 ± 10	2.32	0.021
Lowest DBP, mm HG	59.5 ± 9	57.1 ± 10	1.85	0.065

The correlation between the lowest recorded diastolic blood pressure reading during pregnancy and birth weight was not significant (Table 5.77). The correlation between the highest recorded blood pressure reading during pregnancy and birth weight was statistically significant, with each incremental increase in diastolic blood pressure associated with a 9.7 g decrease in infant birth weight.

Table 5.77. Correlation between highest and lowest diastolic blood pressure readings recorded during pregnancy and infant birth weight among black Michigan mothers.

Variable	Lowest DBP	Highest DBP
R	-.10	-.13
adjusted R ²	.01	.01
Beta	-7.8	-9.7
Standard Error-Beta	5.1	4.7
Constant	3467	3767
F	2.35	4.27
p	0.126	0.040
n	241	243

Highest and lowest diastolic blood pressure values were categorized based on the observations of Grunberger et al (1979) and Naeye (1979). The crude odds ratios indicated no association between any category of diastolic blood pressure and low birth weight (Table 5.78).

Table 5.78. Estimated relative risk of delivering a LBW infant dependent upon highest and lowest maternal diastolic blood pressure readings during pregnancy among black subjects.

Variable	Cases N	Controls N	RR (95% CI)
<u>Highest DBP recorded (n=211):</u>			
< 65 mmHg	6	13	0.49 (0.18-1.35)
65-89 mmHg	81	86	1 ^a
90-99 mmHg	11	9	1.30 (0.51-3.30)
> 99 mmHg	3	2	1.59 (0.26-9.76)
<u>Lowest DBP recorded (n=209):</u>			
< 65 mmHg	77	87	0.77 (0.40-1.49)
65-89 mmHg	24	21	1 ^a
90-99 mmHg	-	-	-
> 99 mmHg	-	-	-

^a referent

These results do not support the observation of Grunberger et al (1979) and Naeye (1979) who independently observed diastolic blood pressure readings less than 65 mm Hg were associated with a decreased infant birth weight. Grunberger et al (1979) suggested that a diastolic blood pressure lower than 65 mmHg reduced uteroplacental perfusion, decreasing transfer of nutrients to the fetus and resulting in a smaller infant. In the present study, the delivery of a larger baby was associated with a lower diastolic blood pressure.

Results presented herein suggest that, while high maternal diastolic blood pressure values did not differ between mothers who delivered optimal and low birth weight infants, low diastolic blood

pressures did differ, and could be used to predict infant birth weight ($r = -0.13$). Based upon these results, the null hypotheses that high diastolic blood pressure readings do not differ between mothers of LBW and OBW mothers is refuted. Mothers of LBW infants had significantly higher "high" diastolic blood pressure readings, with each unit increase in diastolic pressure associated with a 9.7 g decrement in birth weight. The null hypothesis that low diastolic blood pressure readings do not differ between mothers of cases and controls, however, must be retained.

Caution is warranted in interpreting these results. Peak diastolic blood pressure values were discarded during data entry due if an apparent misinterpretation of the question by respondents was noted. Data were discarded if the peak diastolic reading was reported to be 120 mm Hg or greater with no mention made of a diagnosis of hypertension or toxemia. (REMINDER: Subjects were excluded from the sampling frame if, according to the birth certificate, the physician had diagnosed the patient as having hypertension, pre-eclampsia or toxemia during pregnancy). It appeared to this researcher that some respondents had provided the subject's systolic and diastolic blood pressures, rather than the high and low diastolic pressures. This observation was especially noticeable when a medical records assistant had completed the survey. Thus, it appears bias has been introduced into this question. There is no reason to believe, on the other hand, there is bias in the lower diastolic blood pressure readings.

HO₄-4: The quality of prenatal care, as measured by the Kessner Index, does not differ between mothers who deliver optimal and low birth weight infants and cannot be used to predict birth weight.

Results of the Michigan Mother's Study indicated 78% of the mothers of both LBW and OBW infants began their prenatal care in the first trimester. This percentage exceeds the 1986 U.S. average (76%), but is less than the health objective for the year 2000 which recommends that at least 90% of all pregnant women should receive prenatal care in the first trimester of pregnancy (DHHS, 1989).

The Kessner Index indicated 69% of the cases and 74% of controls in the Physician's Prenatal Care Survey of Black Michigan Mothers obtained adequate prenatal care during their pregnancies. The percent of women receiving adequate care in this survey was higher than the state of Michigan in 1987, when adequate prenatal care was obtained by only 61.8% of the mothers of live born black infants (MDPH, 1989). Within this sample, Chi Square analysis indicated no significant difference in the Kessner Index between mothers of cases and controls (Table 5.79).

Table 5.79. Kessner Index classification of prenatal care obtained by black mothers of cases and controls.

Kessner Index Classification	LBW (n=134)	OBW (n=122)	χ^2	p
Adequate Care	92	90	0.83	.6617
Intermediate	31	24		
Inadequate	11	8		

When the Kessner Index was analyzed by its component parts, no significant difference was noted in the month prenatal care began (2.8 vs 2.8; $t=0.237$). However, the number of prenatal visits (11.4 ± 4.0 vs 12.7 ± 4.4 ; $t=2.54$; $p=0.012$) and the estimated weeks of gestation (38.6 ± 1.5 vs 39.8 ± 1.2 ; $t=7.12$; $p=0.000$) were significantly lower among cases than controls. When these three individual components and the Kessner Index were regressed against birth weight, 13% of the variance in infant birth weight was explained (Table 5.80). Of these four variables, only the variable "estimated weeks gestation" was statistically significant, with each week of gestation associated with a 174.5 g increase in birth weight. No other variable contributed significantly to the variance in birth weight in this sample.

Table 5.80 Regression analysis of the Kessner Index, number of prenatal visits, month prenatal care began and estimated weeks gestation with birth weight among infants of black mothers.

Variables	B	SE-B	Regression Coefficient	T	Sig T
Kessner Index	-108	71	-.09	-1.52	.1299
Weeks gestation	174.5	27	.351	6.40	.0000
# Prenatal visits	2.1	3.2	.038	0.64	.5237
Month care began	-0.2	4.6	-.003	-0.04	.9662
Constant	-3766	1069		-3.51	.0005
R	0.36				
R ²	0.13				
F	11.1				
DF	(4,292)				
p	.0000				

Early, high quality prenatal care has been highly correlated with healthier pregnancies and the prevention of poor pregnancy outcome (DHHS, 1989b). Results of the present study, however, do not indicate any significant differences in the quality of care, as defined by the Kessner Index, between mothers of cases and controls. For that reason, the null hypothesis must be retained: the Kessner Index, in this study, is not different between mothers of cases and controls, and cannot be used to predict infant birth weight.

All infants in the present study, however, were selected because they were "term infants". Results obtained herein suggest the selection criteria of "term infants", and the bias that resulted from responders of cases having had significantly higher Kessner Index scores than non-responders, appeared to force the sample population into having a Kessner Index which was not significantly different between groups. Thus, in this study, the Kessner Index does not function as a discriminating independent variable to predict birth weight.

Multiple Regression Analysis to Predict Birth Weight

Two multiple regression equations (stepwise and "enter") to predict birth weight, based on a sample consisting primarily of black LBW and OBW infants, accounted for 34-37% of the variance in birth weight (Table 5.81). Due to the design of this study, these equations are unique to the literature and cannot be directly compared. A

regression equation based solely on black infants was not located in the literature. In general, however, for infants born at all gestational ages, about 40% of the variation in birth weight has been accounted for by weeks of gestation, prenatal weight gain, prepregnancy weight status and smoking during pregnancy (Anderson et al, 1984; Burke et al, 1943; Burke et al, 1949; Metcalf et al, 1981b), with weeks gestation accounting for the largest proportion of variance in each study. Thus, the multiple R and the percent of variance explained by the two equations presented here appear to be in the realm of values reported in the literature.

Table 5.81 Two multiple regression equations to predict birth weight of black infants.

Variable	Equation #1: Stepwise				Equation #2: Enter			
	B	b	t	Sig t	B	b	t	Sig t
Weight gain	18	0.37	5.06	.0000	18.6	0.38	5.17	.0000
Weeks gestation	138	0.28	3.83	.0002	131	0.26	3.57	.0005
Hemoglobin, g/dl	-138	-0.21	2.87	.0048	-158	-0.24	3.10	.0024
Height, inches	41	0.15	2.09	.0383	41.3	0.15	2.07	.0408
Diastolic BP, mmHG				NS	-10.0	-0.13	1.68	.0965
% 1983 prepregnant				NS	3.7	0.13	1.72	.0884
Previous child (n=1)				NS	148	0.10	1.33	.1858
Kessner Index				NS	-120	-0.10	1.34	.1826
Both parents named				NS	53	0.05	0.65	.5170
Mother's age				NS	9.5	0.05	0.67	.5017
Female sex				NS	-30.9	-0.02	0.28	.7812
Mother's education				NS	-3.4	-0.02	0.32	.7472
Constant	-4095		-2.10	.0380	-3592		-1.78	.0790
R ₂	0.563				0.609			
R ² , %	32				37			
SE-B	626 g				619 g			
DF	(4,134)				(12,126)			
F	15.54				6.20			
p	.0000				.0000			

In both equations, pregnancy weight gain accounted for the largest proportion of variance explained in this study (37-38%), accounting for approximately 14% of the total variance in birth weight. Estimated weeks gestation accounted for the next largest proportion of explained variance in birth weight (26-28% of explained, 8% of the total variance in birth weight). Each pound of weight gained during pregnancy was associated with an increase of 180-185 g in infant birth weight.

The inclusion of maternal hemoglobin values in the regression equations indicated the higher the hemoglobin readings, the lower the birth weight. Each incremental increase in hemoglobin (g/dl) was associated with a 158 g decrement in birth weight ($p=0.0024$). The same trend was true for a diastolic blood pressure. Although not significant at $p < 0.05$, each mm Hg increase in diastolic blood pressure was associated with a 10 g decrement in birth weight ($p=0.0965$).

Maternal age and education have been reported to account for as much as eight percent of the variance in birth weight (Metcoff et al, 1981b). Anderson et al (1984) reported a 7.1 g increase in birth weight for each year of maternal age ($R^2=0.003$). In this study, increasing maternal age was associated with a non-significant 9.5 g increase in birth weight for each year (equation #2). Maternal education was not associated with birth weight in this study. Delivery of a female infant was associated with a non-significant decrement in birth weight of 51 g. Previous research indicates female infants weighed 171 g (Anderson et al, 1984) and 118 g (Dougherty et al, 1982) less than males.

In summary, these prediction equations, including the unique variables of "lowest diastolic blood pressure" and "lowest hemoglobin value", appear to make a unique contribution to the field. The lack of inclusion of education, infant sex, number of named parents on the birth certificate and the Kessner Index score of prenatal care was unexpected.

Summary: Physician's Prenatal Care Survey of Black Michigan Mothers

Results of the Physician's Prenatal Care Survey of Black Michigan Mothers, a study of approximately 301 black Michigan residents between the ages of 20-34 who were delivered of either their first or second child between January 1, 1987 and November 30, 1988, identified several modifiable risk factors for the delivery of a low birth weight infant. In addition to the known LBW risk factor of number of weeks gestation, results indicated the following risk factors differed between mothers who delivered LBW and OBW infants and could be used to predict birth weight:

- 1) A weight gain to less than 120% of one's 1983 Metropolitan reference weight at term. A gain to less than 120% was associated with a 275% higher risk of LBW.
- 2) A weight gain of less than 7 kg (15.5 lbs) if one's pre-pregnant weight was 120% or more of the 1959 or 1983 Metropolitan reference. A weight gain of less than 7 kg was associated with an eight-fold increased risk of delivering a LBW infant.
- 3) Pregnancy weight gain. A weight gain less than 22 lbs was associated with a nine-fold increased risk of LBW as compared to a woman who gained more than 27 lbs. A weight gain of 22-27 pounds was still associated with a 279% increased risk of LBW.

- 4) Maternal hemoglobin level. Women who delivered optimal birth weight infants had a significantly lower hemoglobin levels than mothers of LBW infants, although the physiological significance of the difference is questionable.

Several factors hypothesized to be associated with LBW were not associated with an increased risk of LBW in this study. These factors included a subject's prepregnancy weight-for-height, especially if underweight, the Kessner Index of prenatal care, mother's education and age and the number of parents named on the birth certificate. The reason for the lack of association between these variables and birth weight cannot be ascertained from the available information.

Results of this present study can be used in program planning at the local, state and national level to target specific sub-populations at risk for low birth weight. Prenatal care providers must be made aware of the increasing body of literature which supports the association between a higher weight gain during pregnancy and a more "optimal" birth weight of at least 3,300 g or more. Evidence presented indicated a weight gain of 22-27 pounds was not adequate protection against the delivery of a LBW infant for women of all pre-pregnancy weights. Physician's should be urged to record both the subject's height and weight during the first prenatal visit. Through improved patient education, and concomitant patient compliance, an increase in the mean infant birth weight, and reduction in infant mortality and morbidity associated with LBW, should occur.

Results of the Physician's Prenatal Care Survey of Black Michigan Mothers must be considered preliminary. Without complete information regarding such factors as smoking, diet quality, drug use and socioeconomic status, the true effect of the factors presented in this study on birth weight cannot be stated with confidence.

CHAPTER VI

LIMITATIONS, CONCLUSIONS AND RECOMMENDATIONS

Limitations of the Present Study

The reader is encouraged to bear in mind the following limitations of this study in both the interpretation of results and the application of its recommendations:

1. Analysis of sociodemographic data indicated a potential response bias among LBW infants (both black and white). Based on a review of the literature (Institute of Medicine, 1985), the bias would appear to result in an attenuation toward the mean and a potential Type II error (reporting "no difference" when, in fact, a difference exists).

2. Data obtained from the white mothers was self-reported. Validation checks of maternal height and pre-pregnant and term weights indicated a high correlation between the physician-recorded anthropometric data and maternal self-reported data (Table 5.5). However, the validity of the post-term weight, and all other behavioral, dietary and sociodemographic data obtained in this survey directly from the mothers must be considered conditional.

3. Although the validity and reliability of the Willett Semi-Quantitative Food Frequency Questionnaire instrument has been established among a non-pregnant population (Willett et al, 1987), a review of the literature indicated the instrument had not been used previously in a pregnant population in a retrospective study. Thus, the dietary information obtained in this study must be considered conditional.

4. Information obtained in this study from the prenatal care provider of the randomly selected black subjects was insufficient to accurately assess the profile of conditions associated with low birth weight. In addition to a possible geographic response bias (Appendix 32b), information regarding substance abuse, behavioral characteristics, maternal birth weight, economic status, social support and dietary adequacy were missing. Thus, results of the Prenatal Care Survey of Black Michigan Mothers must be considered provisional.

5. Information regarding over-the-counter and illicit drug use was not collected in this study. Reasons for this included concerns of the Human Subject's Committee at Michigan State University, concerns of the researcher and guidance committee regarding the influence of such questions on the response rate, concerns of the validity of self-reported drug use, and legal concerns regarding the provision of this information by the subject's prenatal care provider. It is recognized that the confounding variable, "drug use during pregnancy" may have influenced the results of this study in an unknown fashion.

6. Results of the study must be interpreted with care. Results are based on a case-control sampling design. Subjects consisted of mothers who delivered LBW and OBW infants. It would be incorrect to assume the strength of the associations found in this study would be repeated in a random selection of infants of all birth weights.

7. Lastly, all infants selected in this study were classified as "term" infants according to the computer-calculated number of weeks gestation based on the last menstrual period date. Discrepancies were noted between the physician-reported length of gestation and the computer-generated length of gestation. For this reason, although computer-generated data suggested all subjects were "term", the infants might not have actually been term infants. Which of these two measures of gestation was most accurate is unknown.

Conclusions

Results of this study indicated the following were risk factors for LBW: 1) a weight gain to less than 120% of one's 1983 term Metropolitan reference weight (white and black), 2) a weight gain of less than 7 kg (15.5 lbs) if the mother was obese prior to pregnancy (black), 3) a pre-pregnant weight-for-height less than 90% of reference (white), 4) a weight gain of 27 pounds or less (white and black). In addition, results of the white Michigan mothers' survey indicated the

following risk factors were associated with the delivery of a LBW, as compared to an OBW, infant: 1) maternal birth weight less than 2,500 g, 2) cigarette consumption, 3) consumption of 100 g alcohol/week, 4) consumption of more than 300 mg caffeine/day, 5) consumption of a less nutrient-dense diet and 6) a more positive attitude toward weight gain.

Based on the combined results of the White Michigan Mother's Survey and the Physician's Prenatal Care Survey of Black Michigan Mothers, the following recommendations for pregnancy are made:

1. Women should be encouraged to gain to 120% of their 1983 Metropolitan reference weight-for-height. Clearly, a weight gain to this level was associated with a decreased incidence of LBW and a higher birth weight in both black and white subjects.
2. A weight gain of 22-27 pounds is clearly not adequate to support the development of a 3,500 g infant. A weight gain of 34 pounds was associated with optimal birth weight infants among underweight and normal weight subjects in this study. Women who weigh more than 120% of their 1983 reference prior to pregnancy should be encouraged to gain at least a minimum of 15 pounds, if not more.
3. Physician's should be urged to determine the women's own birth weight. LBW mothers are at increased risk of delivering LBW babies. However, with an increased weight gain, the risk appears to decrease.

4. Women should be encouraged to stop smoking cigarettes and reduce their consumption of caffeine to less than 300 mg per day (approximately three cups of coffee).
5. Women should be encouraged to consult with a dietitian regarding the quality of their diet during pregnancy, especially the selection of nutrient-dense foods.

The determinants of infant birth weight are varied and complex. Results presented here, although statistically significant, only explained 30-40% of the variance in birth weight. This amount of explained variance is similar to that reported by other researchers in the field (Metcoff, 1981b, Anderson et al, 1984). Perhaps because of the physiological complexities and adaptation mechanisms that appear to be associated with pregnancy, researchers will never be able to predict birth weight with greater accuracy than this. Nonetheless, by contrasting low birth weight infants with infants of "optimal birth weight", the results of this study do provide specific recommendations which, if followed, should help reduce the incidence of LBW, and the concomitant infant mortality, in this state and this country.

