The Birth Weight Distribution in Ethnic Chinese Infants

Shi Wu Wen

Department of Epidemiology and Biostatistics

McGill University

Montreal, Quebec

September, 1993

A Thesis Submitted to the Faculty of
Graduate Studies and Research in partial
fulfillment of the requirements for
the degree of
Doctor of Philosophy

Abstract

To examine the reasons for the Chinese-Caucasian differences in birth weight distributions, birth weight, gestational age, the fetal growth ratio, and their determinants were analyzed for three groups of infants: Caucasian and immigrant Chinese infants born at Montreal's Royal Victoria Hospital, and native Chinese infants born at Hefei Maternal and Infant Hospital in Hefei, China.

The distribution of birth weight was quite similar in the two Chinese groups but was quite different from Caucasians. Mean birth weight was lower (by 150 - 250 grams), variation in birth weight was smaller, prevalence of low birth weight (<2,500 grams) was similar, and prevalence of large birth weight (>4,000 grams) was much lower in the two Chinese groups as compared with Caucasians in the overall sample comparison. The Chinese-Caucasian difference in variation of birth weight disappeared, while the Chinese-Caucasian difference in mean birth weight remained in a 'risk-free' subsample (subjects within a "normal" range of maternal demographic, anthropometric, nutritional, and behavioral determinants). But in multivariate analyses with more complete control for "within-normal" differences in these maternal determinants, the Chinese-Caucasian difference in mean birth weight also decreased substantially. The Chinese-Caucasian difference in birth weight distribution was largely attributed to a difference in fetal growth rather than gestational duration.

Relative birth weight for gestational age differed in the two racial groups at different periods of gestation; birth weight in Chinese infants was heavier than that of in Caucasian infants at earlier gestations, but was substantially lower at later gestations.

Since the Chinese-Caucasian differences in the variation of BW disappeared in the 'risk free' subsample comparison, we conclude that the "tighter" distribution of birth weight in Chinese infants is caused by their reduced exposure to 'growth-inhibiting' and 'growth-accelerating' levels of determinants of fetal growth, such as maternal height, prepregnancy body mass index, and net gestational weight gain rate (mediated largely by environmental mechanisms). Because the mean birth weight at or after term in Chinese infants was much lower than Caucasians (even after adjusting for covariables) and the vast majority of Chinese infants were born at or after term, we conclude that the lower mean birth weight in them is largely genetically mediated. Since the low birth weight rate among Caucasians was lower than among Chinese in the 'risk-free' subsample comparison, and since the birth weight in Chinese at earlier gestations was not lower, we conclude that the lower-than-expected low birth weight rate in Chinese infants is caused partly by their reduced exposure to 'growth-inhibiting' levels of environmental determinants of fetal growth, and partly by their genetically-mediated different temporal pattern of fetal growth. The evidence

suggests similar differences in growth patterns at different periods of gestation in other racial groups, the practice of using a common standard for defining fetal growth, small-for-gestational age, and large-for-gestational age requires careful re-examination.

RÉSUMÉ

Dans le but d'examiner les raisons attribuables à la répartition «serrée» du poids de naissance, des nourrissons chinois, les répartitions du poids de naissance, de l'âge gestationnel, de l'indice de croissance foetale et leurs déterminants ont été analysés dans trois groupes de nourrissons: nourrissons d'immigrants chinois et de race blanche nés à l'Hôpital Royal Victoria de Montréal et nourrissons chinois nés à la maternité et à l'Hôpital pour enfants de Hefei, en Chine.

La répartition de poids de naissance est assez semblable dans les deux groupes de nourrissons chinois et diffère de celle des nourrissons de race blanche. Le poids moyen de naissance est inférieur (de 150 à 250 grammes), les variations du poids de naissance sont moindres, la prévalance de faible poids de naissance (< à 2 500 grammes), est comparable et la prévalence de poids de naissance élevé (> à 4 000 grammes) est très inférieure dans les deux groupes de nourrissons chinois, par rapport aux nourrissons de race blanche, pour l'ensemble de l'échantillon. La différence entre Chinois-Blancs au titre de la variation du poids de naissance disparaît dans un sous-échantillon «sans risque» (sujets se situants dans une fourchette «normale» en termes de déterminants démographiques maternels, anthropométriques, nutritionnels et comportementaux), alors que la différence Chinois-Blancs au

titre de poids moyen de naissance se maintient. Dans la cadre d'analyses multrivariées assorties de contrôles plus complets des différences «dans a normale» de ces déterminants maternels, la différence Chinois-Blancs au titre du poids moyen de naissance décroît de façon marquée. La différence Chinois-Blancs au titre de la répartition du poids de naissance est largement attribuable à la difference enregistrée au niveau de la croissance foetale plutôt qu'à la durée gestationnelle. Le poids de naissance relatif pour l'âge gestationnel diffère dans les deux groupes raciaux à différentes étapes de la gestation; le poids de naissance des nourrissons chinois est supérieur à ceux des nourrissons blancs à un stade plus précoce de la gestation mais il est substantiellement inférieur à un stade plus avancé de la gestation. En conclusion, la répartition «serree» du poids de naissance et la prévalance inférieure aux prévisions de faible poids de naissance chez les nourrissons chinois est attribuable d'une part à leur moindre exposition aux déterminants environnementaux «inhibiteurs de croissance foetale» et «accélérateurs de croissance foetale» et, d'autre part, aux différences determinées génétiquement au titre du rythme de croissance à différents stades de la gestation. Puisque les données laissent entrevoir des différences comparables dans d'autres groupes raciaux, l'utilisation d'une norme standard pour définir la croissance foetale, de même que les critères «petit pour l'âge gestationnel» et «gros pour

l'âge gestationnel», doivent faire l'object d'une réévaluation soignée.