Suggestions for Future Studies

The collection, interpretation and discussion of the data for this study provided an opportunity to consider several ideas for future research. An abbreviated list follows:

1. If a similar study was repeated, this researcher suggests the following data be collected.
 - a) the infants' length and head circumference
 - b) the father's birth weight
 - c) information regarding the mother's social support network
 - d) passive smoking in the home/work place
 - e) exercise habits of the mother before and during pregnancy
 - f) a specific question of both the mother and the physician regarding health and behavioral recommendations made during prenatal care, i.e., "did your physician recommend you reduce your caffeine intake?" (mother) and "did you recommend that your patient reduce her caffeine intake?" (physician)
2. These infants, or another similar subset of infants, could be followed throughout their infancy and/or childhood to determine growth patterns of LBW vs OBW infants.
3. A follow-back survey of infants who were either LBW or OBW could be conducted to determine the differences in rates of various anthropometric and medical health risks (i.e., obesity, diabetes, heart disease) that might have occurred between these groups as

they reached adulthood and old age. These data could be used to determine whether an "optimal" birth weight of 3,500-4,000 g, shown to be associated with the lowest incidence of infant mortality, is associated with an increased, decreased, or similar risk of health-related behaviors in the future as compared to infants who were LBW.

4. The correlation between self-reported maternal birth weight and actual maternal birth weight could be determined to validate the self-reported data. The birth certificates of mothers in this study could be located by computer search and matched with their self-reported birth weight.
5. The reduction in birth weight seen in this study among non-smokers who consumed 300 mg or more caffeine per day should be replicated.
6. Additional studies are needed which examine the relationship between pregnancy outcome and maternal attitudes, behavioral intentions and actual behavior, particularly as related to the mother's locus of control and social support network. Results of this study suggest the affective domain may play an important role in pregnancy outcome, particularly regarding the amount of weight gained during pregnancy.

PHYSICAL CHARACTERISTICS, HEALTH-RELATED BEHAVIORS AND
ATTITUDES OF MOTHERS WHO DELIVERED OPTIMAL AND LOW BIRTH
WEIGHT INFANTS IN MICHIGAN, 1987-1988: A RETROSPECTIVE STUDY

Volume II

By

Carol Ann Friesen

A DISSERTATION

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DOCTOR OF PHILOSOPHY

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Appendix 1

Single-Line Chart to Monitor Pregnancy Weight Gain

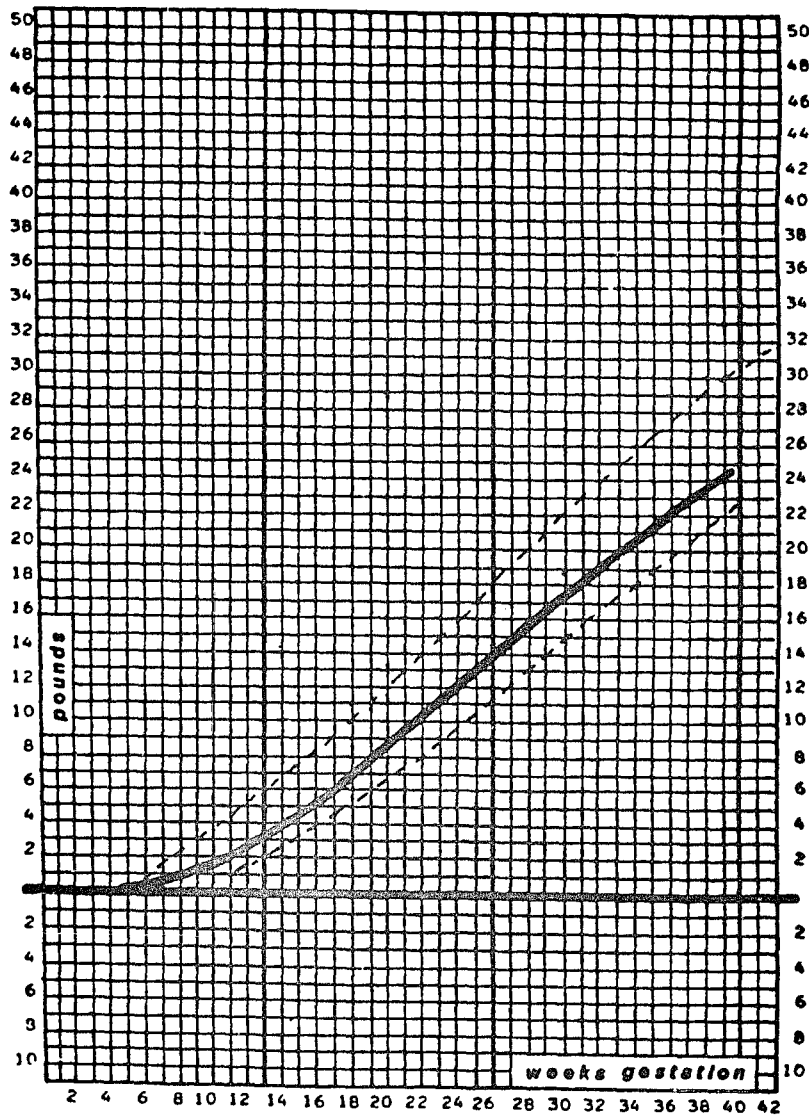


FIG 1. Curve for the assessment of weight gain during pregnancy (8).

Appendix 2

Rosso's Pregnancy Weight Gain Monitoring
Chart Based on Pre-Pregnancy Weight-For-Height

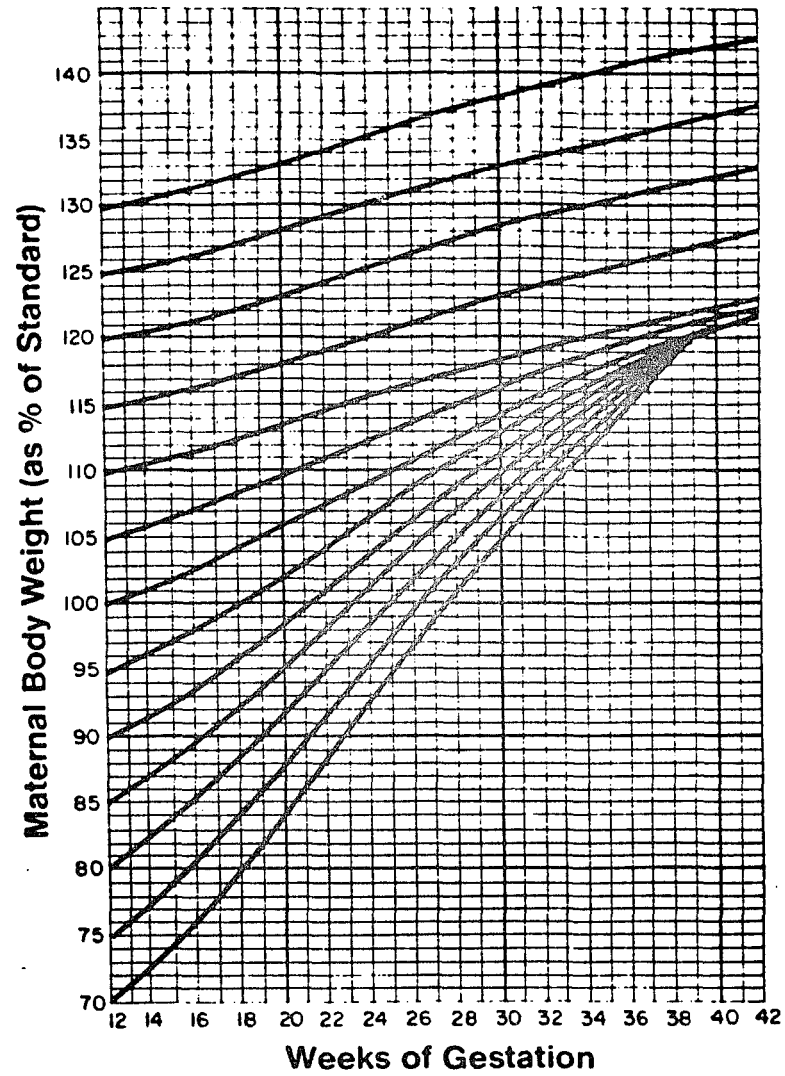


Chart to monitor weight gain during pregnancy considering pre-pregnancy weight and height.

(Rosso, 1985)

Appendix 3

1959 Metropolitan Life Insurance Company
Weight-for-Height Reference Standard

Weight in Pounds According to Frame (In Indoor Clothing)

HEIGHT		SMALL FRAME	MEDIUM FRAME	LARGE FRAME	HEIGHT		SMALL FRAME	MEDIUM FRAME	LARGE FRAME
MEN					WOMEN†				
Feet	Inches				Feet	Inches			
5	2	112-120	118-129	126-141	4	10	92- 98	96-107	104-119
5	3	115-123	121-133	129-144	4	11	94-101	98-110	106-122
5	4	118-126	124-136	132-148	5	0	96-104	101-113	109-125
5	5	121-129	127-139	135-152	5	1	99-107	104-116	112-128
5	6	124-133	130-143	138-156	5	2	102-110	107-119	115-131
5	7	128-137	134-147	142-161	5	3	105-113	110-122	118-134
5	8	132-141	138-152	147-166	5	4	108-116	113-126	121-138
5	9	136-145	142-156	151-170	5	5	111-119	116-130	125-142
5	10	140-150	146-160	155-174	5	6	114-123	120-135	129-146
5	11	144-154	150-165	159-179	5	7	118-127	124-139	133-150
6	0	148-158	154-170	164-184	5	8	122-131	128-143	137-154
6	1	152-162	158-175	168-189	5	9	126-135	132-147	141-158
6	2	156-167	162-180	173-194	5	10	130-140	136-151	145-163
6	3	160-171	167-185	178-199	5	11	134-144	140-155	149-168
6	4	164-175	172-190	182-204	6	0	138-148	144-159	153-173

* Metropolitan Life Insurance Company.

† For girls between 18 and 25, subtract 1 pound for each year under 25.

Appendix 4

1983 Metropolitan Life Insurance Company
Weight-for-Height Reference Standard

WOMEN

Height (Without Shoes)		SMALL FRAME				MEDIUM FRAME				LARGE FRAME			
		1959	1983	Change Since 1959	Percent Change	1959	1983	Change Since 1959	Percent Change	1959	1983	Change Since 1959	Percent Change
Feet	Inches	Weight in Pounds (Without Clothing)											
4	9	90- 97	99-108	9 11	10 11	94-106	106-118	12 12	13 11	102-118	115-128	13 10	13 8
4	10	92-100	100-110	8 10	9 10	97-109	108-120	11 11	11 10	105-121	117-131	12 10	11 8
4	11	95-103	101-112	6 9	6 9	100-112	110-123	10 11	10 10	108-124	119-134	11 10	10 8
5	0	98-106	103-115	5 9	5 8	103-115	112-126	9 11	9 10	111-127	122-137	11 10	10 8
5	1	101-109	105-118	4 9	4 8	106-118	115-129	9 11	8 9	114-130	125-140	11 10	10 8
5	2	104-112	108-121	4 9	4 8	109-122	118-132	9 10	8 8	117-134	128-144	11 10	9 7
5	3	107-115	111-124	4 9	4 8	112-126	121-135	9 9	8 7	121-138	131-148	10 10	8 7
5	4	110-119	114-127	4 8	4 7	116-131	124-138	8 7	7 5	125-142	134-152	9 10	7 7
5	5	114-123	117-130	3 7	3 6	120-135	127-141	7 6	6 4	129-146	137-156	8 10	6 7
5	6	118-127	120-133	2 6	2 5	124-139	130-144	6 5	5 4	133-150	140-160	7 10	5 7
5	7	122-131	123-136	1 5	1 4	128-143	133-147	5 4	4 3	137-154	143-164	6 10	4 6
5	8	126-136	126-139	0 3	0 2	132-147	136-150	4 3	3 2	141-159	146-167	5 8	4 5
5	9	130-140	129-142	-1 2	-1 1	136-151	139-153	3 2	2 1	145-164	149-170	4 6	3 4
5	10	134-144	132-145	-2 1	-1 1	140-155	142-156	2 1	1 1	149-169	152-173	3 4	2 2

Note: Prepared by Metropolitan Life Insurance Company.

Source of basic data: *Build Study*, 1979, and *Build and Blood Pressure Study*, 1959, Society of Actuaries and Association of Life Insurance Medical Directors of America.

Appendix 5

Conversion Chart to Change Infant's Birth Weight From Pounds and Ounces to Grams

GRAM WEIGHT CONVERSION TABLE

To use this table, find the number of pounds in the column to the far left (or right), and the number of ounces in the top row. Read across from the number of pounds and down from the number of ounces; the gram weight is found where the two lines intersect. (i.e., 2 pounds, 6 ounces = 1077 grams). For a weight of less than a pound, find the number of ounces in the top line of the table. The number immediately below it will be the corresponding weight in grams (i.e., 8 ounces = 227 grams).

POUNDS

POUNDS																		
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
0	--	28	57	85	113	142	170	198	227	255	284	312	340	369	397	425	454	0
1	454	482	510	539	567	595	624	652	680	709	737	765	794	822	851	879	907	1
2	907	935	964	992	1021	1049	1077	1106	1134	1162	1191	1219	1247	1276	1304	1332	1361	2
3	1361	1389	1418	1446	1474	1503	1531	1559	1588	1616	1644	1673	1701	1729	1758	1786	1814	3
4	1814	1843	1871	1899	1928	1956	1985	2013	2041	2070	2098	2126	2155	2183	2211	2240	2268	4
5	2268	2296	2325	2353	2381	2410	2438	2466	2495	2523	2552	2580	2608	2637	2665	2693	2722	5
6	2722	2750	2778	2807	2835	2863	2892	2920	2948	2977	3005	3033	3062	3090	3118	3147	3175	6
7	3175	3204	3232	3260	3289	3317	3345	3374	3402	3430	3459	3487	3515	3544	3572	3600	3629	7
8	3629	3657	3686	3714	3742	3771	3799	3827	3856	3884	3912	3941	3969	3997	4026	4054	4082	8
9	4082	4111	4139	4167	4196	4224	4253	4281	4309	4338	4366	4394	4423	4451	4479	4508	4536	9
10	4536	4564	4593	4621	4649	4678	4706	4734	4763	4791	4820	4848	4876	4905	4933	4961	4990	10
11	4990	5018	5046	5075	5103	5131	5160	5188	5216	5245	5273	5301	5330	5358	5387	5415	5443	11
12	5443	5472	5500	5528	5557	5585	5613	5642	5670	5698	5727	5755	5783	5812	5840	5868	5897	12
13	5897	5925	5954	5982	6010	6039	6067	6095	6124	6152	6180	6209	6237	6265	6294	6322	6350	13
14	6350	6379	6407	6435	6464	6492	6521	6549	6577	6606	6634	6662	6691	6719	6747	6776	6804	14
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	

POUNDS

OUNCES

Appendix 6

Human Subjects Approval:
UCRIHS -- Michigan State University's
Committee for the Review and Investigation of Human Subjects

MICHIGAN STATE UNIVERSITY

UNIVERSITY COMMITTEE ON RESEARCH INVOLVING
HUMAN SUBJECTS (UCRIHS)
304 BERKELEY HALL
(517) 353-9738

EAST LANSING • MICHIGAN • 48824-1111

October 11, 1988

IRB# 88-340

Carol A. Friesen
204 Food Science
MSU

Dear Ms. Friesen:

Subject: "THE RELATIONSHIP BETWEEN PERCENT STANDARD BODY
WEIGHT ATTAINED AT TERM AND INFANT BIRTH WEIGHT
IRB# 88-340"

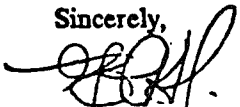
I am pleased to advise that because of the nature of the proposed research, it was eligible for expedited review. This process has been completed, the rights and welfare of the human subjects appear to be adequately protected, and your project is therefore approved.

You are reminded that UCRIHS approval is valid for one calendar year. If you plan to continue this project beyond one year, please make provisions for obtaining appropriate UCRIHS approval prior to September 26, 1989.

Any changes in procedures involving human subjects must be reviewed by the UCRIHS prior to initiation of the change. UCRIHS must also be notified promptly of any problems (unexpected side effects, complaints, etc.) involving human subjects during the course of the work.

Thank you for bringing this project to our attention. If we can be of any future help, please do not hesitate to let us know.

Sincerely,



John K. Hudzik, Ph.D.
Chair, UCRIHS

JKH/sar

cc: S. Hoerr

Appendix 7

Human Subjects Approval:
Michigan Department of Public Health

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

Department Committee for the Evaluation of Studies
Involving Human SubjectsTO: Raj M Wiener
Acting State Health DirectorFROM: *Thany A. Scoblic, Chair*
*IRB*TITLE OF STUDY: *Birth Record Followback Study*PROGRAM: *Office of the State Registrar / MSU*PRINCIPAL INVESTIGATOR(S): *Carol Friesen / Sharon Holrr - Michigan State University*DATE PROJECT RECEIVED: *11/25/88*FUNDING: STATE _____ FEDERAL _____ OTHER ☒

COMMITTEE RECOMMENDATIONS:

☒ Approved through expedited reviewDate: *12/14/88*☐ Approved by review board and full committee
without modifications

Date: _____

☐ Approved by review board and full committee
with modifications

Date: _____

COMMENTS:

DATE: *12/13/88**Thany A. Scoblic*

CHAIRPERSONcc: Bureau Chief
Principal Investigator(s)
Office of Finance and General Services
Committee Members

Appendix 8

Approval of the Study
as a Medical Research Project:
The Michigan Department of Public Health

STATE OF MICHIGAN



JAMES J. BLANCHARD, Governor

DEPARTMENT OF PUBLIC HEALTH

3423 N. LOGAN
P.O. BOX 30195, LANSING, MICHIGAN 48909
Raj M Wiener, Acting Director

November 23, 1988

Carol Friesen, M.S., R.D.
Dept of Food Science & Human Nutrition
Michigan State University
165 Anthony Dairy Annex
East Lansing, MI 48824

Dear Ms. Friesen:

This is to designate your study "The relationship between percent standard body weight attained at term and infant birth weight", described in the letter and material submitted November 23, 1988 as a medical research project.