Abbreviations used in this thesis:

BW=Birth weight

LBW=Low birth weight

HBW=High birth weight

GA=Gestational age

FGR=Fetal growth ratio

SGA=Small-for-GA

LGA=Large-for-GA

LNMP=Last normal menstrual period

BPD=Biparietal diameter

BMI=Body mass index

PIH=Pregnancy-induced-hypertension

EF=Etiologic fraction

EFV=Etiologic fraction for variance

SD=Standard deviation

CV=Coefficient of variantion

CI=Confidence interval

MOND=McGill Obstetric and Neonatal Data Base

RVH=Royal Victoria Hospital

HMIH=Hefei Maternal and Infant Hospital

Terms defined in this thesis:

Rate: "rate" is loosely defined as a proportion in this thesis, and is exchangable with prevalence

Outcome: outcomes in this thesis are restricted to (unless specified) BW, GA, and FGR

Determinant: determinants in this thesis are restricted to (unless specified) variables (factors) which affect the distributions of BW, GA, and FGR

Statement of Originality

To my knowledge, this is the first study to assess the reasons for the "tight" birth weight distribution in ethnic Chinese infants. The two major contributors of birth weight, namely gestational duration and fetal growth, have been analyzed separately; moreover, gestational age estimated by maternal recall of last normal menstrual period has been validated by early ultrasound. The results of this study provide new insights into the determinants of fetal growth, with important implications for clinical practice and public health policy beyond Chinese mothers and infants.

Several original methodologic aspects also deserve mention. First, the approach of using women's maiden names and places of birth to identify them as ethnic Chinese or ethnic Caucasian has not heretofore been explored. This approach proved fairly reliable and may be applicable to future epidemiologic studies. Second, this is the first study to address the importance of terminal digit preference in data obtained from different institutions, which may prompt those epidemiologists who have multicenter data to examine this issue further. Third, this study demonstrates the utility of comparing 'risk-free' populations in partitioning genetic vs environmental variance of diseases and other health-related attributes.

The idea and design for this study were my own, with

inputs from Dr. Kramer. The Montreal data were obtained from McGill Obstetric and Neonatal Data Base with the help and collaboration of the Royal Victoria Hospital's perinatal research team. Hefei's data were collected by the Hefei Maternal & Infant Hospital staff, under my supervision. Data analysis, presentation, and interpretation are also my own.

Acknowledgements

I wish to thank, first of all, my thesis supervisor, Dr. Michael Kramer, for his encourangement, advice, criticism, and innumerable hours correcting my English.

Dr. Robert Usher, Director of Neonatology at Royal Victoria Hospital, kindly provided access to the McGill Obstetric & Neonatal Data Base (MOND), which permitted the study on immigrant Chinese and Caucasian infants; Ms. Frances McLean of the Royal Victoria Hospital and Ms. Marielle Olivier of the McGill Department of Epidemiology & Biostatistics spent much time helping me create a usable SAS file from MOND. Thanks are also due to my colleague and long-standing friend, Dr. Jin Fa Ni, at Anhui Medical University. Without his patience and persistence, the native Chinese data for this project could never have been collected.

Dr. Geoffrey Dougherty served as my acting supervisor during Dr. Kramer's sabbatical leave from September 1991 to August 1992. His timely help and capacity to overcome practical obstacles made the project progress smoothly during this critical period of time.

Numerous discussions along the way with Drs. James Hanley and Sungsub Choi were of great help in the data analysis. Helpful suggestions were also obtained through discussions with Drs. Kenneth Morgan and Jean-Paul Collet.

I was supported financially in this work by fellowships

from the McGill University-Montreal Children's Hospital Research Institute and the Medical Research Council of Canada. The thesis project was supported partially by a grant from the McGill University-Montreal Children's Hospital Research Institute.

Finally, I wish to express my gratitude to my family for their ever-present support and encouragement.

Table of Contents

List of Tables

List of Figures

CHAPTER 1. INTRODUCTION

1.1. General Background

It is widely recognized that birth weight (BW) is governed by two major factors with rather different etiologic determinants: the duration of gestation and the fetal growth rate (1). An infant thus may have a low birth weight (LBW, < 2,500 grams) from being born too soon or too small for its age (or both).

Fetal growth refers to an increase in size of the fetus over time (2). The ideal study of fetal growth would therefore, at least theoretically, involve repeated in utero measurements of fetal size. At first glance, sequential ultrasound studies might appear to approach this ideal, but the variability of ultrasound measurements in late gestation is extremely high, even if accessible and acceptable (2).

Faute de mieux, fetal 'growth' curves have been based on the cross-sectional assessment of BW for gestational age (GA) of different infants born at different GAs. These curves are used in both clinical management and epidemiologic research (2). Other measurements, in particular birth length for GA and head circumference for GA, have also been used as measures of fetal growth (3).

The shortcoming of the cross-sectional approach must be recognized, however. Preterm births, for example, are themselves 'unnatural' and probably bias the curves downwards

at low GA's, since infants born preterm appear slightly smaller than those who remain in utero at the same ages (4). Moreover, the rate of gain in weight begins to slow at about 34-35 weeks gestation and 2.4-2.6 kg body weight (5). This can be interpreted in several ways. It is possible that the placenta is beginning to age at that time and is no longer able to transport the nutrients required for the relatively large fetus to gain weight at the same rate as before, or that pelvic size or limited uterine blood flow begin to restrict further fetal growth. But it may also be that slower-growing smaller fetuses tend to remain in utero longer. Therefore, BW-for-GA at birth is only an approximation of the longitudinal pattern of fetal growth.

Accurate GA information is not only essential in the study of GA and GA determinants, but is obviously also critical in the calculation of BW-for-GA. GA is usually derived from the first day of the last normal menstrual period (LNMP), which, in turn, depends on the mother's accurate recall and on unverifiable assumptions about the dates of ovulation and conception. While the LNMP approach is still commonly used in both clinical practice and epidemiologic research (2), potential bias in the estimation of GA must be recognized, especially for preterm and postterm births (6). Early ultrasound-determined GA is currently considered the 'gold standard' (6).

Unlike fetal growth and GA, BW can be measured easily and

accurately. As a result, BW and its determinants have been studied intensively worldwide over the past several decades. But in many of these studies, no attempt has been made to examine separately the duration of gestation and the fetal growth rate. Previous studies of BW and BW determinants have yielded inconsistent results, at least partly because of their failure to distinguish maturity from growth (1).

Despite the limitations of such studies, some consistent themes do emerge. For example, it has long been recognized that the BW distribution varies considerably among different populations (7-21). According to statistics assembled by the World Health Organization (7,8), the lowest BWs are reported from the poorest Asian countries, like India and Pakistan, with mean values ranging from about 2,700-2,800 grams, and corresponding LBW rates of 20-30%. On the other hand, Caucasian populations in western Europe countries like Sweden and Norway have the highest BWs, with mean values of about 3,500 grams and corresponding LBW rates of about 4.0%. These BW variations are often attributed to genetic differences linked to racial/ethnic origin. But because the data are usually obtained from birth certificates, which lack important information on potential environmental determinants, the extent to which such differences may be due to acquired anthropometric differences (including differences in maternal nutrition) or to other environmental factors (e.g. cigarette smoking during pregnancy) is unclear.

Early in the summer of 1987, when searching for an M.Sc.'s thesis topic, I noticed a different shape of the BW distribution in Chinese infants compared with infants of Caucasian, black, or other racial/ethnic origins. Although the mean of the distribution is 150-200 g lower than the mean for North American Caucasians, the standard deviation is lower, and the degree of skew in the lower tail (LBW) is smaller. Thus despite having a lower mean BW, Chinese infants show a similar prevalence of LBW when based on the same (<2,500 g) standard (9). Several other studies have reported similar findings (10-14). Comparisons of the overall BW distribution between Chinese and Caucasian infants have shown a negligible difference at the lower end, but a substantial difference at the higher end of the BW distribution (9-11). These studies also found that Chinese babies are heavier at earlier GAs, but are substantially lighter at later GAs, as compared with Caucasian babies (9,10).

The explanation(s) for this unique BW distribution in ethnic Chinese infants is the focus of this thesis.

1.2. Objectives

1) To examine the differences in overall BW, GA, and fetal growth (BW-for-GA) distributions in Caucasian, immigrant Chinese, and native Chinese infants, and to estimate the extent to which differences in BW distributions can be attributed to differences in the distributions of GA vs fetal

growth.

2) To describe the mean BW and relative weight at different GAs in Caucasian, immigrant Chinese, and native Chinese infants and their contribution to the Chinese-Caucasian difference in overall BW distribution.

3) To examine the differences in distributions of environmentally-related determinants of gestational duration and fetal growth among Caucasian, immigrant Chinese, and native Chinese infants.

4) To estimate the extent to which differences in the gestational duration and fetal growth distributions among Caucasian, immigrant Chinese, and native Chinese infants can be attributed to differences in the distributions of environmentally-related determinants.

1.3. Outline

A general background of BW, GA, fetal growth, and their interrelationship and a brief review of the BW distribution differences in ethnic groups have already been discussed in this Chapter. Chapter 2 details the BW distribution in ethnic Chinese infants, reviews previous studies of genetic and environmental determinants of BW, GA, and fetal growth, and conceptual and methodological issues in partitioning genetic from environmental variance for dichotomized or continuously distributed diseases and attributes. The subjects and methods of the current study are described in Chapter 3: study sites,

populations, outcomes, potential determinants, data collection, and analyses.

Chapter 4 presents the results of this study: a comparison of distributions of outcomes and determinants among the three study groups; and results of bivariate and multivariate analyses.

Chapter 5 discusses the validity of the results of this study and their interpretation, and briefly summarizes the study's findings, limitations, and implications.

CHAPTER 2. LITERATURE REVIEW

2.1. The BW Distribution of Chinese Infants

In recent years, several studies have described the BW distribution of Chinese infants (9-14). Compared with other racial/ethnic populations, the Chinese BW distribution shows several important distinguishing features. First, although economic development in China is considerably behind that of Japan, the BW distribution in China (a mean of about 3,215-3,285 grams, and a LBW rate of 6.0%) is very similar to that in Japan (a mean of 3,200 grams and a LBW rate of 5.2%) (7,8). Second, while the distribution of Chinese BW is centered slightly below the mean of the North American Caucasian distribution, the spread of the distribution is considerably reduced, with fewer infants with low or high BW (9-14). Third, Chinese infants living in different countries or regions with large socioeconomic differences, specifically in mainland China, Taiwan, and the USA, have similar BW distributions (10). This finding suggests that mothers in all three areas meet basic health and nutritional needs for adequate fetal growth and share important genetic and/or environmental determinants. Fourth, two large studies using U.S. birth certificate data reported slightly heavier BW among Chinese infants than among Caucasian infants before 36 weeks GA, while from 38 to 39 weeks on, Chinese infants were consistently about 100 to 200 g lighter (9,10).

In summary, compared with Caucasians, Chinese infants appear to have a lower mean BW, a "tighter" overall BW distribution, and a lower than expected prevalence of LBW.

As discussed in Chapter 1, BW is governed by two major factors: the gestational duration and the fetal growth rate. In the analyses of Chinese-Caucasian differences in BW, this distinction should be taken into account. Thus the lower mean BW seen in Chinese infants might be caused by a lower mean gestational duration or fetal growth rate (or both); the "tighter" BW distribution might be caused by a "narrowed" range in gestational duration or fetal growth rate (or both); and the lower than expected LBW rate might be caused by a lower than expected rate of preterm delivery or SGA (or both).

Part of the Chinese-Caucasian difference in mean BW may be due to differences in maternal height, prepregnancy weight, and gestational weight gain. Previous studies report that Chinese mothers are shorter, lighter, and gain less weight during pregnancy than Caucasian mothers (21).

There are several possible explanations for the "tight" BW distribution observed in Chinese infants. First, it might be caused by the effect of natural selection, mediated by selective spontaneous abortion or fetal death. Natural selection has been recognized as a major force in stablizing and optimizing attributes including BW (22,23). If natural selection was the reason for the observed differences in BW distribution, one would have to hypothesize a stronger

selection pressure among the Chinese than among other ethnic groups. No previous study has examined this issue. Our data might permit us to test it, at least for the current generation. However, natural selection is a long process that might take many generations to achieve optimal status. As a result, inferences regarding natural selection must rely largely on knowledge from external sources.

Second, the "tight" Chinese BW distribution might be caused by selective therapeutic abortion, although such an explanation would require the rather unlikely scenario that fetuses destined for subsequent growth retardation or preterm birth are selectively targeted for abortion.