This designation is provided under the provisions of the Michigan Public Health Code, P.A. 368 of 1978, as amended, being MCL 333.2631-333.2635. This assures that information collected from participating parties will be kept confidential. A copy of the referenced sections is enclosed.

Sincerely,

Kenneth S. Rowland
by Raj M Wiener
Acting State Health Director



PRINTED ON
RECYCLED PAPER

Appendix 9

PILOT: Michigan Mother's Pregnancy Lifestyle Questionnaire

CODE NO: _____

PREGNANCY LIFESTYLE QUESTIONNAIRE

DIRECTIONS: Please complete the following questions as completely as possible. Simply write in the correct information in the space provided or check the box of the answer you think is most correct. All the questions refer to your **MOST RECENT PREGNANCY**.

1. What is the name, address and phone number of the doctor or clinic you went to for most of your medical care during your pregnancy?

NAME: _____

CLINIC or
HOSPITAL NAME: _____

STREET ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

PHONE: (____) _____

2. How tall are you, without shoes? _____ feet _____ inches

3. Approximately how much did you weigh **BEFORE** you became pregnant with your last child?

_____ pounds

4. Approximately how much did you weigh **JUST BEFORE YOU DELIVERED** your baby?

_____ pounds

5. Do you, or does someone in your family, remember how much **YOU** weighed when **YOU** were born? If you know, record the amount below.

_____ pounds _____ ounces

6. Did a doctor, nurse or nutrition counselor tell you how much weight you should gain during this pregnancy?

☐

YES (if yes, go to next question)

☐

NO (if no, go to question 8)

7. How many pounds were you told to gain from the **BEGINNING** to the **END** of this pregnancy?

_____ pounds

Page 2

During your recent pregnancy, did you do any of the following on a regular basis? Check only **ONE BOX** per question.

	YES, based on doctor's or other medical source's suggestion.	YES, based on my decision without asking a doctor or other medical source.	NO, I did NOT.	Does NOT apply to me
8. Take a vitamin supplement?				
9. Restrict your calorie intake?				
10. Restrict your salt intake?				
11. Cut down or stop drinking alcohol?				
12. Cut down or stop smoking cigarettes?				
13. Stop taking aspirin the last 3 months?				

DIRECTIONS: Circle the number which most closely represents your opinion about the following statements. **EXAMPLE: 5 = Strongly Agree.**

	STRONGLY AGREE	AGREE	NO OPINION	DISAGREE	STRONGLY DISAGREE
14. Nutrition is extremely important during pregnancy.	5	4	3	2	1
15. A poor diet during pregnancy will NOT affect the baby's health.	5	4	3	2	1
16. Mother's who eat well produce healthier babies than mother's who do not eat well.	5	4	3	2	1
17. I worried that I might get fat during my recent pregnancy.	5	4	3	2	1
18. I tried to keep my weight down so I didn't look so pregnant.	5	4	3	2	1
19. As long as I ate a well-balanced diet, I didn't care how much I gained during my pregnancy.	5	4	3	2	1

Page 3

		STRONGLY AGREE	AGREE	NO OPINION	DISAGREE	STRONGLY DISAGREE
20.	I think a pregnant woman is beautiful.	5	4	3	2	1
21.	I was embarrassed by how big I got during my pregnancy.	5	4	3	2	1
22.	I would gain 40 pounds if it meant my baby would be healthier.	5	4	3	2	1
23.	I feel that women have to be especially careful about getting fat during pregnancy.	5	4	3	2	1
24.	Just before I went to the doctor, I tried not to eat.	5	4	3	2	1

25. How would you rate the **QUALITY** of your diet during your pregnancy, on a scale of 1 to 10? **Circle your rating.**

1 2 3 4 5 6 7 8 9 10
POOR AVERAGE EXCELLENT

26. On the average, how many drinks of alcoholic beverages, if any, did you have the three months **BEFORE** and then **DURING** your pregnancy? A drink is 12 ounces of beer (1 can), 4 ounces of wine (1/2 cup) , or 1 1/2 ounces of liquor. Mark ONE box for **BEFORE** and one box for **DURING** your recent pregnancy.

BEFORE PREGNANCY

DURING PREGNANCY

☐	21 or more drinks a week	☐
☐	14 to 20 drinks a week	☐
☐	9 to 13 drinks a week	☐
☐	6 to 8 drinks a week	☐
☐	3 to 5 drinks a week	☐
☐	2 drinks a week	☐
☐	1 drink a week	☐
☐	2 to 3 drinks a month	☐
☐	1 drink a month	☐
☐	Less than one drink a month	☐
☐	I did NOT drink	☐

Page 4

27. On the average, how many cigarettes, if any, did you smoke **A DAY** during the 3 months **BEFORE** you found out you were pregnant and **DURING** your pregnancy? Write in "0" if you did **NOT** smoke.

_____ average number of cigarettes a day **BEFORE** I found out I was pregnant

_____ average number of cigarettes a day **DURING** my pregnancy

28. Which of the following **health problems** or symptoms did you have during this pregnancy? Check **ALL** that apply.

☐
☐
☐
☐
☐
☐

nausea
vomiting
stomach cramps
vaginal bleeding
swollen feet
severe headaches

☐
☐
☐
☐
☐

diarrhea
constipation
hemorrhoids
none of the above
other -- specify

29. Which of the following **problems** or **feelings** did you have about getting medical care during your pregnancy? Check **ALL** that apply.

☐
☐
☐
☐
☐
☐
☐
☐
☐
☐
☐
☐

I did not have anyone to take care of my children
I could not miss work or school
I did not have a way to get to the clinic or doctor's office
There were no doctors or clinics nearby
I did not know where to go to get prenatal care
I did not think it was important to see a doctor
The wait at the doctor's office or clinic was too long
I was afraid of medical tests and examinations
I did not like the doctor's or nurse's attitudes
The office hours were not convenient
I could not get an appointment
None of the above were problems
Other -- specify

Page 5

30. How did you pay for your medical bills during your pregnancy? Check ALL that apply.

☐	Self-pay (include self, family or friends)
☐	HMO (Health Maintenance Organization)
☐	Health Insurance (like Blue Cross, Prudential)
☐	Medicaid
☐	Care provided by the military
☐	Other -- please specify _____

31. Did you receive assistance from any social services programs during your pregnancy? If yes, please check ALL that apply.

☐	WIC (Supplemental Program for Women, Infants and Children)
☐	EFNEP (Expanded Food and Nutrition Education Program)
☐	MCH (Maternal and Child Health Program)
☐	Food Stamps
☐	Food Bank (church, community)
☐	AFDC (Welfare)
☐	No social service assistance was received
☐	Other -- please specify _____

32. On the average, what was the **TOTAL MONTHLY INCOME** (after taxes) of all household members you lived with (include yourself) during your pregnancy? Please check your **BEST ESTIMATE**.

☐	\$0 to \$299
☐	\$300 to \$499
☐	\$500 to \$999
☐	\$1000 to \$1499
☐	\$1500 to \$1999
☐	\$2000 to \$2499
☐	\$2500 or more
☐	I do not know or wish to say

33. How many individuals did this total income serve (including you)?

Page 6

34. Thinking back to JUST BEFORE you became pregnant with your new baby, did you WANT to become pregnant at that time? Check only ONE BOX.

☐ I wanted this pregnancy AT AN EARLIER TIME, as well as at that time.

☐ I wanted to become pregnant AT THAT TIME.

☐ I did NOT want to become pregnant at that time, but rather I wanted a child sometime IN THE FUTURE.

☐ I did NOT want to become pregnant at that time OR at any time in the future.

35. If we have questions about anything you have written down, could we call you? If so, please give us a number where you can be reached and when it would be convenient.

PHONE: (____) _____ TIME: _____

36. In case we can't reach you, would you give us the name and address of a person who would likely know where you could be reached?

NAME: _____

ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

PHONE: (____) _____

37. Would you like us to send you some of the results of this survey?

☐ YES ☐ NO

38. Is there anything else you would like to tell us about yourself, your pregnancy, your baby or anything else in this questionnaire?

CODE: _____

It is important for you to read and sign the **CONSENT STATEMENT** below. Your doctor can tell us more about the care you and your baby received. What your doctor can tell us is also very important. All of the information we obtain will be kept strictly confidential.

CONSENT STATEMENT

I have voluntarily participated in this pregnancy survey. I give my permission for the Michigan Department of Public Health to obtain additional information about my pregnancy from the medical source listed in question 1 above. I understand that the Department will use this information **ONLY** for statistical purposes in health research, and no information which identifies either me or the medical source will **EVER** be released or published.

(Signature -- in INK)

(Today's Date)

Thank you for your help and cooperation! Please check to make sure all your responses to **BOTH** this **QUESTIONNAIRE** and the **FOOD FREQUENCY** are completed and returned in the enclosed envelope **at your earliest convenience.**

Appendix 10

PILOT: The Willett Semi-Quantitative Food
Frequency Questionnaire (SQFFQ)

DIET ASSESSMENT®

INSTRUCTIONS: PLEASE USE AN ORDINARY (o.g. # 2) PENCIL TO ANSWER ALL QUESTIONS BY COMPLETELY FILLING IN THE APPROPRIATE RESPONSE CIRCLE, OR BY WRITING IN THE REQUESTED INFORMATION WHEN A SPACE IS PROVIDED.

EXAMPLE 1: DO YOU LIVE IN THE UNITED STATES? ☐ NO ☒ YES (FILL CIRCLE COMPLETELY)

EXAMPLE 2: WHERE WERE YOU BORN? OREGON (KEEP HAND-WRITING WITHIN BORDERS OF RESPONSE BOX)

BECAUSE THIS FORM IS MEANT TO BE READ BY OPTICAL-SCANNING EQUIPMENT, IT IS IMPORTANT THAT YOU MAKE NO STRAY MARKS. TO CHANGE A RESPONSE, ERASE THE INCORRECT MARK COMPLETELY.

1. DO YOU REGULARLY TAKE MULTIPLE VITAMINS? ☐ NEVER HAVE ☐ HAVE IN THE PAST ONLY ☐ YES, CURRENTLY TAKE THEM
- a) IF YOU CURRENTLY TAKE THEM, WHAT BRAND DO YOU USE? (SPECIFY EXACT BRAND)
- b) IF YOU CURRENTLY TAKE THEM, HOW MANY DO YOU TAKE PER WEEK?
- ☐ 2 OR LESS ☐ 3-5 ☐ 6-9 ☐ 10 OR MORE
- BRAND

2. NOT COUNTING MULTIPLE VITAMINS, DO YOU TAKE ANY OF THE FOLLOWING PREPARATIONS?

PREPARATION	NEVER TAKEN	TAKEN IN THE PAST ONLY	YES, CURRENTLY TAKE IT	IF YOU TAKE IT CURRENTLY, WHAT AVERAGE DAILY DOSE?	HOW LONG HAVE YOU BEEN TAKING IT?
VITAMIN A	☐	☐	☒	☐ LESS THAN 8,000 IU ☐ 8,000 to 12,000 IU ☐ 13,000 to 22,000 IU ☐ 23,000 IU OR MORE ☐ DON'T KNOW	☐ 0-1 YR. ☐ 2-4 YRS. ☐ 5-9 YRS. ☐ 10 YRS. OR MORE
VITAMIN C	☐	☐	☒	☐ LESS THAN 400 mg. ☐ 400 to 700 mg. ☐ 750 to 1,250 mg. ☐ 1,300 mg. OR MORE ☐ DON'T KNOW	☐ 0-1 YR. ☐ 2-4 YRS. ☐ 5-9 YRS. ☐ 10 YRS. OR MORE
VITAMIN E	☐	☐	☒	☐ LESS THAN 100 IU ☐ 100 to 250 IU ☐ 300 to 500 IU ☐ 600 IU OR MORE ☐ DON'T KNOW	☐ 0-1 YR. ☐ 2-4 YRS. ☐ 5-9 YRS. ☐ 10 YRS. OR MORE
SELENIUM	☐	☐	☒	☐ LESS THAN 80 mcg. ☐ 80 to 130 mcg. ☐ 140 to 250 mcg. ☐ 260 mcg. OR MORE ☐ DON'T KNOW	☐ 0-1 YR. ☐ 2-4 YRS. ☐ 5-9 YRS. ☐ 10 YRS. OR MORE
IRON	☐	☐	☒	☐ LESS THAN 51 mg. ☐ 51 to 200 mg. ☐ 201 to 400 mg. ☐ 400 mg. OR MORE ☐ DON'T KNOW	☐ 0-1 YR. ☐ 2-4 YRS. ☐ 5-9 YRS. ☐ 10 YRS. OR MORE
ZINC	☐	☐	☒	☐ LESS THAN 25 mg. ☐ 25 to 74 mg. ☐ 75 to 100 mg. ☐ 101 mg. OR MORE ☐ DON'T KNOW	☐ 0-1 YR. ☐ 2-4 YRS. ☐ 5-9 YRS. ☐ 10 YRS. OR MORE
CALCIUM OR DOLOMITE	☐	☐	☒	☐ LESS THAN 400 mg. ☐ 400 to 900 mg. ☐ 901 to 1,300 mg. ☐ 1,301 mg. OR MORE ☐ DON'T KNOW	☐ 0-1 YR. ☐ 2-4 YRS. ☐ 5-9 YRS. ☐ 10 YRS. OR MORE

ANY OTHER VITAMINS OR MINERALS? (SPECIFY TYPE AND DAILY DOSE)

3. FOR EACH FOOD LISTED, FILL IN THE CIRCLE INDICATING HOW OFTEN, ON AVERAGE, YOU HAVE USED THE AMOUNT SPECIFIED, DURING THE PAST YEAR.

FOODS AND AMOUNTS	AVERAGE USE LAST YEAR								
	NEVER, OR LESS THAN ONCE PER MONTH	1-3 PER MO.	1 PER WEEK	2-4 PER WEEK	5-6 PER WEEK	1 PER DAY	2-3 PER DAY	4-5 PER DAY	6+ PER DAY
DAIRY FOODS									
SKIM OR LOW FAT MILK (8 oz. GLASS)	☐	☐	☒	☐	☐	☐	☐	☐	☐
WHOLE MILK (8 oz. GLASS)	☐	☐	☒	☐	☐	☐	☐	☐	☐
CREAM, e.g. COFFEE, WHIPPED (TBS)	☐	☐	☒	☐	☐	☐	☐	☐	☐
SOUR CREAM (TBS)	☐	☐	☒	☐	☐	☐	☐	☐	☐
NON-DAIRY COFFEE WHITENER (tsp.)	☐	☐	☒	☐	☐	☐	☐	☐	☐
SHERBET OR ICE MILK (1/2 CUP)	☐	☐	☒	☐	☐	☐	☐	☐	☐
ICE CREAM (1/2 CUP)	☐	☐	☒	☐	☐	☐	☐	☐	☐

PLEASE TURN TO PAGE 2

PAGE 2

3. (CONTINUED) PLEASE FILL IN YOUR AVERAGE USE, DURING THE PAST YEAR, OF EACH SPECIFIED FOOD.

FOODS AND AMOUNTS		AVERAGE USE LAST YEAR									
		NEVER, OR LESS THAN ONCE PER MONTH	1-3 PER MO.	1 PER WEEK	2-4 PER WEEK	5-6 PER WEEK	1 PER DAY	2-3 PER DAY	4-5 PER DAY	6+ PER DAY	
	YOGURT (1 CUP)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	COTTAGE OR RICOTTA CHEESE (1/2 CUP)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	CREAM CHEESE (1 oz.)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	OTHER CHEESE, e.g. AMERICAN, CHEDDAR, etc., PLAIN OR AS PART OF A DISH (1 SLICE OR 1 oz. SERVING)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	MARGARINE (PAT), ADDED TO FOOD OR BREAD; EXCLUDE USE IN COOKING	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	BUTTER (PAT), ADDED TO FOOD OR BREAD; EXCLUDE USE IN COOKING	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
FRUITS	RAISINS (1 oz. OR SMALL PACK) OR GRAPES	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	PRUNES (1/2 CUP)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	BANANAS (1)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	PEACHES, APRICOTS OR PLUMS (1 FRESH, OR 1/2 CUP CANNED)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	FRESH APPLES OR PEARS (1)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	APPLE JUICE OR CIDER (SMALL GLASS)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	ORANGES (1)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	ORANGE JUICE (SMALL GLASS)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	GRAPEFRUIT (1/2)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	GRAPEFRUIT JUICE (SMALL GLASS)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	OTHER FRUIT JUICES (SMALL GLASS)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	STRAWBERRIES, FRESH, FROZEN OR CANNED (1/2 CUP)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	BLUEBERRIES, FRESH, FROZEN OR CANNED (1/2 CUP)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	CANTALOUPE (1/4 MELON)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	WATERMELON (1 SLICE)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
VEGETABLES	BROCCOLI (1/2 CUP)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	CABBAGE OR COLE SLAW (1/2 CUP)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	CAULIFLOWER (1/2 CUP)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	BRUSSELS SPROUTS (1/2 CUP)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	CARROTS (1 WHOLE OR 1/2 CUP COOKED)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	CORN (1 EAR OR 1/2 CUP FROZEN OR CANNED)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	PEAS, OR LIMA BEANS (1/2 CUP FRESH, FROZEN, CANNED)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	MIXED VEGETABLES (1/2 CUP)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	YELLOW (WINTER) SQUASH (1/2 CUP)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	EGGPLANT, ZUCCHINI, OR OTHER SUMMER SQUASH (1/2 CUP)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	YAMS OR SWEET POTATOES (1/2 CUP)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	SPINACH, COOKED (1/2 CUP)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	SPINACH, RAW AS IN SALAD	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	KALE, MUSTARD OR CHARD GREENS (1/2 CUP)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	ICEBERG OR HEAD LETTUCE (SERVING)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	ROMAINE OR LEAF LETTUCE (SERVING)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	TOMATOES (1)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	TOMATO JUICE (SMALL GLASS)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	TOMATO SAUCE (1/2 CUP) e.g. SPAGHETTI SAUCE	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	RED CHILI SAUCE (1 TBS)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	TOFU OR SOYBEANS (3-4 oz.)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	STRING BEANS (1/2 CUP)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	BEANS OR LENTILS, BAKED OR DRIED (1/2 CUP)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	MEATS	EGGS (1)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐
		CHICKEN OR TURKEY, WITH SKIN (4-6 oz.)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐
CHICKEN OR TURKEY, WITHOUT SKIN (4-6 oz.)		☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
BACON (2 SLICES)		☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
HOT DOGS (1)		☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	
	PROCESSED MEATS, e.g. SAUSAGE, SALAMI, BOLOGNA, etc. (PIECE OR SLICE)	☐	☐	☐ (W)	☐	☐	☐ (D)	☐	☐	☐	

PLEASE GO TO PAGE 3

AVERAGE USE LAST YEAR

**PLEASE TURN
TO PAGE 4**

NEVER, OR LESS THAN ONCE PER MONTH		1-3 PER MO.	1 PER WEEK	2-4 PER WEEK	5-6 PER WEEK	1 PER DAY	2-3 PER DAY	4-5 PER DAY	6+ PER DAY
	☐	☐	☐ W	☐	☐	☐ D	☐	☐	☐
	☐	☐	☐ W	☐	☐	☐ D	☐	☐	☐
	☐	☐	☐ W	☐	☐	☐ D	☐	☐	☐
	☐	☐	☐ W	☐	☐	☐ D	☐	☐	☐
T	☐	☐	☐ W	☐	☐	☐ D	☐	☐	☐
	☐	☐	☐ W	☐	☐	☐ D	☐	☐	☐
	☐	☐	☐ W	☐	☐	☐ D	☐	☐	☐
	☐	☐	☐ W	☐	☐	☐ D	☐	☐	☐
	☐	☐	☐ W	☐	☐	☐ D	☐	☐	☐
	☐	☐	☐ W	☐	☐	☐ D	☐	☐	☐
	☐	☐	☐ W	☐	☐	☐ D	☐	☐	☐
	☐	☐	☐ W	☐	☐	☐ D	☐	☐	☐
	☐	☐	☐ W	☐	☐	☐ D	☐	☐	☐

POUNDS

[illegible]

Appendix 11

PILOT: Physician's Prenatal Care Survey

PATIENT NAME: _____

DELIVERY DATE:_____

CODE NO: _____

PHYSICIAN PREGNANCY SURVEY

DIRECTIONS: Please complete the following questions for the patient listed above. Be as thorough as possible. If the information is **NOT AVAILABLE**, please record "NA"; do not leave the space blank.

1. What is this patient's **HEIGHT**, without shoes?
_____ feet _____ inches or _____ cm
2. Did you suggest that this patient limit her total weight gain during her recent pregnancy?
- ☐ YES (If YES, go to question 3)
- ☐ NO (If NO, go to question 4)
3. What limit in total weight gain did you recommend?
- ☐ less than 16 pounds
- ☐ 16-21 pounds
- ☐ 22-27 pounds
- ☐ 28-34 pounds
- ☐ 35 pounds or more

Did you **RECOMMEND** any of the following to this woman during her most recent pregnancy?
"NR" = Not Recorded.

4. Take a vitamin-mineral supplement?
5. Restrict her calorie intake?
6. Restrict her salt intake?
7. Use diuretics?
8. Cut down or stop drinking alcohol?
9. Cut down or stop smoking cigarettes?
10. Restrict her use of aspirin and ibuprofen-products, especially during the last trimester?

[illegible]

Page 2

11. According to the medical charts, was this woman exposed to any of the following medical risk factors during her pregnancy? "NR" = Not RECORDED.

	YES	NO	NR
a. Anemia (Hct < 30%; Hg < 10 g/dL)			
b. Cardiac disease			
c. Lung disease, acute or chronic			
d. Diabetes, chronic			
e. Diabetes, gestational			
f. Genital herpes			
g. Hypertension, chronic (less than 20 weeks gestation)			
h. Hypertension, pregnancy-related (20 weeks or more gestation)			
i. Diagnosed Eclampsia			
j. Incompetent Cervix			
k. Previous infant 4000+ grams			
l. Previous pre-term or small-for-gestational age infant (less than 37 weeks or less than 2500 g)			
m. Renal disease			
n. Rh sensitization			
o. Short inter-pregnancy period (less than 1 year)			
p. Uterine bleeding or threatened abortion			
q. AIDS			
r. Cesarean delivery			
s. Other--please specify _____			

Page 3

According to the medical charts, was this woman exposed to any of the following behavioral risk factors during her pregnancy? "NR" = NOT RECORDED.

12. Tobacco use during her pregnancy?
13. Alcohol use during her pregnancy?
14. Inadequate weight gain?

YES	NO	NR

15. Please record the woman's **INITIAL** and **FINAL** hemoglobin and/or hematocrit values you measured during her recent pregnancy.

	WEEK OF GESTATION (estimated)	HEMATOCRIT (%)	HEMOGLOBIN (g/dL)
First Iron Value			
Last Iron Value			

16. The following information is **CRITICAL** to this study.

- a. What was the woman's **PRE-PREGNANCY WEIGHT**? _____
(Please make a good estimate if the actual value is not recorded.)
- b. What is the **FIRST** pregnant weight recorded for this woman? _____

Approximately how far into the pregnancy was this? _____
- c. What is the **LAST** recorded weight for this woman during this pregnancy? _____

Approximately how long after this weight was recorded did the woman deliver? _____

Page 4

17. It would be extremely helpful if you could provide ALL of the weights which are charted for this woman. Though time consuming, the information would significantly enhance the results of this study.

WEIGHT	EST. WK. GESTATION

WEIGHT	EST. WK. GESTATION

18. Are there any other observations or comments you would like to make about any factor(s) which, in your opinion, influenced this woman's pregnancy outcome?

Please record the name, degree and telephone number of the person completing this questionnaire so that, if clarifications are needed, the appropriate individual may be contacted.

NAME: _____

PHONE: (____) _____

Thank you for your cooperation. Please return promptly in the enclosed postage-paid envelope at your earliest convenience.

Appendix 12

PILOT: First Letter to the Michigan Mother

STATE OF MICHIGAN



JAMES J. BLANCHARD, Governor

DEPARTMENT OF PUBLIC HEALTH3423 N. LOGAN
P.O. BOX 30195, LANSING, MICHIGAN 48909

January 7, 1989

Jane Doe
2005 Southview Blvd.
East Lansing, MI 48823

Dear mother of Beatrice Doe:

We are inviting you to participate in a statewide research project. Its purpose is to gain a better understanding of the health care that women receive during their pregnancy and their attitudes and actions during this time. The information you provide can help women and babies in the future.

You are one of a small number of women statewide you have been scientifically selected to be in this survey. Whether or not you agree to participate, you receive a FREE Gerber bib for you baby. If you agree to participate, all you have to do is complete the enclosed questionnaire and food frequency form and return them in the postage-paid, return envelope provided. The questions in this survey ask about your recent pregnancy with Beatrice.

Please complete the questionnaire and return it in the enclosed envelope. The Michigan Department of Public Health will use this information only for statistical purposes; no information that identifies you or your baby will ever be published. The questionnaire has an identification number for mailing purposes only. This number will allow us to check your name off our mailing list when your questionnaire is returned. Your participation is voluntary and your refusal to answer some or all of the questions will not result in any penalty or loss of services or benefits from the Michigan Department of Public Health.

If you have any further questions regarding this project, or if you would prefer a telephone interview, please call our Project Coordinator, Carol Friesen, collect at (517) 351-8334.

We hope you will accept our request to be in this study.

Sincerely,

George H. Van Amburg, MPH
State Registrar and Chief
Office of the State Registrar
and Center for Health Statistics

George H. Baker, MD
Chief, Office of Maternal and
Child Health

Appendix 13

Michigan Mother's Reminder Postcard

Last week, a questionnaire was mailed to you that asked about your recent pregnancy. You were scientifically selected to be in this important statewide research study.

If you have already completed and returned it to us, please accept our sincere thanks. If not, please do so today. Because it has been sent to only a small sample of women, it is very important that we receive your response. The more women we hear from, the better will be our information for use in improving programs for pregnant women and infants in the future.

If you did not receive the questionnaire, or if it got misplaced, please call Carol Friesen right now collect at (517) 351-8334, and we will get another one in the mail to you today.

Sincerely,


George Van Amburg, State Registrar and Chief
Office of the State Registrar and Center for Health Statistics
Michigan Department of Public Health

Appendix 14

PILOT: Second Letter to Michigan Mothers

STATE OF MICHIGAN



JAMES J. BLANCHARD, Governor

DEPARTMENT OF PUBLIC HEALTH3423 N. LOGAN
P.O. BOX 30195, LANSING, MICHIGAN 48909

February 7, 1989

Jane E. Doe
2005 Southview Blvd.
East Lansing, MI 48823

Dear mother of Beatrice Doe:

About three weeks ago, we invited you to participate in a statewide research project. Its purpose is to gain a better understanding of the health care that women receive during their pregnancy and their attitudes and actions during this time. The information you provide can help women and babies in the future.

As mentioned in our previous letter, you are one of a small number of women statewide who have been scientifically selected to be in this survey. If you agree to participate, all you have to do is complete the enclosed questionnaire and food frequency form and return them in the postage-paid, return envelope provided. The questions in this survey ask about your recent pregnancy with Beatrice.

If you have returned the questionnaire in the past few days, we appreciate it very much. If you have not, please complete the questionnaire and return it in the enclosed envelope. The Michigan Department of Public Health will use this information only for statistical purposes; no information that identifies you or your baby will ever be published. The questionnaire has an identification number for mailing purposes only. This number will allow us to check your name off our mailing list when your questionnaire is returned.

Your participation is voluntary and your refusal to answer some or all of the questions will not result in any penalty or loss of services or benefits from the Michigan Department of Public Health.

If you have any further questions regarding this project, or if you would prefer a telephone interview, please call our Project Coordinator, Carol Friesen, collect at (517) 351-8334.

We hope you will accept our request to be in this study.

Sincerely,

George H. Van Amburg, MPH
State Registrar and Chief
Office of the State Registrar
and Center for Health StatisticsGeorge H. Baker, MD
Chief, Office of Maternal and
Child Health

Appendix 15

PILOT: First Letter to Physicians

STATE OF MICHIGAN



JAMES J. BLANCHARD, Governor

DEPARTMENT OF PUBLIC HEALTH3423 N. LOGAN
P.O. BOX 30195, LANSING, MICHIGAN 48909

February 7, 1989

Thomas Lowe, M.D.
Westview Clinic
100 Southview Blvd.
East Lansing, MI 48823

Dear Dr. Lowe:

Your assistance is needed in a statewide research project conducted by the Michigan Department of Public Health. The purposes of the study are: 1) to determine if the attainment of a specific percentage of a woman's desirable body weight is associated with successful fetal outcome, and 2) to identify and quantify factors associated with low birth weight (LBW) in Michigan. Because Michigan is tied with Pennsylvania as the state with the highest incidence of LBW in Blacks in the nation (12.9% Black, 5.5% White, 6.8% Statewide), identification of factors contributing to, and the prevention of, LBW has become a priority public health concern of the Department.

You were identified as being the prenatal health care provider of Jane E. Doe, who provided us with your name and address. She has authorized you to provide us with information from her medical records about her pregnancy with Beatrice Doe. All information you report will be kept strictly confidential. No information which identifies either you or the patient will be released. Your participation is voluntary. The director of public health has declared this a medical research project under the provision of MCL 333.2631-333.2635. As such, any information shared with us is not subject to disclosure. The data collected will be used in program planning and epidemiological research to be published in professional journals. Because this survey is based on a small random sample of Michigan women, it is important that we obtain as much information as possible on all women in this study.

Please complete the questionnaire and return it in the enclosed pre-addressed, postage-paid envelope at your earliest convenience. If you should have any questions, please call the Project Coordinator, Carol Friesen, at (517) 351-8334. Your cooperation is greatly appreciated.

Sincerely yours,

Sincerely yours,

George Van Amburg, MPH
State Registrar & Chief
Office of the State Registrar
and Center for Health Statistics

George H. Baker, Jr., M.D.
Chief, Office of Maternal and
Child Health

Appendix 16

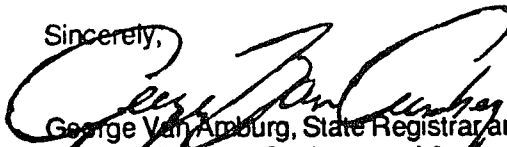
Physician's Reminder Postcard

Last week, a questionnaire was mailed to you that asked specific information about a recent pregnancy of one of your patients. Your patient was scientifically selected to be in this important statewide research study.

If you have already completed and returned it to us, please accept our sincere thanks. If not, please do so today. Because it has been sent to only a small sample of women and their physicians, it is very important that we receive your response. The more subjects we hear from, the better will be our information for use in improving programs for pregnant women and infants.

If you did not receive the questionnaire, or if it got misplaced, please call Carol Friesen collect at (517) 351-8334, and we will get another one in the mail to you today.

Sincerely,

A handwritten signature in black ink, appearing to read "George Van Amburg", written over the typed name.

George Van Amburg, State Registrar and Chief
Office of the State Registrar and Center for Health Statistics
Michigan Department of Public Health

Appendix 17

Michigan Mother's Pregnancy Lifestyle Questionnaire

CODE NO: _____

PREGNANCY LIFESTYLE QUESTIONNAIRE

DIRECTIONS: Please complete the following questions as completely as possible. Write the information in the space provided or check the box of the answer you think is most correct. All the questions refer to your pregnancy with your child named in the enclosed letter.

1. What is the name, address and phone number of the doctor you saw for most of your medical care during your pregnancy?

PHYSICIAN'S
NAME: _____

CLINIC or
HOSPITAL NAME: _____

STREET ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

PHONE: (____) _____

2. How tall are you, without shoes? _____ feet _____ inches
3. Approximately how much did you weigh **BEFORE** you became pregnant? _____ lbs
4. Approximately how much did you weigh **JUST BEFORE YOU DELIVERED** your baby? _____ lbs
5. How much do you weigh **today**? _____ lbs Date: ____/____/____
6. Do you, or does someone in your family, remember how much **YOU** weighed when **YOU** were born? _____ lbs _____ ounces
7. Did a doctor, nurse or nutrition counselor tell you how much weight you should gain during this pregnancy?
- ☐ YES (if yes, go to next question)
- ☐ NO (if no, go to question 8)
8. How many pounds were you told to gain from the **BEGINNING** to the **END** of this pregnancy? _____ lbs
9. Did you breastfeed? If yes, for approximately how long (please specify weeks or months)?
- ☐ NO ☐ YES : _____

Page 2

During your recent pregnancy, did you do any of the following on a regular basis? Check only **ONE** **BOX** per question.

	YES, based on doctor's or other medical source's suggestion.	YES, based on my decision without asking a doctor or other medical source.	NO, I did NOT.	Does NOT apply to me.
10. Restrict your calorie intake?				
11. Restrict your caffeine intake (i.e. coffee/tea)?				
12. Cut down or stop drinking alcohol?				
13. Cut down or stop smoking cigarettes?				
14. Take a vitamin/mineral supplement?				

15. If you took a vitamin/mineral supplement, what was the brand name? _____

If you took an iron supplement, what was the brand name? _____

16. How often would you say you took the supplement(s) during your pregnancy?

MULTI-VITAMIN SUPPLEMENT

- ☐ daily
☐ 5 times per week
☐ 3 times per week
☐ 1-2 times per week
☐ irregularly

IRON SUPPLEMENT

- ☐ daily
☐ 5 times per week
☐ 3 times per week
☐ 1-2 times per week
☐ irregularly

17. On the average, how many **CUPS** of each of the following beverages did you consume **PER DAY** during the last three months of your pregnancy?

LAST 3 MONTHS

Coffee, regular

Tea, regular

Soda pop, caffeinated

HOW DO YOU LIKE YOUR COFFEE OR TEA (please check)?

Strong

Medium

Weak

Page 3

DIRECTIONS: Circle the number which most closely represents your opinion about the following statements. **EXAMPLE:** 5 = Strongly Agree.

	STRONGLY AGREE	AGREE	NO OPINION	DISAGREE	STRONGLY DISAGREE
18. Nutrition is important during pregnancy.	5	4	3	2	1
19. A poor diet during pregnancy will NOT affect the baby's health.	5	4	3	2	1
20. Mothers who eat good diets deliver healthier babies than mothers who do not eat well.	5	4	3	2	1
21. I worried that I might get fat during my recent pregnancy.	5	4	3	2	1
22. I tried to keep my weight down so I didn't look so pregnant.	5	4	3	2	1
23. I felt that eating a well-balanced diet was more important than how much weight I gained while pregnant.	5	4	3	2	1
24. I think a pregnant woman is beautiful.	5	4	3	2	1
25. I was embarrassed by how big I got during my pregnancy	5	4	3	2	1
26. As long as I took my vitamin pill in the morning, I didn't worry about what I ate.	5	4	3	2	1
27. I would gain 40 pounds if it meant my baby would be healthier.	5	4	3	2	1
28. I feel that women have to be especially careful about getting fat during pregnancy.	5	4	3	2	1
29. The weight I gained during my pregnancy made me feel unattractive.	5	4	3	2	1
30. Good eating habits during pregnancy are very important to the baby's health.	5	4	3	2	1
31. Just before I went to the doctor, I tried not to eat, because I was worried about my weight gain.	5	4	3	2	1

Page 5

36. On the average, how many cigarettes, if any, did you smoke **A DAY** during the 3 months **BEFORE** you found out you were pregnant and **DURING** your pregnancy? Write in "0" if you did **NOT** smoke.

_____ average number of cigarettes a day **BEFORE** I was pregnant

_____ average number of cigarettes a day **DURING** my pregnancy

37. Did you receive assistance from any public services or support programs during your pregnancy? If yes, please check **ALL** that apply.

☐

WIC (Supplemental Program for Women, Infants and Children)

☐

EFNEP (Expanded Food and Nutrition Education Program)

☐

MCH (Maternal and Child Health Programs like MSS and MIC)

☐

Food Stamps

☐

Food Closets (church, community)

☐

Community kitchen

☐

AFDC (Welfare)

☐

No public service assistance or support was received

☐

Other -- please specify _____

38. On the average, what was the **TOTAL MONTHLY INCOME** (after taxes) of all household members you lived with (include yourself) during your pregnancy? Please check your **BEST ESTIMATE**.