Third, the "tight" overall BW distribution of Chinese infants might be caused by a different pattern of growth with advancing GA. As discussed above, Chinese babies have been reported to be heavier (or at least not lighter) at earlier GAs, but substantially lighter at later GAs. Since weight increases monotonicaly with advancing GA, a heavier mean BW at earlier GAs, when combined with a lighter mean BW at later GAs, might cause a "tighter" overall BW distribution in Chinese infants, since the deviation of BW from the reference mean BW would be reduced both at earlier and later GAs. Heavier BW at earlier GAs in Chinese infants might also provide an explanation for why the LBW rate in Chinese babies is not higher than that of Caucasians despite a much lower mean BW. Most LBW occurs at earlier GAs (24,25), at which time

the growth of Chinese babies may be more rapid. At later GAs, the growth of Chinese babies slows relative to that of Caucasians, but the LBW rate increases little in them, since most of the babies have already passed the 'threshold' point (2,500 g).

Fourth, the "tight" BW distribution might be caused by greater genetic homogeneity among the Chinese. To our knowledge, no evidence of this has been obtained, but there is no reason to assume a lesser degree of heterogeneinity in the Chinese population than, say, the Caucasian population.

A final explanation for the "tight" BW distribution is a sharing of culturally-determined nutritional and other environmental determinants of fetal growth or gestational duration. Several studies have reported a rather homogeneous distribution of environmental determinants of BW in Chinese populations (9,21,26-28). Such a homogenous distribution of environmental determinants may result in lower exposure to 'growth-inhibiting' and 'gestation-shortening' levels of determinants in Chinese infants (9,21,26-28), which might provide a partial explanation for the lower than expected LBW rate, despite a lower mean BW, observed in Chinese populations living in different countries or regions.

Most studies of the BW distribution in Chinese infants have been descriptive in nature, and have not been able to include important determinants like maternal height, weight, gestational weight gain, information on other nutritional and

dietary habits, and cigarette smoking in their analyses. More importantly, previous studies have failed to distinguish whether the "tight" BW distribution observed in Chinese infants was caused by a "narrowed" range in duration of gestation or in fetal growth. In addition, most previous studies have analyzed live births only. One possible explanation for the reported findings might be fewer live Chinese babies at the two extremes of the BW distribution, simply because more of the Chinese babies at the two extremes (mostly at the lower end, i.e. LBW babies) died in utero, as the natural selection theory would dictate. Finally, previous studies of growth pattern with advancing GA have relied solely on LNMP-determined GA, which is highly vulnerable to misclassification, especially at the two extremes of the GA distribution (6).

In summary, it is not clear why Chinese infants have a "tight" BW distribution, and in particular, whether this "tight" distribution is due to a "narrowed" range in GA or FGR (or both), to different growth rates at different periods of gestation, to greater genetic homogeneity, or to a sharing of culturally-determined nutritional and other environmental influences. Our study is an attempt to fill this gap.

2.2. Genetic vs Environmental Determinants of BW

Experimental studies in animals and nonexperimental familial studies in human beings have attempted to partition genetic

effects from environmental effects on BW. Since no specific genes or gene products (other than trisomies, fetal gender, parentally imprinted chromosomes (29), and other defined syndromes) have been identified, however, indirect procedures have been used to investigate genetic effects.

Experimental studies in animals show that maternal environmental factors are the primary determinants of fetal size. For example, Walton and Hammond (30) carried out reciprocal crosses between large Shire horses and small Shetland ponies by means of artificial insemination. At birth, the foals were proportional in weight to the weights of their mothers, and not dissimilar to foals of the pure breeds to which the mothers belonged. The cross-foals from the Shire mares were three times the size of the cross-foals from the Shetland mares. In other words, maternal regulation of fetal growth was very marked and obscured any paternal genetic contribution. Although the study included no formal statistical analysis and was based on small sample sizes, the reported differences are simply too impressive to be attributable to chance. Three possibilities for the maternal regulation mechanism were suggested by the authors: a) maternal regulation of fetal nutrition; b) maternal hormonal control; and c) cytoplasmic inheritance. However, to clearly identify the mechanism, new experiments involving such techniques as embryo implantation, would be needed.

Results from nonexperimental familial studies in human

beings have not been consistent, however. Morton analyzed BW in 220 like-sex twin pairs, 40 unlike-sex twin pairs, and 60,000 singleton births of Japanese half-siblings, twins, and full siblings from the Atomic Bomb Casualty population of Hiroshima and Nagasaki. He concluded that 'permanent' or 'temporary' maternal factors were responsible for 65% of BW variance, while fetal genes contributed nothing (31). In contrast, Magnus analyzed 13,970 sons and daughters of monozygotic (MZ) and dizygotic (DZ) twins (the sample included half-siblings and cousins related either through females or males) and found that 50% of the total variation in BW was caused by variation in fetal genes, less than 20% was caused by variation in maternal genes, and the remaining variance (20%-30%) could be explained by random environmental effects (32). Little & Sing studied the BWs of sons and daughters and their fathers and mothers among 377 primarily white, middle-class families in Washington state. They estimated 26% heritability for male infants and 48% heritability for female infants. They further reported that if the mothers smoked before conception, the expression of fetal BW genes in males was significantly reduced, and that multiparity increased the explained variance due to genetic factors (33). Differences in model assumptions and analytic approaches make it difficult to reconcile the differences among these studies.

There is, however, other evidence of a genetic effect on BW in humans. BW in boys is about 100 g heavier than in girls,

yet no sex difference has been observed in GA (1). This sex difference in BW is usually attributed to a genetic effect on fetal growth. The genetic difference between male and female is based on the sex chromosomes: females have two X chromosomes, whereas males have one X and one Y. Several syndromes affecting human stature have been linked to sex chromosome abnormalities (23). But it is unclear why and how the mean BW is lower in the normal female fetus. Is it because of the lack of a Y-specific gene? Are other mechanisms involved? These questions remain unanswered.