☐

\$0 to \$299

☐

\$300 to \$499

☐

\$500 to \$999

☐

\$1000 to \$1499

☐

\$1500 to \$1999

☐

\$2000 to \$2499

☐

\$2500 or more

☐

I do not know or wish to say

39. How many individuals did this total income serve (including you)?

Page 6

40. Thinking back to **JUST BEFORE** you were pregnant, how did you feel about becoming pregnant? Check only **ONE BOX**.

I wanted to be pregnant sooner.



I wanted to become pregnant later.

☐

I wanted to be pregnant then.



I did NOT want to be pregnant then, or at any time in the future.



I don't know or wish to say.

41. If we have questions about anything you have written down, could we call you? If so, please give us a number where you can be reached and when it would be convenient.

PHONE: () _____ TIME: _____

42. In case we can't reach you, would you give us the name and address of a person who would likely know where you could be reached?

NAME: _____

ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

PHONE: () _____

- 43. Would you like us to send you results of this survey?**
NOTE: Expect results sometime this fall.

11

YES

NO

44. Is there anything else you would like to tell us about yourself, your pregnancy, your baby or something in this questionnaire?

CODE: _____

It is important for you to read and sign the **CONSENT STATEMENT** below. Your doctor can tell us more about the care you and your baby received. What your doctor can tell us is also very important. All of the information we obtain will be kept strictly confidential.

CONSENT STATEMENT

I have voluntarily participated in this pregnancy survey. I give my permission for the Michigan Department of Public Health to obtain additional information about my pregnancy from the medical source listed in question 1. I understand that the Department will use this information **ONLY** for statistical purposes in health research, and no information which identifies either me or the medical source will **EVER** be released or published.

(Signature -- in INK)_____
(Today's Date)

Thank you for your help and cooperation! Please check to make sure your responses to BOTH this **QUESTIONNAIRE** and the **FOOD FREQUENCY** are completed and returned in the enclosed postage-paid envelope
at your earliest convenience.

Appendix 18

Revised Willett Semi-Quantitative Food Frequency Questionnaire

DIET ASSESSMENT

ID: _____

1. Do you currently take multiple vitamins? (Please report individual vitamins under question 2.)

☐ No ☐ Yes → If yes, a) How many do you take per week? ☐ 2 or less ☐ 6-9 ☐ 3-5 ☐ 10 or more

b) What specific brand do you usually use? _____ Specify exact brand and type

2. Not counting multiple vitamins, do you take any of the following preparations:

a) Vitamin A? ☐ No ☐ Yes, seasonal only ☐ Yes, most months If Yes, How many years? → ☐ 0-1 yr. ☐ 2-4 yrs. ☐ 5-9 yrs. ☐ 10+ yrs. ☐ Don't know What dose per day? → ☐ Less than 8,000 IU ☐ 8,000 to 12,000 IU ☐ 13,000 to 22,000 IU ☐ 23,000 IU or more ☐ Don't know

b) Vitamin C? ☐ No ☐ Yes, seasonal only ☐ Yes, most months If Yes, How many years? → ☐ 0-1 yr. ☐ 2-4 yrs. ☐ 5-9 yrs. ☐ 10+ yrs. ☐ Don't know What dose per day? → ☐ Less than 400 mg. ☐ 400 to 700 mg. ☐ 750 to 1250 mg. ☐ 1300 mg. or more ☐ Don't know

c) Vitamin B₆? ☐ No ☐ Yes → If yes, How many years? → ☐ 0-1 yr. ☐ 2-4 yrs. ☐ 5-9 yrs. ☐ 10+ yrs. ☐ Don't know What dose per day? → ☐ Less than 10 mg. ☐ 10 to 39 mg. ☐ 40 to 79 mg. ☐ 80 mg. or more ☐ Don't know

d) Vitamin E? ☐ No ☐ Yes → If yes, How many years? → ☐ 0-1 yr. ☐ 2-4 yrs. ☐ 5-9 yrs. ☐ 10+ yrs. ☐ Don't know What dose per day? → ☐ Less than 100 IU ☐ 100 to 250 IU ☐ 300 to 500 IU ☐ 600 IU or more ☐ Don't know

e) Selenium? ☐ No ☐ Yes → If yes, How many years? → ☐ 0-1 yr. ☐ 2-4 yrs. ☐ 5-9 yrs. ☐ 10+ yrs. ☐ Don't know What dose per day? → ☐ Less than 80 mcg. ☐ 80 to 130 mcg. ☐ 140 to 250 mcg. ☐ 260 mcg. or more ☐ Don't know

f) Iron? ☐ No ☐ Yes → If yes, How many years? → ☐ 0-1 yr. ☐ 2-4 yrs. ☐ 5-9 yrs. ☐ 10+ yrs. ☐ Don't know What dose per day? → ☐ Less than 51 mg. ☐ 51 to 200 mg. ☐ 201 to 400 mg. ☐ 401 mg. or more ☐ Don't know

g) Zinc? ☐ No ☐ Yes → If yes, How many years? → ☐ 0-1 yr. ☐ 2-4 yrs. ☐ 5-9 yrs. ☐ 10+ yrs. ☐ Don't know What dose per day? → ☐ Less than 25 mg. ☐ 25 to 74 mg. ☐ 75 to 100 mg. ☐ 101 mg. or more ☐ Don't know

h) Calcium? (Include Calcium in Dolomito.) ☐ No ☐ Yes → If yes, How many years? → ☐ 0-1 yr. ☐ 2-4 yrs. ☐ 5-9 yrs. ☐ 10+ yrs. ☐ Don't know What dose per day? → ☐ Less than 400 mg. ☐ 400 to 900 mg. ☐ 901 to 1300 mg. ☐ 1301 mg. or more ☐ Don't know

i) Are there other supplements that you take on a regular basis? Please mark if yes:

☐ Folic acid ☐ Cod liver Oil ☐ Iodine ☐ Beta-Carotene ☐ Other (please specify): _____

☐ Vitamin D ☐ Copper ☐ Brewer's Yeast ☐ Magnesium

☐ B-Complex Vitamins ☐ Omega-3 Fatty-acids

3. For each food listed, fill in the circle indicating how often on average you have used the amount specified during the past year.

DAIRY FOODS	AVERAGE USE LAST YEAR								
	Never, or less than once per month	1-3 per mo.	1 per week	2-4 per week	5-6 per week	1 per day	2-3 per day	4-5 per day	6+ per day
Skim or low fat milk (8 oz. glass)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Whole milk (8 oz. glass)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cream, e.g. coffee, whipped (Tbs)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sour cream (Tbs)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Non-dairy coffee whitener (tsp.)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sherbet or ice milk (½ cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ice cream (½ cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Yogurt (1 cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cottage or ricotta cheese (½ cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cream cheese (1 oz.)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other cheese, e.g. American, cheddar, etc., plain or as part of a dish (1 slice or 1 oz. serving)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Margarine (pat), added to food or bread; exclude use in cooking	☐	☐	☐	☐	☐	☐	☐	☐	☐
Butter (pat), added to food or bread; exclude use in cooking	☐	☐	☐	☐	☐	☐	☐	☐	☐

Please turn to page 2

3. (Continued) Please fill in your average use,
during the past year, of each specified food.

Please try to
average your
seasonal use
of foods over
the entire year.
For example, if
a food such as
cantaloupe is
eaten 4 times a
week during the
approximate 3
months that it is
in season, then
the average use
would be once
per week.

	Never, or less than once per month	1-3 per mo.	1 per week	2-4 per week	5-6 per week	1 per day	2-3 per day	4-5 per day	6+ per day	P
FRUITS										
Raisins (1 oz. or small pack) or grapes	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Prunes (1/2 cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bananas (1)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cantaloupe (1/4 melon)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Watermelon (1 slice)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Fresh apples or pears (1)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Apple juice or cider (small glass)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Oranges (1)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Orange juice (small glass)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Grapefruit (1/2)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Grapefruit juice (small glass)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other fruit juices (small glass)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Strawberries, fresh, frozen or canned (1/2 cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Blueberries, fresh, frozen or canned (1/2 cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Peaches, apricots or plums (1 fresh, or 1/2 cup canned)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

	Never, or less than once per month	1-3 per mo.	1 per week	2-4 per week	5-6 per week	1 per day	2-3 per day	4-5 per day	6+ per day	P
VEGETABLES										
Tomatoes (1)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Tomato juice (small glass)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Tomato sauce (1/2 cup) e.g. spaghetti sauce	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Red chili sauce (1 Tbs)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Tofu or soybeans (3-4 oz.)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
String beans (1/2 cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Broccoli (1/2 cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cabbage or cole slaw (1/2 cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cauliflower (1/2 cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Brussels sprouts (1/2 cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Carrots, raw (1/2 carrot or 2-4 sticks)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Carrots, cooked (1/2 cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Corn (1 ear or 1/2 cup frozen or canned)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Peas, or lima beans (1/2 cup fresh, frozen, canned)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mixed vegetables (1/2 cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Beans or lentils, baked or dried (1/2 cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Yellow (winter) squash (1/2 cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Eggplant, zucchini, or other summer squash (1/2 cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Yams or sweet potatoes (1/2 cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Spinach, cooked (1/2 cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Spinach, raw as in salad	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Kale, mustard or chard greens (1/2 cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Iceberg or head lettuce (serving)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Romaine or leaf lettuce (serving)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Celery (4" stick)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Beets (1/2 cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Alfalfa sprouts (1/2 cup)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Garlic, fresh or powdered (1 clove or shake)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

	Never, or less than once per month	1-3 per mo.	1 per week	2-4 per week	5-6 per week	1 per day	2-3 per day	4-5 per day	6+ per day	P
EGGS, MEAT, ETC.										
Eggs (1)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Chicken or turkey, with skin (4-6 oz.)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Chicken or turkey, without skin (4-6 oz.)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bacon (2 slices)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Hot dogs (1)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Please go
to page 3

3. (Continued) Please fill in your average use, during the past year, of each specified food.

	Never, or less than once per month	1-3 per mo.	1 per week	2-4 per week	5-6 per week	1 per day	2-3 per day	4-5 per day	6+ per day
MEATS (CONTINUED)									
Processed meats, e.g. sausage, salami, bologna, etc. (piece or slice)	☐	☐	☒	☐	☐	☐	☐	☐	☐
Liver (3-4 oz.)	☐	☐	☒	☐	☐	☐	☐	☐	☐
Hamburger (1 patty)	☐	☐	☒	☐	☐	☐	☐	☐	☐
Beef, pork, or lamb as a sandwich or mixed dish, e.g. stew, casserole, lasagne, etc.	☐	☐	☒	☐	☐	☐	☐	☐	☐
Beef, pork, or lamb as a main dish, e.g. steak, roast, ham, etc. (4-6 oz.)	☐	☐	☒	☐	☐	☐	☐	☐	☐
Canned tuna fish (3-4 oz.)	☐	☐	☒	☐	☐	☐	☐	☐	☐
Dark meat fish, e.g. mackerel, salmon, sardines, bluefish, swordfish (3-5 oz.)	☐	☐	☒	☐	☐	☐	☐	☐	☐
Other fish (3-5 oz.)	☐	☐	☒	☐	☐	☐	☐	☐	☐
Shrimp, lobster, scallops as a main dish	☐	☐	☒	☐	☐	☐	☐	☐	☐

	Never, or less than once per month	1-3 per mo.	1 per week	2-4 per week	5-6 per week	1 per day	2-3 per day	4-5 per day	6+ per day
BREADS, CEREALS, STARCHES									
Cold breakfast cereal (1 cup)	☐	☐	☒	☐	☐	☐	☐	☐	☐
Cooked oatmeal (1 cup)	☐	☐	☒	☐	☐	☐	☐	☐	☐
Other cooked breakfast cereal (1 cup)	☐	☐	☒	☐	☐	☐	☐	☐	☐
White bread (slice), including pita bread	☐	☐	☒	☐	☐	☐	☐	☐	☐
Dark bread (slice)	☐	☐	☒	☐	☐	☐	☐	☐	☐
English muffins, bagels, or rolls (1)	☐	☐	☒	☐	☐	☐	☐	☐	☐
Muffins or biscuits (1)	☐	☐	☒	☐	☐	☐	☐	☐	☐
Brown rice (1 cup)	☐	☐	☒	☐	☐	☐	☐	☐	☐
White rice (1 cup)	☐	☐	☒	☐	☐	☐	☐	☐	☐
Pasta, e.g. spaghetti, noodles, etc. (1 cup)	☐	☐	☒	☐	☐	☐	☐	☐	☐
Other grains, e.g. bulgar, kasha, couscous, etc. (1 cup)	☐	☐	☒	☐	☐	☐	☐	☐	☐
Pancakes or waffles (serving)	☐	☐	☒	☐	☐	☐	☐	☐	☐
French fried potatoes (4 oz.)	☐	☐	☒	☐	☐	☐	☐	☐	☐
Potatoes, baked, boiled (1) or mashed (1 cup)	☐	☐	☒	☐	☐	☐	☐	☐	☐
Potato chips or corn chips (small bag or 1 oz.)	☐	☐	☒	☐	☐	☐	☐	☐	☐
Crackers, Triskets, Wheat Thins (1)	☐	☐	☒	☐	☐	☐	☐	☐	☐
Pizza (2 slices)	☐	☐	☒	☐	☐	☐	☐	☐	☐

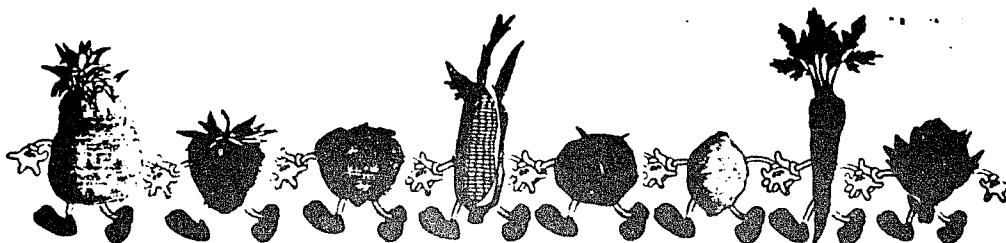
		Never, or less than once per month	1-3 per mo.	1 per week	2-4 per week	5-6 per week	1 per day	2-3 per day	4-5 per day	6+ per day
BEVERAGES										
CARBONATED BEVERAGES	Low Calorie (sugar-free) types	Low calorie cola, e.g. Tab with caffeine	☐	☐	☒	☐	☐	☐	☐	☐
		Low calorie caffeine-free cola, e.g. Pepsi Free	☐	☐	☒	☐	☐	☐	☐	☐
		Other low calorie carbonated beverage, e.g. Fresca, Diet 7-Up, diet ginger ale	☐	☐	☒	☐	☐	☐	☐	☐
	Regular types (not sugar-free)	Coke, Pepsi, or other cola with sugar	☐	☐	☒	☐	☐	☐	☐	☐
		Caffeine Free Coke, Pepsi, or other cola with sugar	☐	☐	☒	☐	☐	☐	☐	☐
		Other carbonated beverage with sugar, e.g. 7-Up, ginger ale	☐	☐	☒	☐	☐	☐	☐	☐
OTHER BEVERAGES	Hawaiian Punch, lemonade, or other non-carbonated fruit drinks (1 glass, bottle, can)	☐	☐	☒	☐	☐	☐	☐	☐	☐
	Decaffeinated coffee (1 cup)	☐	☐	☒	☐	☐	☐	☐	☐	☐
	Coffee (1 cup)	☐	☐	☒	☐	☐	☐	☐	☐	☐
	Tea (1 cup), not herbal teas	☐	☐	☒	☐	☐	☐	☐	☐	☐
	Beer (1 glass, bottle, can)	☐	☐	☒	☐	☐	☐	☐	☐	☐
	Red wine (4 oz. glass)	☐	☐	☒	☐	☐	☐	☐	☐	☐
	White wine (4 oz. glass)	☐	☐	☒	☐	☐	☐	☐	☐	☐
	Liquor, e.g. whiskey, gin, etc. (1 drink or shot)	☐	☐	☒	☐	☐	☐	☐	☐	☐

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ID:	3. (Continued) Please fill in your average use during the past year, of each specified food.												4. How much of the visible fat on your meats do you remove before eating?												5. What kind of fat do you usually use for frying and sautéing? (Exclude "Pam"-type spray)												6. What kind of fat do you usually use for baking?												7. What form of margarine do you usually use?												8. How often do you eat food that is fried at home? (Exclude the use of "Pam"-type spray)												9. How often do you eat fried food away from home? (e.g. french fries, fried chicken, fried fish)											
	0	1	2	3	4	5	6	7	8	9	Never, at less than once per month	1-3 per week	1 per week	2-4 per week	5-6 per week	1 per day	2-3 per day	4-5 per day	6+ per day	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9					
	SWEETS, BAKED GOODS, MISCELLANEOUS												☐ Remove small part of fat												☐ Real butter												☐ None												☐ Daily																																			
	Chocolate (bars or pieces) e.g. Hershey's, M&M's												☐ Remove all visible fat												☐ Margarine												☐ Stick												☐ 1-3 times per week																																			
	Candy bars, e.g. Snickers, Milky Way, Reeses												☐ Remove majority												☐ Vegetable oil												☐ Low-calorie stick												☐ 4-6 times per week																																			
	Candy without chocolate (1 oz.)												☐ (Don't eat meat)												☐ Vegetable shortening												☐ Low-calorie tub												☐ Less than once a week																																			
	Cookies, home baked (1)																								☐ Lard																																																											
	Cookies, ready made (1)																								☐ Real butter																																																											
	Brownies (1)																								☐ Margarine																																																											
	Doughnuts (1)																								☐ Vegetable oil																																																											
	Cake, home baked (slice)																								☐ Vegetable shortening																																																											
	Cake, ready made (slice)																								☐ Low-calorie shortening																																																											
	Sweet roll, coffee cake or other pastry, home baked (serving)																								☐ Spread																																																											
	Sweet roll, coffee cake or other pastry, ready made (serving)																								☐ Low-calorie tub																																																											
	Pie, homemade (slice)																								☐ Lard																																																											
	Pie, ready made (slice)																								☐ Real butter																																																											
	Jams, jellies, preserves, syrup, or honey (1 Tbs)																								☐ Margarine																																																											
	Peanut butter (Tbs)																								☐ Vegetable oil																																																											
	Popcorn (1 cup)																								☐ Vegetable shortening																																																											
	Nuts (small packet or 1 oz.)																								☐ Spread																																																											
	Bran, added to food (1 Tbs)																								☐ Low-calorie stick																																																											
	Wheat germ (1 Tbs)																								☐ Low-calorie tub																																																											
	Chowder or cream soup (1 cup)																								☐ Lard																																																											
	Oil and vinegar dressing, e.g. Italian (1 Tbs)																								☐ Real butter																																																											
	Mayonnaise or other creamy salad dressing (1 Tbs)																								☐ Margarine																																																											
	Mustard, dry or prepared (1 tsp)																								☐ Vegetable oil																																																											
	Pepper (1 shake)																								☐ Vegetable shortening																																																											
	Salt (1 shake)																								☐ Spread																																																											
																									☐ Low-calorie stick																																																											
																									☐ Low-calorie tub																																																											
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Appendix 19

Instructions for the Willett Semi-Quantitative Food Frequency Questionnaire



FOOD QUESTIONNAIRE DIRECTIONS

This form asks about your usual food intake **during your recent pregnancy**. It takes about 20 minutes to complete. Please follow these instructions. If you have any questions, call Carol Friesen collect at (517) 351-8334, and she will be happy to help you.