Maternal height and prepregnancy weight have been demonstrated as important independent determinants of BW (1). Maternal height, prepregnancy weight, and gestational weight gain have independent effects on fetal growth but little or no impact on gestational duration (1,34,35). Maternal height and prepregnancy weight are determined by both genetic and environmental factors. Since the effects of paternal height and weight are much smaller than maternal height and weight (1), it is reasonable to attribute more of the effects of maternal height and prepregnancy weight on infants' BW to nongenetic influences.

Migone et al compared the BW distribution for babies of different parental race groups (both parents white, mother white-father black, mother black-father white, and both parents black) and found that mean BW decreased in that order from the white-white reference group and that, conversely,

there were increasing trends for LBW and preterm delivery (36). Adjustment for the usual sociodemographic determinants did not alter these trends appreciably. Because the father's race had a significant effect, genetic factors are probably of some importance for both BW and GA distributions, or at least in explaining part of the black-white difference. But since in Migone's study, mother's race was a far more important determinant for both BW and GA distributions, nongenetic maternal factors predominated, especially at the lower ends of the distributions (i.e., LBW and preterm delivery). The results of Migone's analysis are thus consistent with Walton and Hammond's horse experiment (30).

Additional evidence for a genetic effect is the tendency for BW and GA to correlate across generations. Hackman et al. reported a significant partial correlation between maternal BW and infant BW after controlling for a number of potential confounders (37). Klebanoff et al. found that maternal BW had no significant correlation with either GA or preterm birth, but had a significant correlation with both BW and LBW (38). In a study comparing pregnancy outcomes in sisters vs sisters-in-law of women who delivered SGA or preterm infants, Johnstone and Inglis (39) reported that both SGA and preterm birth tended to 'breed true.' In a case-control study carried out in a racially mixed population, Leff et al found that the odds of a LBW infant having a LBW mother was 80% higher than for adequate-weight infants, and the association between

maternal LBW and infant LBW was greater for those infants who were LBW due to IUGR than those who were preterm (40). In an investigation on intergenerational effects on BW, Alberman et al (41) found a positive association between parental and offspring BW (significant for both mothers and fathers after allowing for confounding factors), but a negative association with parental GA (significant only for mothers). The authors suggested that at least part of this effect is mediated through the association between the mother's own intrauterine growth rate and that of her baby's BW: the faster the mother's own growth, the heavier was her baby for a given GA (41). But the results of intergenerational studies should be interpreted with caution. The intergenerational effect on BW, for example, may not be genetic, but may be caused by culturally-determined sharing of environmental factors across generations.

The overall assessment of genetic determinants of BW thus indicates a probable genetic effect on fetal growth and a possible effect on gestational duration, although the magnitude of the genetic effect appears small.

BW increases with parity (about 45g/birth, except for extremely high parity, at which BW levels off) after controlling for potential confounders, most likely owing to a higher fetal growth rate (1).

Gestational energy balance is an environmental determinant (or group of determinants) that can be measured in two ways: gestational weight gain and energy intake. Energy intake

during pregnancy is closely related to gestational weight gain, but it is more purely nutritional than the latter, since it is not "contaminated" by increases in plasma volume and in breast and uterine size. Compared with gestational weight gain, energy intake has two main disadvantages, however, in assessing the effect of maternal nutrition on the fetus. First, it takes no account of energy expenditure. Second, it is difficult to be measured validly and reproducibly. Gestational weight gain has shown an independent positive association with fetal growth in observational studies (1), while clinical trials have demonstrated a small but positive effect of energy supplementation on fetal growth (42-44).

Maternal cigarette smoking during pregnancy has been demonstrated to be one of the most important single environmental factors affecting both fetal growth and (to a lesser extent) gestational duration (1,34). Maternal alcohol and social drug use during pregnancy are also independent factors affecting fetal growth, but have little or no effect on gestational duration (1,34). Cocaine is an exception, however, with well-documented adverse effects on both fetal growth and gestation duration (45,46).

Other environmental factors which have shown independent effects on fetal growth or gestational duration include: prior history of LBW or preterm birth, general maternal morbidity (especially in developing countries), prior spontaneous abortion, and in utero exposure to diethylstilbestrol. These

factors are less important because of their small etiologic fractions [owing to low prevalence (1)]. Malaria has large detrimental effects on fetal growth (especially among primiparas women) in endemic areas (1).

It should be emphasized that race is merely a proxy of many underlying determinants (both genetically and environmentally related) of BW. Only if all (or most) of the environmental effects related to race were adjusted for, one can declare that the racial differences are genetically related.

2.3. Conceptual and Methodological Issues in Partitioning Genetic vs Environmental Variance for Dichotomized or Continuously Distributed Diseases and Attributes

2.3.1. Quantitative genetic approaches

It is well known that many diseases and other health-related attributes in human beings are determined by multiple genes and multiple environmental factors. The complexity of such 'multifactorial' features complicates studies aimed at clarifying the etiologic mechanisms of these diseases and attributes or identifying the specific genes or gene products that may be involved. An indirect approach is often necessary, therefore, in genetic etiologic studies.

Geneticists have recognized the importance of partitioning genetic effects from environmental effects, and have used the concept of heritability as a measure of genetic contribution

to diseases and health-related attributes.

According to genetic theory, phenotypic variation in a quantitative attribute is the result of a combination of genetic and environmental effects. The genetic analysis of quantitative attribute is based on the construction of models that take into account both the effects of environmental variation and the joint effects of many genes on the given attribute. According to these models, the phenotypic variance (V_p) for a quantitative attribute can be partitioned into several components (47):

$$V_p = V_a + V_d + V_i + V_e + COV_{ge} + V_m \qquad (1)$$

in which V_a = variance resulting from differences between homozygotes, the additive genetic variance

V_d = variance resulting from specific effects of various alleles in heterozygotes, the dominance variance

V_i = variance resulting from interaction between non-allelic genes

V_e = variance resulting from environmental determinants

COV_{ge} = covariance of genetic and environmental determinants

V_m = variance resulting from measurement errors

It is usually assumed that there is no covariance of genetic and environmental determinants, and that the measurement errors and interaction between non-allelic genes can be

ignored. So Formula (1) can be reduced to:

$$V_p = V_a + V_d + V_e \quad (2)$$

In general, there are two kinds of heritability: heritability in the broad sense, h_b^2, which can be written as:

$$h_b^2 = (V_a + V_d)/V_p \quad (3)$$

and heritability in the narrow sense, h_n^2, which can be written as:

$$h_n^2 = V_a/V_p \quad (4)$$

The ratio of V_a/V_p expresses the extent to which phenotypes are determined by the genes transmitted from the parents. The additive variance (V_a) is an important component, since it is the chief cause of resemblance between relatives and therefore the chief determinant of the observable genetic properties of the population. As a result, h_n^2, the heritability in the narrow sense (which I shall henceforth refer to simply as the heritability) is of far more practical importance than h_b^2, although bias can occur easily in carelessly designed studies.