1. Answer each question as best you can--estimate if you aren't sure.
2. Use **ONLY** the enclosed pencil or any other #2 pencil.
DO NOT USE INK.
3. Be certain to completely blacken in each of your answers, and erase completely if you make any changes. Keep any hand-written words within the border of the respondent box.
4. Do not make any other marks on this form.
5. If you wish to make comments, please use a separate piece of paper.
6. Start the questionnaire where you see:

**START
HERE**



You have already provided the vitamin and mineral information, so it is not necessary to answer the first two questions.

EXAMPLE: Do you live in the United States?

☐ NO ☒ YES
(fill circle completely)

Appendix 20
Physician's Prenatal Care Survey

PATIENT NAME: _____

DELIVERY DATE: _____

CODE NO: _____

PHYSICIAN PREGNANCY SURVEY

DIRECTIONS: Please complete the following questions for the patient listed above. If the information is **NOT AVAILABLE**, please record "NA"; do not leave the space blank.

1. What is this patient's **HEIGHT**, without shoes? _____ ft _____ in
2. What weight gain recommendation, if any, did you suggest to this patient during her pregnancy? _____ lbs
3. Please record the woman's **HIGHEST** and **LOWEST** hemoglobin and/or hematocrit values you measured during her pregnancy.

	WEEK OF GESTATION (estimated)	HEMATOCRIT (%)	HEMOGLOBIN (g/dL)
Highest Iron Value			
Lowest Iron Value			

4. Please record the woman's **HIGHEST** and **LOWEST** diastolic blood pressures recorded during her pregnancy. Approximately how long do you estimate these peak and trough values last?

	WEEK OF GESTATION (estimated)	DIASTOLIC PRESSURE	ESTIMATED WEEKS AT THIS DBP
Highest Diastolic			
Lowest Diastolic			

5. What was the woman's **PRE-PREGNANCY WEIGHT**? _____ lbs
(Please make a good estimate, if the actual value is not recorded.)
6. What is the **FIRST** pregnant weight recorded for this woman? _____ lbs

7. Approximately how far into the pregnancy was this? _____ weeks
8. What is the **LAST** recorded weight for this woman during this pregnancy? _____ lbs
9. Approximately how many days after this weight was recorded did the woman deliver? _____ days
10. It would be extremely helpful if you could provide **ALL** of the weights charted for this woman. This information would significantly enhance the results of this study.

WEIGHT	ESTIMATED WK. GESTATION

WEIGHT	ESTIMATED WK. GESTATION

11. Are there any other observations or comments you would like to make about any factor(s) which, in your opinion, influenced this woman's pregnancy outcome?

Please record the name, degree and telephone number of the person completing this questionnaire so that if clarifications are needed, the appropriate individual may be contacted.

NAME: _____

PHONE: (____) _____

Thank you for your cooperation. Please return in the enclosed postage-paid envelope at your earliest convenience.

Appendix 21

First Letter to Michigan Mothers

STATE OF MICHIGAN



JAMES J. BLANCHARD, Governor

999

DEPARTMENT OF PUBLIC HEALTH

June 9, 1989

Jane E. Doe
 2005 Southview Blvd.
 East Lansing, MI 48823

3423 N. LOGAN
 P.O. BOX 30195, LANSING, MICHIGAN 48909

Dear mother of Beatrice Doe:

We are inviting you to participate in a statewide research project. Its purpose is to help us better understand women's attitudes, actions and health care during pregnancy. This information will be used to improve services to pregnant women and infants.

You are one of a small number of women statewide who have been scientifically selected to be in this survey. To participate, just complete the enclosed questionnaire and food frequency form and return them in the postage-paid envelope provided. To thank you for your help, we have enclosed a bib for your baby courtesy of Gerber's and a copy of "A Food Guide for the First Five Years", courtesy of the Michigan Beef Council. We hope you enjoy these gifts.

The questions in this survey ask about your recent pregnancy with Beatrice. If Beatrice is not alive, we realize that it might be painful for you to answer some of these questions. However, we believe that by doing so, you might provide information that could help some other woman or baby in the future.

Please complete the questionnaire and return it in the enclosed envelope. The Michigan Department of Public Health will use this information only for statistical purposes; no information identifying you or your baby will ever be published. The questionnaire has an identification number for mailing purposes only. This number will allow us to check your name off our mailing list when your questionnaire is returned. Your participation is voluntary and your refusal to answer some or all of the questions will not result in any penalty or loss of services or benefits from the Michigan Department of Public Health.

If you have any further questions regarding this project, or if you would prefer a telephone interview, please call our Project Coordinator, Carol Friesen, collect at (517) 351-8334.

We hope you will accept our request to be in this study.

Sincerely,

George H. Van Amburg, MPH
 State Registrar and Chief
 Office of the State Registrar
 and Center for Health Statistics

George H. Baker, MD
 Chief, Office of Maternal and
 Child Health

Appendix 22

Second Letter to Michigan Mothers

STATE OF MICHIGAN



JAMES J. BLANCHARD, Governor

DEPARTMENT OF PUBLIC HEALTH

3423 N. LOGAN

P.O. BOX 30195, LANSING, MICHIGAN 48909

999

July 7, 1989

Jane E. Doe
2005 Southview Blvd.
East Lansing, MI 48823

Dear mother of Beatrice Doe:

About three weeks ago, we invited you to participate in a statewide research project. Its purpose is to gain a better understanding of the health care that women receive during their pregnancy and their attitudes and actions during this time. The information you provide can help women and babies in the future.

As mentioned in our previous letter, you are one of a small number of women statewide who have been scientifically selected to be in this survey. If you agree to participate, all you have to do is complete the enclosed questionnaire and food frequency form and return them in the postage-paid, return envelope provided. The questions in this survey ask about your recent pregnancy with Beatrice.

If you have returned the questionnaire in the past few days, we appreciate it very much. If you have not, please complete the questionnaire and return it in the enclosed envelope. The Michigan Department of Public Health will use this information only for statistical purposes; no information that identifies you or your baby will ever be published. The questionnaire has an identification number for mailing purposes only. This number will allow us to check your name off our mailing list when your questionnaire is returned.

Your participation is voluntary and your refusal to answer some or all of the questions will not result in any penalty or loss of services or benefits from the Michigan Department of Public Health.

If you have any further questions regarding this project, or if you would prefer a telephone interview, please call our Project Coordinator, Carol Friesen, collect at (517) 351-8334 evenings and weekends.

We truly hope you will accept our request to be in this study.

Sincerely,

George H. Van Amburg, MPH
State Registrar and Chief
Office of the State Registrar
and Center for Health Statistics

George H. Baker, MD
Chief, Office of Maternal and
Child Health



Appendix 23

Letter Requesting the Subject to Complete the
Survey or Food Frequency Questionnaire

STATE OF MICHIGAN



JAMES J. BLANCHARD, Governor

DEPARTMENT OF PUBLIC HEALTH

3423 N. LOGAN
P.O. BOX 30195, LANSING, MICHIGAN 48909

August 2, 1989

Dear Beatrice:

Thank you so much for filling out the pregnancy survey sent to you recently from the Michigan Department of Public Health. I appreciate your response!

I noticed you did not complete the last page of the food frequency questionnaire. Perhaps it was an oversight? I know it gets to be pretty long, but I sure would appreciate it if you could complete the last page and return it to me in the enclosed envelope. Thank you so much.

I hope you are having a good summer.

Sincerely,

Carol A. Friesen, M.S., R.D.
Pregnancy Project Coordinator
Michigan Department of Public Health

P.S. If you want to talk to me about this, call collect during the evenings or weekends at (517) 351-8334.

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Appendix 24

Letter Requesting Subject's Reconsideration
to Sign the Physician's Release Form

STATE OF MICHIGAN



JAMES J. BLANCHARD, Governor

DEPARTMENT OF PUBLIC HEALTH

3423 N. LOGAN
P.O. BOX 30195, LANSING, MICHIGAN 48909

August 21, 1989

Dear Beatrice:

Thank you so much for filling out the pregnancy survey sent to you recently from the Michigan Department of Public Health. I appreciate your response!

I noticed you did not sign the consent form which would allow me to contact your prenatal care provider. I thought that if I sent you a copy of the physician's questionnaire that, perhaps, you might reconsider. I am primarily interested in your rate of weight gain, your diastolic blood pressure and your iron levels during pregnancy. I hope you will reconsider not signing the consent form knowing specifically what your doctor will be asked about your pregnancy.

Of course, if you still prefer not to allow your doctor to provide me with the above information, I will comply with your wishes. I would appreciate it, however, if you could sign the consent form and return it to me in the enclosed envelope.

I hope you are having a good summer!

Sincerely,

Carol A. Friesen, M.S., R.D.
Pregnancy Project Coordinator
Michigan Department of Public Health

P.S. If you want to talk to me about this, call collect during the evenings or weekends at (517) 351-8334.

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Appendix 25

First Letter Sent to White Subjects' Physicians

STATE OF MICHIGAN



JAMES J. BLANCHARD, Governor

999

DEPARTMENT OF PUBLIC HEALTH

August 8, 1989

3423 N. LOGAN

P.O. BOX 30195, LANSING, MICHIGAN 48909

Thomas Lowe, M.D.

Westview Clinic

100 Southview Blvd.

East Lansing, MI 48823

Dear Dr. Lowe:

Your assistance is needed in a statewide research project conducted by the Michigan Department of Public Health. The purposes of the study are: 1) to determine if the attainment of a specific percentage of a woman's desirable body weight is associated with successful fetal outcome, and 2) to identify and quantify factors associated with low birth weight (LBW) in Michigan. Identification of factors contributing to, and the prevention of, LBW has become a priority public health concern of the Department.

You were identified as being the prenatal health care provider of Jane E. Doe, who provided us with your name and address. She has authorized you to provide us with information from her medical records about her pregnancy with Beatrice Doe. All information you report will be kept strictly confidential. No information which identifies either you or the patient will be released. Your participation is voluntary. The director of public health has declared this a medical research project under the provision of MCL 333.2631-333.2635. As such, any information shared with us is not subject to disclosure. The data collected will be used in program planning and epidemiological research to be published in professional journals.

Because this survey is based on a small random sample of Michigan women, it is important that we obtain as much information as possible on all women in this study. Due to the limited number of physicians delivering babies in Michigan, you may have delivered more than five randomly selected subjects. If so, we would appreciate it if you would fill out five surveys. However, we would be grateful if you would complete as many as you receive.

We would appreciate it if you, or one of your staff, would complete the questionnaire and return it in the enclosed envelope at your earliest convenience. If you should have any questions, please call the Project Coordinator, Carol Friesen, at (517) 351-8334. Your cooperation is greatly appreciated.

Sincerely,

Sincerely,

George Van Amburg, MPH
State Registrar & Chief
Office of the State Registrar
and Center for Health Statistics

George H. Baker, Jr., M.D.
Chief, Office of Maternal and
Child Health

Appendix 26

Second Letter Sent to White Subjects' Physicians

STATE OF MICHIGAN



JAMES J. BLANCHARD, Governor

DEPARTMENT OF PUBLIC HEALTH

3423 N. LOGAN
P.O. BOX 30195, LANSING, MICHIGAN 48909

999

September 1, 1989

Thomas Lowe, M.D.
Westview Clinic
100 Southview Blvd.
East. Lansing, MI 48823

Dear Dr. Lowe:

A few weeks ago we mailed you a letter requesting your assistance in a statewide research project conducted by the Michigan Department of Public Health. The purposes of the study are: 1) to determine if the attainment of a specific percentage of a woman's desirable body weight is associated with successful fetal outcome, and 2) to identify and quantify factors associated with low birth weight (LBW) in Michigan. If you recently returned the survey, please accept our thanks. If not, we would appreciate it if you, or someone in your office, would assist us in this project by completing the survey and returning it as soon as possible. Your response is very important to us.

You were identified as the prenatal health care provider of Jane E. Doe, who provided us with your name and address. She has authorized you to provide us with information from her medical records about her pregnancy with Beatrice Doe. All information you report will be kept strictly confidential. No information identifying either you or the patient will be released. Your participation is voluntary. The director of public health has declared this a medical research project under the provision of MCL 333.2631-333.2635. As such, any information shared with us is not subject to disclosure. The data collected will be used in program planning and epidemiological research to be published in professional journals.

Because this survey is based on a small random sample of Michigan women, it is important that we obtain as much information as possible on all women in this study. We would appreciate it if you, or one of your staff, would complete the questionnaire and return it in the enclosed envelope at your earliest convenience. If you should have any questions, please call the Project Coordinator, Carol Friesen, at (517) 351-8334. Thank you for your cooperation.

Sincerely,

Sincerely,

George Van Amburg, MPH
State Registrar & Chief
Office of the State Registrar

George H. Baker, Jr., M.D.
Chief, Office of Maternal and
Child Health

Appendix 27

First Letter Sent to Black Subjects' Physicians

STATE OF MICHIGAN



JAMES J. BLANCHARD, Governor

999

DEPARTMENT OF PUBLIC HEALTH

July 28, 1989

Thomas Lowe, M.D.
Westview Clinic
100 Southview Blvd.
East Lansing, MI 48823

3423 N. LOGAN
P.O. BOX 30195, LANSING, MICHIGAN 48909

Dear Dr. Lowe:

Your assistance is needed in a statewide research project conducted by the Michigan Department of Public Health. The purposes of the study are: 1) to determine if the attainment of a specific percentage of a woman's desirable body weight is associated with successful fetal outcome, and 2) to identify and quantify factors associated with low birth weight (LBW) in Michigan. Because Michigan ranks second only to the District of Columbia in the incidence of low birth weight (LBW), identification of factors contributing to, and the prevention of, LBW has become a priority public health concern of the Department.

You were identified as the physician who delivered Beatrice Doe, the baby of Jane E. Doe, born April 10, 1988. Jane E. Doe was randomly selected to be in this research study. No information which identifies either you or the patient will be released. Your participation is voluntary. The director of public health has declared this a medical research project under the provision of MCL 333.2631-333.2635. As such, any information shared with us is not subject to disclosure. The data collected will be used in program planning and epidemiological research to be published in professional journals. This survey is based on a small random sample of Michigan women, thus it is important that we obtain as much information as possible on all women in this study. Because of the limited number of physicians delivering babies in Michigan, you may have been the physician of record for more than five randomly selected subjects. We would appreciate it if you would fill out five of the surveys. However, we would be grateful if you would complete as many as you receive.

We would appreciate it if you, or one of your staff, would complete the questionnaire and return it in the enclosed envelope at your earliest convenience. If you should have any questions, please call the Project Coordinator, Carol Friesen, at (517) 351-8334. If you did not see Jane E. Doe for her prenatal care, but know who did, we would appreciate obtaining that individual's name and address. If you do not know where her care was obtained, please indicate this on the survey and return it in the enclosed envelope.

Your cooperation is greatly appreciated.

Sincerely,

Sincerely,

George Van Amburg, MPH
State Registrar & Chief
Office of the State Registrar
and Center for Health Statistics

George H. Baker, Jr., M.D.
Chief, Office of Maternal and
Child Health



Appendix 28

Second Letter Sent to Black Subjects' Physicians

STATE OF MICHIGAN



JAMES J. BLANCHARD, Governor

999

DEPARTMENT OF PUBLIC HEALTH

September 1, 1989

Thomas Lowe, M.D.
Westview Clinic
100 Southview Blvd.
East Lansing, MI 48823

3423 N. LOGAN
P.O. BOX 30195, LANSING, MICHIGAN 48909

Dear Dr. Lowe:

A few weeks ago we sent a letter requesting your assistance in a statewide research project conducted by the Michigan Department of Public Health. The purposes of the study are: 1) to determine if the attainment of a specific percentage of a woman's desirable body weight is associated with successful fetal outcome, and 2) to identify and quantify factors associated with low birth weight (LBW) in Michigan. Both LBW infants (cases) and controls are included in this study. If you recently returned the survey, please accept our sincere thanks. If not, we would appreciate it if you, or one of your staff, would complete the survey and return it at your earliest convenience. Your response is important to us. If the subject's social security number would assist you in pulling this patient's records, please call the project coordinator, Carol Friesen, at (517) 351-8334, and she can obtain it for you.

You were identified as the physician who delivered Beatrice Doe, the baby of Jane E. Doe, born April 10, 1988. Jane E. Doe was randomly selected to be in this research study. No information which identifies either you or the patient will be released. Your participation is voluntary. The director of public health has declared this a medical research project under the provision of MCL 333.2631-333.2635. As such, any information shared with us is not subject to disclosure. The data collected will be used in program planning and epidemiological research to be published in professional journals. This survey is based on a small random sample of Michigan women, thus it is important that we obtain as much information as possible on all women in this study.