Dichotomized (all-or-none) diseases and attributes (e.g., disease presence or absence) that are not simply inherited (not determined by a single gene) may be converted into quantitative attributes by using the concepts of the threshold model (47). Thus, an estimate of the heritability of a threshold attribute can be obtained from a comparison of its incidence in relatives of persons having the attribute with that in the general population.

Heritability is a quantitative estimate of relevant genetic

effect, which is pertinent for genetic counselling, intervention strategies, and etiologic research. But there are several limitations for the heritability approach in population studies of diseases and other health-related attributes. First, the data required to calculate heritability cannot be obtained from routinely derived records or epidemiologic studies. Instead, specific family and twin studies are needed. Since such studies are both difficult and expensive, it is usually more feasible to partition specific environmental variance from total variance than to partition genetic variance from total variance.

Second, few diseases or health-related attributes can be effectively manipulated genetically; by contrast, environmental intervention is often possible, even when the etiologic mechanism of the environmental determinant is unclear.

Third, it is usually difficult to distinguish genetic determinants from common environments or cultural inheritance, even using complicated analytic tools such as path analysis.

Fourth, in calculating heritability, environmental factors are usually defined as unobserved factors which may be shared among relatives. Often, however, this is not true. Specific occupational and environmental exposures, for example, are determined by many historical and concurrent political and socioeconomic factors, which are not evenly distributed among relatives. Failure to take individual environmental exposures

adequately into consideration may produce a biased heritability estimate.

Fifth, many assumptions required for calculating heritability (including the independence between genetic and environmental factors, minimum interaction among nonallelic genes, and the 'bell-shaped' distribution of susceptibility in threshold theory) may not hold.

Finally, the numerator of heritability, V_a (or V_a+V_d), is the variance of multiple allelic (and dominant) genes. By integrating many small components into a single large one, mistakes are more likely to occur, since each component contributes some errors.

The heritability of attributes calculated from different studies varies greatly. In the context of BW, we have already discussed this issue in section 2.2. Methodologic evolution in this field might explain some of the discrepancies in results obtained at different periods of time. Rao and Morton criticized the 'inconsistent' and 'greatly oversimplified' models developed in earlier stages, and advocate the 'power of resolution' of path analytic methodology in distinguishing the degree of biological and cultural determination of traits aggregating in families (48). But since more arbitrary assumptions are needed in the more advanced models, other problems might occur. In a critique of path analysis, Karlin et al (49) pointed out that for the same data on IQ heritability, Rao and Morton (50) obtained an estimate of

0.68, and Rice et al. (51) an estimate of 0.29. Karlin et al doubted the usefulness of the model, since a slight change in assumptions produced such a strikingly different result. On the other hand, Cloninger et al. (52) defended the utility of path analysis by pointing out that it is primarily limited by an investigator's biological insight and analytical skill. There is no consensus on this issue yet. But one point is clear: path analysis should be used with caution.

2.3.2. Etiologic fraction analysis for dichotomized diseases and attributes and analogy to continuously distributed attributes

In the context of dichotomized attributes, such as disease presence or absence, the etiologic fraction (EF) has been used in epidemiology to partition the proportion of disease caused by a given exposure, trait, or intervention (53):

$$EF = (I_t - I_o)/I_t \qquad (5)$$

Where I_t = Overall incidence rate in the combined population of exposed and unexposed individuals

I_o = Incidence rate in unexposed individuals

EF conveys a sense of the extent to which the disease in a population might be prevented by blocking the effect of the exposure or eliminating the exposure. It is pertinent not only from the scientific point of view, but for the planning of intervention as well.

The idea used for dichotomized attributes can be easily

adapted to continuously distributed attributes:

$$EFV = (V_t - V_o)/V_t \qquad (6)$$

where EFV = "etiologic fraction for variance"

V_t = overall variance in the combined population of exposed and unexposed individuals

V_o = variance in the unexposed individuals

Formula (6) is nothing new. V_a in Formula (4) or $(V_a + V_d)$ in Formula (3) is merely replaced by V_e. So Formula (6) can be re-written as:

$$EFV = V_e/V_t \qquad (7)$$

where V_e = variance due to specific exposures, traits, or interventions. (This may be a combination of nongenetic factors and does not necessarily denote environmental variance, as I will discuss later.)

As with EF, EFV is determined by the effect of the exposures (or traits or interventions) and the proportion of the target population with those exposures, traits, or interventions. EFV is equivalent to r^2 in linear regression or correlation analysis with continuous dependent variables. We prefer the term EFV, because it avoids confusion with the test for 'goodness-of-fit,' is more straightforward to clinicians and public health workers, and is analogous to the term of EF for dichotomous phenomena. But since readers are more familiar with r^2, r^2 will still be used in place of EFV in much of this thesis.

The advantages of using EFV appear to overcome many of the limitations of the heritability approach. EFV can be calculated from data available in clinical records or epidemiologic studies. It does not require a clear distinction between genetic and environmental determinants. Epidemiologists often use the term 'risk factor' to denote a factor that may affect disease or attribute distribution in populations. Risk factors include demographic descriptors, such as sex, race, and age; socioeconomic indices, such as family income and educational attainment; exposure to specific toxic substances, such as cigarette smoking, alcohol, social drugs, and chemicals; and 'genetic risk factors,' as represented either by a positive family history or by polymorphic genetic markers. Although less satisfactory from a purely mechanistic point of view, this epidemiologic approach has proven fruitful. Finally, rather than trying to partition total variance into two pieces (genetic and environmental), this approach can be utilized to partition variance of more specific exposures, traits, or interventions from the total variance.