We would appreciate it if you, or one of your staff, would complete the questionnaire and return it in the enclosed envelope at your earliest convenience. If you should have any questions, please call the Project Coordinator, Carol Friesen, at (517) 351-8334. If you did not see Jane E. Doe for her prenatal care, but know who did, we would appreciate obtaining that individual's name and address. If you do not know where her care was obtained, please indicate this on the survey and return it in the enclosed envelope.

Your cooperation is greatly appreciated.

Sincerely,

Sincerely,

George Van Amburg, MPH
State Registrar & Chief
Office of the State Registrar
and Center for Health Statistics

George H. Baker, Jr., M.D.
Chief, Office of Maternal and
Child Health



Appendix 29
Supporting Statistical Analysis

Appendix 29-1

Response rate to the Michigan Mother's Survey by wave.

Group	First Wave	Second Wave	Telephone Contact	Look-Up Unit	Surveys Received
	n (%) [*]	n (%)	n (%)	n (%)	n
LBW	139 (81)	28 (16)	3 (2)	1 (1)	171
MBW	37 (82)	7 (16)	- -	1 (2)	45
OBW	146 (79)	38 (21)	- -	- -	184
TOTAL	322 (80)	73 (18)	3 (1)	2 (1)	400

* Percent of total surveys received within each group.

Appendix 29-2a

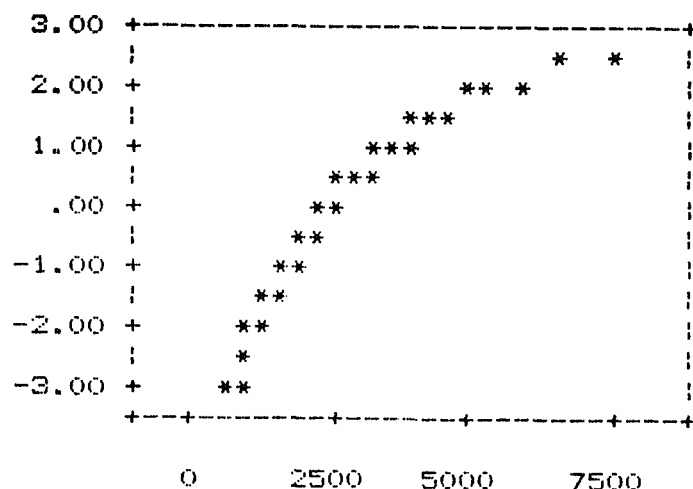
Stemleaf plot of calorie distribution prior to applying
any exclusion criteria (n=380).

CALORIES

Valid cases: 380.0 Missing cases: .0

Mean	2451.828	Std Err	46.5255	Min	629.8800
Median	2299.260	Variance	822556.7	Max	7493.890
5% Trim	2395.541	Std Dev	906.9491	Range	6864.010
				IQR	1046.255

Frequency	Stem &	Leaf
9.00	0 .	789%
28.00	1 *	012333444
90.00	1 .	555566666677778888888888999999
102.00	2 *	0000000011111111222233333333444444
67.00	2 .	555556666667777888888999
42.00	3 *	000111122233344
21.00	3 .	5677889
9.00	4 *	023%
11.00	Extremes	(4541), (4679), (4937), (5063), (5153), (5913)
1.00	Extremes	(6444), (7494)



Skewness	1.3079
S E Skew	.1252
Kurtosis	3.5707
S E Kurt	.2497

Normal Plot

Appendix 29-2b

Stemleaf and normal plot of calorie distribution after applying the exclusion criterion of greater than 4,500 calories and less than 600 calories (n=368).

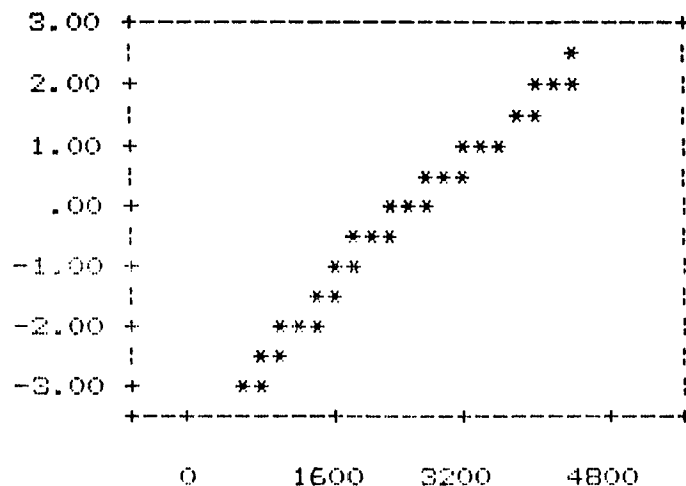
CALORIES

Valid cases: 368.0

Mean	2359.782	Std Err	38.8700	Min	629.9800
Median	2247.210	Variance	556003.6	Max	4443.730
5% Trim	2341.040	Std Dev	745.6565	Range	3813.850
				IQR	1011.298

CALORIES

Frequency	Stem &	Leaf
9.00	0 .	789%
28.00	1 *	012333444
90.00	1 .	55556666667777888888888999999
102.00	2 *	0000000011111111222233333344444
67.00	2 .	555566666777788888999
42.00	3 *	000111122233344
21.00	3 .	5677889
7.00	4 *	02%
2.00	Extremes	(4370), (4444)



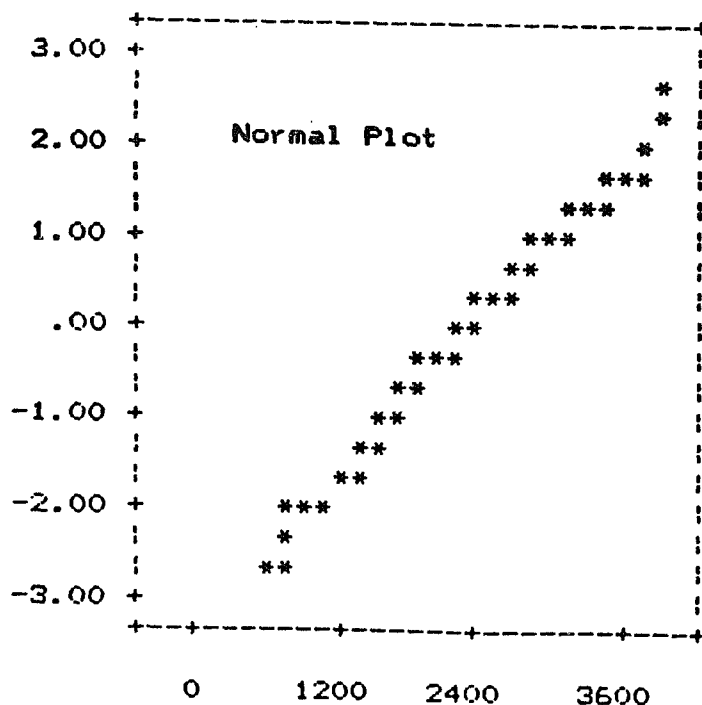
Skewness	.4449
S E Skew	.1272
Kurtosis	-.0407
S E Kurt	.2537

Normal Plot

Appendix 29-2c

Stemleaf and normal plot of calorie distribution after applying the exclusion criterion of greater than 4,000 calories and less than 600 (n=359).

Frequency	Stem &	Leaf
4.00	0 s	7&
5.00	0 .	89
6.00	1 *	01
13.00	1 t	223333
20.00	1 f	444455555
32.00	1 s	666666666777777
47.00	1 .	88888888888888999999999
51.00	2 *	0000000000011111111111111
33.00	2 t	2222233333333333
34.00	2 f	44444444455555555
27.00	2 s	6666666677777
24.00	2 .	888888899999
20.00	3 *	000011111
17.00	3 t	22223333
9.00	3 f	4455
7.00	3 s	677
10.00	3 .	88899



Mean	2312.751
Median	2226.150
5% Trim	2303.438
Std Err	36.5226
Variance	478870.3
Std Dev	692.0046
Min	629.8800
Max	3971.840
Range	3341.960
IQR	937.2600
Skewness	.2653
S E Skew	.1287
Kurtosis	-.2747
S E Kurt	.2568

Appendix 29-3

Effect of problems in locating the prenatal care provider of the white consenters on the response rate to the Prenatal Care Survey.

Physicians of White Consenters	Total Number of Problems	Number of Problems Solved (%)
LBW	12	6 (50)
MBW	7	4 (57)
OBW	13	7 (54)
TOTAL	32	17 (53)

Appendix 29-4a

Comparison of White LBW Responders and Non-Responders:
Birth Certificate Date by Oneway ANOVA.

Variable	LOW BIRTH WEIGHT		t	p
	Responders (n=169)	Non-Responders (n=119)		
<u>SIGNIFICANT DIFFERENCES</u>				
Mother's education, yrs	12.7±2.0	12.1±1.8	2.84	.0049
Month prenatal care began	2.4±1.2	3.2±2.0	4.07	.0001
Number of prenatal visits	11.7±3.4	10.3±4.0	3.16	.0017
Fathers education, yrs	13.0±1.8	12.5±1.8	2.04	.0429
<u>NOT SIGNIFICANTLY DIFFERENT</u>				
Birth weight	2187±309	2172±305	0.41	.6824
Mothers age, yrs	25.8±3.8	25.0±3.9	1.79	.0740
Weeks gestation	38.6±1.5	38.9±1.6	1.82	.0693
Previous child	0.4±0.5	0.4±0.5	0.32	.7448
Fathers age, yrs	28.6±4.5	28.1±5.4	0.82	.4093
1 minute Apgar	7.4±1.8	7.5±1.8	0.28	.7741
5 minute Apgar	8.7±1.1	8.7±0.8	0.26	.7887

Appendix 29-4b

Comparison of Birth Certificate Data of White LBW
 Responders and Non-Responders: Chi-Square Analysis^a.

Variable	LOW BIRTH WEIGHT		X ²	p
	Responders (n=169)	Non-Responders (n=119)		
<u>SIGNIFICANT DIFFERENCES</u>				
Named Parent				
One parent named	20	34	11.2	.0008
Both parents named	149	85		
Kessner Index				
Adequate	132	73	15.2	.0005
Intermediate	33	31		
Inadequate	4	15		
<u>NOT SIGNIFICANTLY DIFFERENT</u>				
Sex of Infant				
Male	71	61	2.03	.15
Female	98	58		
Complications of Pregnancy				
Yes	30	21	.0006	.94
No	135	98		
Concurrent Illness				
Yes	7	7	.15	.69
No	159	110		
Complications Labor/Delivery				
Yes	65	43	.11	.75
No	100	74		
Attendant (MD or DO)				
MD	143	103	.19	.66
DO	26	16		

^aafter Yates correction.

Appendix 29-4c

Comparison of White OBW Responders and Non-Responders:
Birth Certificate Date by Oneway ANOVA.

Variable	OPTIMAL BIRTH WEIGHT Responders (n=184)	Non-Responders (n=66)	t	p
<u>SIGNIFICANT DIFFERENCES</u>				
Mother's education, yrs	13.5±2.0	12.2±2.0	4.53	.0000
Month prenatal care began	2.4±1.2	2.7±1.4	2.02	.0464
Fathers education, yrs	13.8±2.0	12.6±2.1	3.81	.0002
<u>NOT SIGNIFICANTLY DIFFERENT</u>				
Birth weight	3761±143	3732±148	1.38	.1698
Mothers age, yrs	26.9±3.4	26.0±3.8	1.75	.0819
Number prenatal visits	12.3±2.8	11.8±3.6	1.26	.2086
Weeks gestation	40.0±1.1	39.9±1.3	0.72	.4711
Fathers age, yrs	29.6±5.0	28.7±4.7	1.16	.2469
1 minute Apgar	8.1±1.1	8.3±1.0	1.06	.2898
5 minute Apgar	9.1±0.4	9.2±0.6	1.87	.0628

Appendix 29-4d

Comparison of Birth Certificate Data of White OBW
Responders and Non-Responders: Chi-Square Analysis^a.

Variable	OPTIMAL BIRTH WEIGHT		X ²	p
	Responders (n=184)	Non-Responders (n=66)		
<u>SIGNIFICANT DIFFERENCES</u>				
none				
<u>NOT SIGNIFICANTLY DIFFERENT</u>				
Named Parent				
One parent named	10	7	1.3	.2515
Both parents named	174	59		
Kessner Index				
Adequate	156	47	5.9	.0534
Intermediate	22	15		
Inadequate	6	4		
Sex of Infant				
Male	111	41	0.11	.912
Female	73	25		
Complications of Pregnancy				
Yes	8	7	2.35	.125
No	176	59		
Concurrent Illness				
Yes	7	1	0.25	.620
No	177	65		
Complications Labor/Delivery				
Yes	47	15	0.08	.770
No	137	51		
Attendant (MD or DO)				
MD	160	55	0.27	.60
DO	24	11		

^aafter Yates correction.

Appendix 29-5

Birth weight by percent of 1983 Metropolitan Reference weight attained
at term by maternal stature (short, medium, tall).

% 1983 Metropolitan Term Reference Weight		Short (≤ 62 ")	Medium (62.5-65.5")	Tall (≥ 66 ")
< 90%		1368 $\pm$ 373	2373 $\pm$ 570	2031 $\pm$ 212
90-119%		2518 $\pm$ 557	2834 $\pm$ 777	2929 $\pm$ 801
120-149%		3014 $\pm$ 874	3150 $\pm$ 759	3504 $\pm$ 576
150% or more		3306 $\pm$ 729	3521 $\pm$ 430	3434 $\pm$ 648
MEAN		2729 $\pm$ 760	3017 $\pm$ 773	3191 $\pm$ 763
N		96	156	144
F	10.49			
Sig F	0.00			

Appendix 29-6a

Estimated daily micronutrient intake during pregnancy between cases and controls (Willett SQFFQ).

Nutrient	LBW	OBW	t	Sig t
Calcium, mg	1289 ± 596	1391 ± 548	1.58	.1152
Iron, mg	14 ± 6	16 ± 6	2.28	.0231
Zinc, mg	14 ± 5	16 ± 5	2.35	.0195
Ascorbic Acid, mg	179 ± 122	192 ± 116	0.95	.3421
Thiamin, mg	1.6 ± 0.6	1.7 ± 0.6	2.74	.0064
Riboflavin, mg	2.5 ± 1.0	2.7 ± 1.0	1.77	.0779
Pyridoxine, mg	2.2 ± 0.8	2.4 ± 0.9	2.52	.0124
Folacin, mcg	305 ± 140	337 ± 139	2.04	.0423
A, IU	2683 ± 2438	2876 ± 2638	0.67	.5010
D, IU	352 ± 195	394 ± 192	1.94	.0531
E, mg TE	8.0 ± 5.4	9.2 ± 5.7	1.69	.0920
B ₁₂	9.7 ± 7.7	10.2 ± 7.6	0.57	.5661

Appendix 29-6b

Comparison of the Index of Nutritional Quality (Nutrient per 1000 calories) between mothers of cases and controls.

Nutrient	LBW	OBW	t	Sig t
Protein	1.80 ± 0.32	1.87 ± 0.30	2.20	.0289
Calcium	1.20 ± 0.44	1.24 ± 0.39	0.87	.3827
Iron	0.53 ± 0.17	0.57 ± 0.20	2.00	.0466
Zinc	1.07 ± 0.21	1.14 ± 0.29	2.29	.0227
Ascorbic Acid	2.83 ± 1.48	2.93 ± 1.59	0.61	.5247
Thiamin	1.17 ± 0.25	1.25 ± 0.30	2.78	.0058
Riboflavin	1.72 ± 0.48	1.78 ± 0.48	1.17	.2416
Pyridoxine	1.11 ± 0.29	1.19 ± 0.34	2.19	.0294
Folacin	0.86 ± 0.29	0.91 ± 0.33	1.64	.1025
A	0.76 ± 0.64	0.77 ± 0.66	0.14	.8992
D	0.99 ± 0.49	1.06 ± 0.45	1.20	.2305
E	0.90 ± 0.45	1.00 ± 0.65	1.50	.1305
B ₁₂	4.96 ± 3.5	4.97 ± 3.26	0.00	.9720
<u>INQ Summary Scores</u>				
INQ-12	1.62 ± 0.58	1.68 ± 0.54	0.96	.3384
INQ-4	0.90 ± 0.28	0.94 ± 0.30	1.28	.2019

Appendix 29-7

Attitude Questions for each of the Three Constructs.

Weight Factor Attitude Questions (R=was recoded in the analysis).

1. I worried that I might get fat during my pregnancy. (R)
2. The weight I gained during my pregnancy made me feel unattractive (R).
3. Just before I went to the doctor I tried not to eat because I was worried about my weight gain (R).
4. I was embarrassed by how big I got during my pregnancy (R).
5. I tried to keep my weight down so I didn't look so pregnant (R).

Nutrition Factor Attitude Questions (R=was recoded in the analysis).

1. Mothers who eat good diets deliver healthier babies than mother who do not eat well.
2. Good eating habits during pregnancy are very important to the baby's health.
3. A poor diet during pregnancy will not affect the baby's health (R).
4. Nutrition is important during pregnancy.

Attitude Toward Being Pregnant

1. I think a pregnant woman is beautiful.
2. Thinking back to just before you were pregnant, how did you feel about becoming pregnant?
 - a. I wanted to be pregnant sooner (5).
 - b. I wanted to be pregnant then (4).
 - c. I don't know or wish to say (3).
 - d. I wanted to be pregnant later (2).
 - e. I did not want to be pregnant at all (1).

Appendix 29-8

Multiple regression formulas from which the partial regression coefficients used in the model to predict birth weight were determined.

Independent Variables	Dependent Variable		Partial r	t	Sig t
	B	SE-B			
Birth Weight					
Sex of infant	155	69.3	.10	2.237	.0259
Weeks gestation	171	23.0	.33	7.439	.0000
Mothers birth weight	0.32	0.06	.24	5.468	.0000
% term reference weight	9.38	1.66	.25	5.620	.0000
# cigarettes/day	-12.9	3.86	-.15	3.324	.0010
Constant	-5904	904		6.529	.0000
Multiple R	0.594				
R ² ,%	35				
SE-B	638 g				
DF	(5,339)				
F	36.92				
p	.0000				
% 1983 Reference Weight, Term					
Mother's age	0.89	0.25	.16	3.560	.0004
Weight gain, lbs	0.65	0.08	.37	7.735	.0000
Constant	78.8	7.11		11.08	.0000
Multiple R	0.402				
R ² ,%	16				
SE-B	19.1				
DF	(2,393)				
F	37.91				
p	.0000				

Appendix 29-8, cont.