Compared with EF, the advantage of EFV is that it can take the whole distribution into account. On the other hand, EFV cannot examine whether the variation stems primarily from the left or right extremes of the distribution. Since clinicians are usually more interested in abnormal individuals or values, which are often located in one of the tails of the

distribution, EFV may not be as clinically meaningful as EF. In this sense, EFV and EF analyses complement one another.

One disadvantage of EF is that by dichotomizing the outcome, precision will be lower than when using the corresponding EFV. Another difficulty in the EF calculation is that the choice of cutpoint and reference, especially for multi-category determinants, is arbitrary; the proportion 'exposed' will change according the choice of cutpoint and reference. This will create difficulties in comparing EFs for different determinants in the same population, as well as EFs for the same determinant in different populations.

2.3.3. The role of other conventional approaches in delineating interrelationships between genetic and environmental determinants for dichotomized or continuously distributed diseases and attributes

A variety of epidemiologic approaches have been used to investigate the genetic and environment determinants of diseases.

2.3.3.1. Immigrant study

Immigrant populations are of epidemiologic interest, because they provide opportunities for clarification of mechanisms of unique distribution patterns of certain diseases and health-related attributes noted in particular geographic regions or particular ethnic groups (54). In theory, studies of immigrant

populations should provide powerful tools in distinguishing genetic effects from environmental effects, since they enable comparison of persons of similar genetic background (same ethnic group, for instance) living in different environments (e.g., in different countries), and of persons with different genetic backgrounds living in the same environment. Generally speaking, if the distribution of diseases or other health-related attributes is similar for the same ethnic group living in different countries, but different for different ethnic groups living in the same country, the diseases or attributes are more likely to be genetically determined; otherwise the diseases or attributes are more likely to be environmentally determined. In practice, however, interpretation of the available evidence is rather difficult. The extent to which immigrants retain specific environmental characteristics of their homeland is, for example, highly variable. If the main environmental determinants in immigrants remain the same as in their homeland, the major argument that their environment has been changed is invalidated.

One way to overcome this difficulty is to measure both the distribution of environmental determinants and the distribution of diseases or other health-related attributes in immigrants simultaneously, and to compare these distributions both with those of native populations from the immigrant's homeland and those of natives from the adoptive country. If the distribution of environmental determinants and

distribution of diseases or other health-related attributes in immigrants are both similar to that of the homeland's native population but different from that of the adoptive country's, however, no useful information is obtained to permit inferences concerning genetic vs environmental etiology.

Most immigrant studies of diseases or other health-related attributes (55-57), including immigrant studies of BW distributions (15,17), have been based on vital statistics (e.g., birth certificates) or other registry data, and often lack important information on environmental determinants.

2.3.3.2. 'Risk-free' subsample comparison

In this approach, comparison is made between subjects of different ethnic groups at 'risk-free' levels of environmental determinants. A diminished or absent ethnic group difference in 'risk-free' subsamples, as compared with overall populations, would suggest an environmentally-determined distribution of diseases or attributes, while an unchanged ethnic group difference would suggest a genetically-determined distribution. In addition, by selective choice of specific environmental determinants in a step-by-step way, the effect of each individual environmental determinant can be examined. But the quantitative estimation of environmental effect by this 'risk-free' approach depends on quantitative estimation of the effect of each environmental determinant used to define 'risk-free' subsamples.

The 'risk-free' approach can usually eliminate only extreme determinant values, since otherwise the remaining sample size would be too small for suitable comparison. Thus residual 'normal' variation of determinants might still exert a substantial influence on outcome distributions.

One obvious advantage of such a 'risk-free' subsample comparison over approaches like multivariate analysis is its straightforwardness and visibility. Another advantage is that it examines not only one particular parameter (such as mean or prevalence), but the entire distribution.

2.3.3.3. Matching

Matching has been widely used in epidemiologic research of disease etiology (58). The principle of matching in multi-ethnic population comparisons is the same as in other epidemiologic research. The comparability of environmental determinants for different ethnic groups depends on the matching conditions, and should theoretically be as high as possible. Similar to the 'risk-free' subsample comparison approach, a diminished or absent ethnic group difference in an environmentally-matched sample comparison would suggest predominant environmental determination, while a retained or unchanged ethnic group difference would suggest a genetic etiology. But the power of 'matching' in distinguishing a genetic vs environmental effect again depends on a clear understanding of the mechanism of each individual determinant

used in matching. If most of the 'determinants' are environmental, one can declare rather confidently that most of the 'removed' effects are environmentally-related; otherwise, little useful information is obtained.

2.3.3.4. Conventional multivariate regression analyses

Ready access to multivariate analysis and computers has substantially facilitated modern epidemiologic research (58). In a multi-ethnic group comparison, for example, one can "easily" examine the independent ethnic effect by entering a term for ethnic status into a multiple linear or multiple logistic model. If the ethnic group difference in diseases or other health-related attributes is significant in a 'crude' comparison but diminishes or disappears in a multivariate analysis, one can infer that the 'crude' ethnic group difference is explained by those covariates included in the model. The ability of multivariate analyses to make a 'fair' adjustment for independent racial/ethnic-related genetic effect estimation, however, depends on clear understanding of the mechanisms of 'covariates' in the models. If most of the 'covariates' are environmental, a 'fair' independent racial/ethnic-related genetic effect estimation is likely; otherwise, 'over-adjustment' might occur (since the racial/ethnic-related genetic effect might be partially mediated through the other covariates).

Multiple linear regression estimates the mean for continuous

outcomes, while multiple logistic regression estimates prevalence or incidence for dichotomous outcomes. To address the issue of a "tight" distribution, however, the entire distribution should be examined. As a result, one cannot rely solely on multivariate analysis. Other approaches, like 'risk-free' subsample comparisons and etiologic fraction analyses, should be utilized as well.

2.3.4. Summary

Few diseases or other health-related attributes are determined solely by either genes or the environment. Furthermore, one usually does not know, when beginning an investigation of diseases or other health-related attributes, whether and to what extent they are genetically or environmentally determined.