Independent Variables	Dependent Variable				
	B	SE-B	Partial r	t	Sig t
Number of Cigarettes/Day					
Mother's education	-1.43	0.211	-.325	6.780	.0000
Attitude: nutrition	-2.17	0.858	-.122	2.534	.0117
Constant	33.88	4.30		7.881	.0000
Multiple R	0.371				
R ² , %	14				
SE-B	8.27				
DF	(2,393)				
F	31.40				
p	.0000				
Weight Gain					
Weeks gestation	1.23	0.39	.16	3.152	.0018
MAR-12 score	0.06	0.05	.06	1.215	.2250
# cigarettes/day	-0.15	0.07	-.11	2.170	.0307
Attitude: weight gain	-2.16	0.77	-.15	2.82	.0051
Constant	-14.5	16.23		-.891	.3737
Multiple R	0.283				
R ² , %	7				
SE-B	10.9				
DF	(4,350)				
F	7.59				
p	.0000				
Diet Quality MAR-12					
Attitude: Nutrition	4.76	1.25	.20	3.799	.0002
Mother's Education	0.78	0.30	.13	2.551	.0000
Constant	43.46	6.19		7.02	.0000
Multiple R	0.266				
R ² , %	7				
SE-B	11.4				
DF	(2,356)				
F	13.50				
p	.0000				

Appendix 29-9a

Comparison of black OBW responders and non-responders based on birth certificate data: Comparison of mean differences.

Variable	Responders (n=122)	Non-Responders (n=203)	t	p
<u>SIGNIFICANT DIFFERENCES</u>				
Mother's education, yrs	13.5±1.7	12.8±1.6	3.53	.0005
<u>NOT SIGNIFICANTLY DIFFERENT</u>				
Birth weight	3753±137	3754±144	0.06	.9502
Mothers age, yrs	25.6±4.2	24.9±3.9	1.60	.1115
Month prenatal care began	2.8±1.5	2.6±1.5	1.04	.2984
Number prenatal visits	12.7±4.4	12.6±3.4	0.22	.8278
Weeks gestation (B50)	39.8±1.2	39.7±1.2	0.67	.5041
Fathers age, yrs	29.4±5.8	28.3±4.9	1.22	.2215
Fathers education, yrs	13.5±1.7	13.1±1.5	1.55	.1233
1 minute Apgar	8.1±1.1	8.0±1.3	0.24	.4457
5 minute Apgar	9.0±0.5	8.9±0.6	0.15	.8781

Appendix 29-9b

Comparison of Birth Certificate Data of Black OBW
 Responders and Non-Responders: Chi-Square Analysis^a.

Variable	OPTIMAL BIRTH WEIGHT		X ²	p
	Responders (n=122)	Non-Responders (n=203)		
<u>SIGNIFICANT DIFFERENCES</u>				
none				
<u>NOT SIGNIFICANTLY DIFFERENT</u>				
Named Parent				
One parent named	53	106	2.01	.1563
Both parents named	69	97		
Kessner Index				
Adequate	90	156	0.55	.7610
Intermediate	24	61		
Inadequate	8	18		
Sex of Infant				
Male	71	129	0.71	.3997
Female	51	125		
Complications of Pregnancy				
Yes	6	3	2.23	.1350
No	115	200		
Concurrent Illness				
Yes	6	5	2.02	.3645
No	115	197		
Drug Addiction	0	1		
Complications Labor/Delivery				
Yes	39	59	0.03	.8705
No	84	144		
Attendant (MD or DO)				
MD	105	189	3.60	.0579
DO	17	14		

^aafter Yates correction.

Appendix 29-9c

Comparison of black LBW responders and non-responders based
on birth certificate data: t-test of mean differences.

Variable	Responders (n=134)	Non-Responders (n=266)	t	p
<u>SIGNIFICANTLY DIFFERENT</u>				
Mother's education, yrs	12.7±1.7	12.3±1.5	2.88	.0042
<u>NOT SIGNIFICANTLY DIFFERENT</u>				
Birth weight	2225±284	2219±283	0.61	.8479
Mothers age, yrs	25.1±4.1	25.2±4.0	0.02	.8935
Month prenatal care began	2.8±2.8	3.1±3.1	0.14	.1422
Number prenatal visits	11.3±4.0	11.5±5.1	0.74	.7411
Weeks gestation (B50)	38.6±1.5	38.7±1.4	0.47	.4939
Fathers age, yrs	28.7±6.0	29.1±5.4	0.15	.7037
Fathers education, yrs	13.0±1.8	12.6±1.5	1.86	.1749
1 minute Apgar	7.7±1.6	7.5±1.8	0.83	.3617
5 minute Apgar	8.8±0.8	8.6±1.0	3.70	.0551

Appendix 29-9d

Comparison of Birth Certificate Data of Black LBW
Responders and Non-Responders: Chi-Square Analysis^a.

Variable	LOW BIRTH WEIGHT Responders (n=134)	Non-Responders (n=266)	X ²	p
<u>SIGNIFICANT DIFFERENCES</u>				
Named Parent				
One parent named	77	184	4.50	.0339
Both parents named	56	82		
Complications of Pregnancy				
Yes	28	15	19.80	.0000
No	106	249		
Concurrent Illness				
Yes	10	26	8.78	.0124
No	124	348		
Drug Abuse	0	15		
<u>NOT SIGNIFICANTLY DIFFERENT</u>				
Sex of Infant				
Male	56	108	0.02	.9040
Female	78	158		
Kessner Index				
Adequate	92	174	1.15	.5628
Intermediate	31	61		
Inadequate	11	31		
Complications Labor/Delivery				
Yes	41	109	3.77	.0521
No	93	156		
Attendant (MD or DO)				
MD	120	251	2.39	.1220
DO	14	15		

^aafter Yates correction.

Appendix 30

Infant Mortality Rate in Michigan by 50 g Birth Weight
Intervals: 3,000-4,000 g, 1984-1986

Appendix 30-a

White Infant Mortality Rate In Michigan by 50 g Birth Weight
Intervals: 3000-4500 g, 1984-1986.

Birth Weight	1984	1985	1986	Mean (84-86)
3001-3050	5.6	5.1	3.4	4.7
3051-3100	4.0	3.4	5.1	4.2
3101-3150	4.7	4.3	3.6	4.2
3151-3200	3.1	4.2	3.8	3.7
3201-3250	4.3	2.8	3.3	3.5
3251-3300	3.0	4.0	4.6	3.9
3301-3350	2.2	4.2	3.4	3.3
3351-3400	2.7	5.0	4.8	4.2
3401-3450	2.0	2.6	3.8	2.8
3451-3500	3.8	3.6	1.6	3.0
3501-3550	2.3	3.4	2.9	2.9
3551-3600	2.6	2.4	2.2	2.4
3601-3650	4.6	1.0	2.4	2.7
3651-3700	3.3	4.3	2.8	3.5
3701-3750	2.9	2.3	3.0	2.7
3751-3800	3.7	2.3	1.3	2.4
3801-3850	1.5	0.0	1.4	1.0
3851-3900	2.4	0.1	2.3	1.6
3901-3950	2.9	0.7	2.1	1.9
3951-4000	1.1	2.5	1.8	1.8
4001-4050	2.8	3.5	0.7	2.3
4051-4100	1.9	0.4	3.6	2.0
4101-4150	6.3	2.0	3.3	3.9
4151-4200	3.8	4.6	4.2	4.2
4201-4250	2.3	1.2	3.6	2.4
4251-4300	1.7	0.0	1.7	1.1
4301-4350	1.9	4.5	3.8	3.4
4351-4400	1.2	3.4	1.1	1.9
4401-4450	2.2	2.0	0.0	1.4
4451-4500	3.0	0.0	5.0	2.7
MEAN:	3.1	3.0	3.0	3.0

Appendix 30-b

Black Infant Mortality Rate In Michigan by 50 g Birth Weight
Intervals: 3000-4500 g, 1984-1986.

Birth Weight	1984	1985	1986	Mean (84-86)
3001-3050	5.6	6.6	8.4	6.9
3051-3100	5.5	5.1	6.9	5.8
3101-3150	8.6	4.5	2.2	5.1
3151-3200	6.3	4.9	9.3	6.8
3201-3250	1.9	7.3	4.7	4.6
3251-3300	2.0	5.0	0.0	2.3
3301-3350	1.1	0.0	2.0	1.0
3351-3400	1.2	3.7	4.0	3.0
3401-3450	5.5	3.3	4.9	4.6
3451-3500	1.3	2.5	3.6	2.5
3501-3550	2.5	6.4	3.7	4.2
3551-3600	9.1	5.7	6.9	7.2
3601-3650	2.7	2.4	4.8	3.3
3651-3700	5.2	6.8	3.3	5.1
3701-3750	0.0	3.9	1.9	1.9
3751-3800	2.0	2.3	2.2	2.2
3801-3850	2.1	0.0	7.9	3.3
3851-3900	0.0	8.3	0.0	2.8
3901-3950	3.4	3.3	0.0	2.2
3951-4000	3.7	3.9	14.5	7.4
4001-4050	0.0	8.8	8.3	5.7
4051-4100	5.0	1.1	4.9	3.7
4101-4150	7.0	6.1	0.0	4.4
4151-4200	1.5	7.0	0.0	2.8
4201-4250	1.7	0.0	0.0	0.6
4251-4300	9.2	0.0	0.0	3.1
4301-4350	0.0	21.5	0.0	7.2
4351-4400	27.0	29.0	0.0	19.0
4401-4450	0.0	0.0	0.0	0.0
4451-4500	0.0	0.0	0.0	0.0
MEAN:	4.5	4.8	4.2	4.5

Appendix 31

Comparison of the Unpublished NHANES II Weight-for-Height
Data for Women Between 20-24 Years of Age with the 1983 and
1959 Metropolitan Reference Weight-for-Height Standards

Appendix 31a

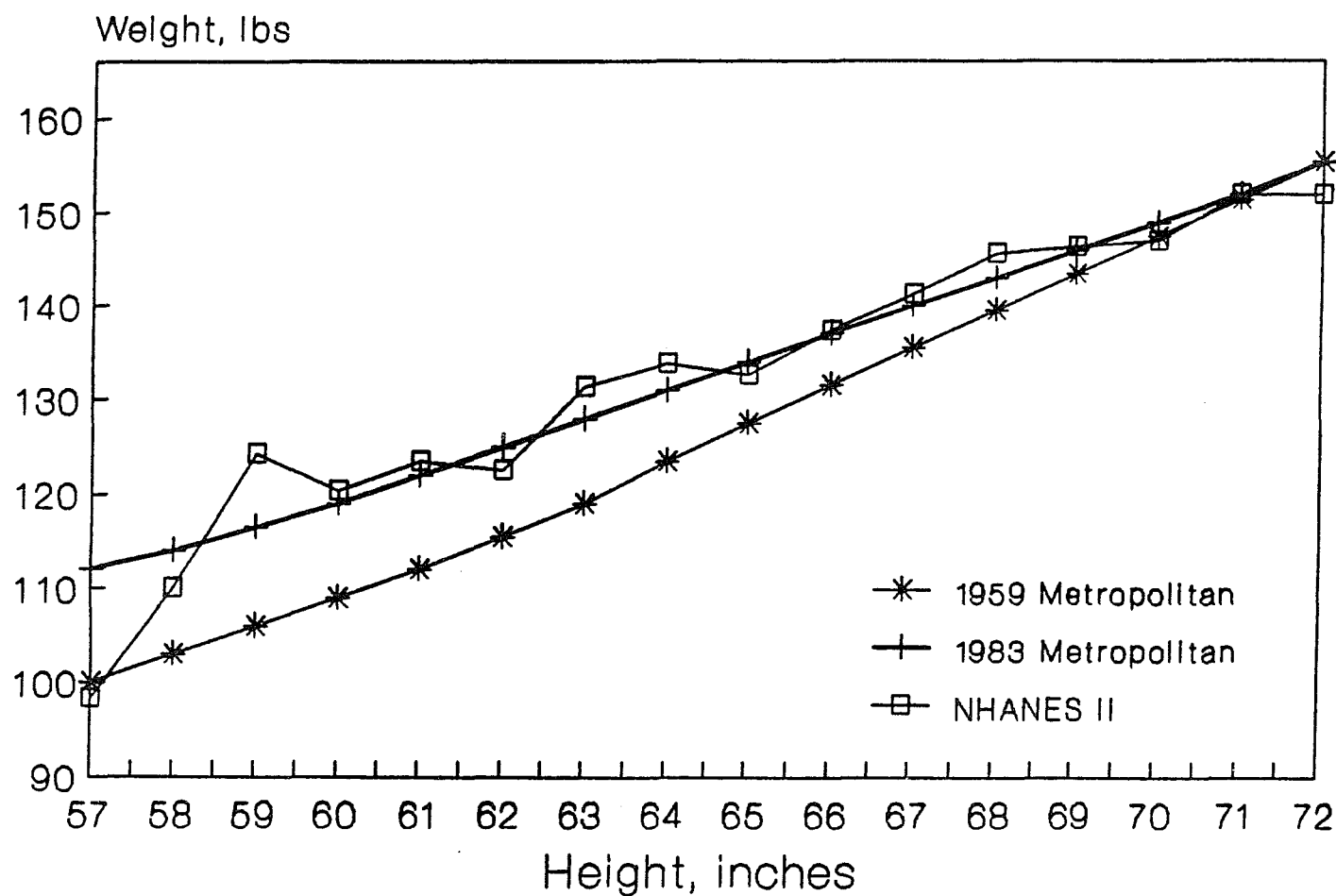
Unpublished NHANES II Weight-for-Height Data:
White Females 20-34 Years of Age

Table 5. Weight in pounds for females 20-34 years of age--number examined, mean, standard deviation, and selected percentiles, by height in inches: United States, 1976-80

Height	Number of examined persons	Mean	Standard deviation	Percentile										
				5th	10th	15th	25th	50th	75th	95th	90th	95th		
Total.....	1,909	136.3	31.1	103.3	109.0	112.3	118.6	132.5	150.7	166.6	179.5	197.6		
Less than 5 inches.....	12	109.2	27.3	•	•	•	•	98.3	•	•	•	•		
58 inches.....	23	112.3	19.8	•	•	•	97.9	110.0	116.3	•	•	•		
59 inches.....	47	120.6	25.9	•	•	108.1	114.0	124.3	137.1	160.3	•	•		
60 inches.....	63	125.4	27.3	•	•	100.3	107.3	120.4	137.3	153.0	•	•		
61 inches.....	153	130.3	29.5	97.1	103.9	107.5	111.8	123.5	140.2	154.3	168.8	193.8		
62 inches.....	232	130.3	29.1	103.3	106.5	109.6	112.3	122.5	141.9	155.2	163.7	185.1		
63 inches.....	244	138.2	31.2	126.0	107.9	111.3	116.3	131.4	152.5	174.1	184.0	194.9		
64 inches.....	283	141.2	31.0	137.0	111.5	115.0	120.8	135.8	149.6	167.7	194.0	206.1		
65 inches.....	588	141.5	31.7	109.3	116.3	117.1	122.3	132.6	151.3	165.8	180.9	206.0		
66 inches.....	199	144.5	23.6	113.3	117.3	119.8	127.3	137.3	152.4	164.5	179.9	202.9		
67 inches.....	142	151.1	30.7	119.1	122.5	124.9	129.3	161.3	167.9	184.0	192.3	219.3		
68 inches.....	70	151.5	29.9	•	122.4	127.6	136.1	145.7	157.9	163.2	181.1	•		
69 inches.....	42	153.9	33.1	•	•	131.0	133.8	166.6	165.8	170.2	•	•		
70 inches.....	14	154.1	22.0	•	•	•	•	187.0	•	•	•	•		
71 inches or more.....	10	166.4	30.4	•	•	•	•	152.0	•	•	•	•		

NOTE: Includes clothing weight; estimated as ranging from 0.20 to 0.62 pound.

Comparison: Weight-for-Height Standards -1959, 1983 Metropolitan and NHANES II-



Appendix 32

Response Rate to the White Michigan Mother's Survey and
the Physician's Prenatal Care Survey of Black Michigan
Mother's by County of Birth

Appendix 32a

White Michigan Mothers Response Rate by County of Birth

County/County Type	Responders (n)	Eligible (n)	Response Rate, %
Primarily Rural (less than 20 Subjects ¹)	129	186	69
Primarily Urban			
Genesee	24	36	67
Ingham	16	26	62
Kalamazoo	20	23	87
Kent	48	77	62
Macomb	18	30	60
Oakland	65	100	65
Washtenaw	12	21	57
Wayne	66	101	65
TOTAL	269	414	65
OVERALL RESPONSE RATE	398	600	66

¹ Counties include Allegan, Alpena, Bay, Berrien, Calhoun, Cass, Cheboygan, Chippewa, Claire, Clinton, Crawford, Delta, Dickenson, Emmett, Gogebic, Grand Traverse, Gratiot, Hillsdale, Houghton, Huron, Ionia, Iosco, Jackson, LaPeer, Lenawee, Marquette, Mason, Macosta, Midland, Monroe, Montcalm, Muskegon, Newaygo, Oceana, Ogemaw, Osceola, Otsego, Ottawa, Saginaw, St. Claire, Sanilac, Shiawasee, Van Buren, Wexford

Appendix 32b

Physician's Prenatal Care Survey of Black Michigan Mothers
Response Rate by County of Birth

County/County Type	Responders (n)	Eligible (n)	Response Rate, %
Primarily Rural (less than 20 Subjects ¹)	49	74	66
Primarily Urban			
Berrien	17	20	85
Genesee	21	60	35
Ingham	23	26	88
Kent	15	37	41
Oakland	29	80	36
Saginaw	21	32	66
Washtenaw	9	23	39
Wayne	113	473	24
TOTAL	248	751	33
OVERALL RESPONSE RATE	297	825	36

¹ Counties include Calhoun, Cass, Emmett, Iosco, Jackson, Kalamazoo, Lenawee, Macomb, Marquette, Macosta, Muskegon, Newaygo, St. Claire, and Van Buren.

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