As major determinants of the frequency and distribution of diseases and other health-related attributes, genes must be considered in the development of hypotheses proposed to explain epidemiologic observations. Recognizing the complexity of determinants of diseases or other health-related attributes, modern epidemiology has aimed at isolating specific environmental effects, especially modifiable environmental effects (59). In this context, genetic effects have been treated as confounding factors, much like other environmental confounding factors.

It is clear that a quantitative estimation of overall

genetic effect (and thus, by subtraction, a quantitative estimation of overall environmental effect) by population genetic approaches is of great theoretical and practical importance. But such a quantitative estimation requires a clear understanding of the mechanisms of diseases or other health-related attributes to make adequate assumptions for modeling. Unfortunately, such a clear understanding of the mechanisms is often lacking for many diseases and attributes. Simpler and more straightforward epidemiologic approaches, such as etiologic fraction analysis, 'risk-free' subsample comparison, and conventional multivariate analysis, require fewer assumptions, although usually only a "semi-quantitative" estimation is possible. Using such conventional epidemiologic approaches to derive a preliminary understanding of disease mechanisms, we can then apply this knowledge to construct more sophisticated models capable of yielding more quantitative estimation.

CHAPTER 3. SUBJECTS AND METHODS

3.1. Study Sites

This study was carried out in Montreal, the second largest city in Canada, with a population of 2.7 million, and Hefei, a middle-sized city in central China with a population of 1 million. Both cities are at sea level. The economic development in Hefei is about the national average of China, which is much lower than Canada. The study sample was taken from Montreal's Royal Victoria Hospital (RVH) and Hefei Maternal and Infant Hospital (HMIH). Both institutions are University Teaching Hospitals, with comparable staff and equipment support for ordinary maternal and infant health care. The patients in both institutions comprise mainly local urban residents, with some high-risk patients referred from remote districts or rural areas.

3.2. Study Populations

Three study groups were included in the analysis: Canadian Caucasian, Canadian immigrant Chinese, and native Chinese. The sources of the study subjects are as follows:

1) The McGill Obstetric and Neonatal Data Base (MOND), derived from births at Montreal's RVH from January 1, 1978, to March 31, 1990. In April, 1977, a proposal was made to develop a computerization system for RVH to collect research-oriented perinatal data, including data for both mother and baby, for

all deliveries in the hospital (60). A coding manual and code sheet were developed by January 1978 after extensive discussions among a neonatologist, an obstetrician, an information officer, and an engineer (60). Maternal and infant charts were coded after discharge by a clerk for routine entries, and by three professionals (nurse, obstetrician and neonatologist) for items requiring judgmental decision (60). There are currently 221 items of data for each mother/baby case (60). Only 15 items were selected from them for the current study. There were approximately 45,000 deliveries during the 12-year study period in this hospital. Since referred patients were usually at high risk for adverse pregnancy outcomes (including LBW), such patients were excluded from the analysis.

Unfortunately, no racial/ethnic information is available in MOND. So a list of Chinese family names was obtained from Montreal's Chinese Community Association, and a computer program was created to select Chinese women in the data set by the mother's maiden name. Most (>95%) of the Chinese mothers' maiden names are unique enough to distinguish them from other racial/ethnic groups. A list of Chinese mothers' maiden names recorded in MOND is contained in Appendix A.

There were some difficulties, however, in distinguishing some mothers' maiden names obtained from MOND, mostly because of sharing names with Caucasians. When these difficulties occurred, the following algorithm was used to determine the

mother's racial/ethnic groups. If the name is uncommon among the Chinese but common in other ethnic groups, or if the name is uncommon both in Chinese and in other ethnic groups (such as Lang), or if the name is common both in Chinese and other ethnic groups but the number of subjects in the data base was small (such as Young), the subject was excluded from the analysis; if the name is common in Chinese but uncommon in other ethnic groups and the number of subjects in the data base was large (such as Lee), the subject was classified as Chinese if she was born in a non-Caucasian country (denoted in the data base as 'other') but was excluded from the analysis otherwise. [Since the sample size for Caucasians is quite large, and since we expect most of the Chinese mothers to have been born outside Canada (Appendix B), the latter decision rule should minimize misclassification of ethnic group without substantial loss of informative study subjects.] 1,597 deliviries were identified as given by Chinese women using this algorithm.

The remaining subjects from MOND served as the basis for native Caucasian mothers. Montreal has long been a predominantly Caucasian society, but in recent years, immigrants from Haiti, Southeast Asia, and other non-Caucasian countries and regions have changed the picture. To reduce misclassification of racial/ethnic status of the study subjects, only women born in Canada and other predominantly Caucasian countries (after excluding those with Chinese names)

were classified as Caucasian. Since mother's place of birth was not recorded in MOND before 1983, the Canadian Caucasian group included only those deliveries between January 1, 1983 and March 31, 1990. As a result, 18,665 deliveries were identified as given by Canadian Caucasian women from this source.

2) Prospective data collection in Mainland China: prospective data collection for native Chinese births was undertaken at HMIH, a teaching Hospital of Anhui Medical College, at Hefei, Anhui province, P.R. of China, from September 1, 1990, to August 31, 1991. The same information recorded in MOND was collected in China (Appendix C). There were 1,862 nonreferred deliveries in HMIH during the study period, all of them native Chinese.

3.3. Outcome Measures

1) BW. First weight (within 24 hours) after birth (live birth) or death (fetal death) to the nearest 5 grams.

2) GA. Both early ultrasound-determined GA (calculated from ultrasound measurement of fetal biparietal diameter (BPD) usually at 16-18 weeks, almost all before 20 weeks of GA) and LNMP-determined GA estimates were retrieved from the medical charts (HMIH) or the computer file (MOND). The same table for ultrasound-determined GA calculation was used for patients at both institutions (see Appendix D). The analyses were based on GA calculated from LNMP, but in the main analyses (results

presented in the body rather than in the Appendix), only subjects with concordant (±10 days) ultrasound- and LNMP-determined GAs were included.

3) Indices derived from BW and GA. FGR: ratio of the observed BW to the mean BW-for-GA (in days) for the RVH population as recently updated (61,62). All of the births at the RVH and in China used a single standard (see Appendix E) to calculate the FGR. LBW: BW <2,500 grams, high BW (HBW): BW >4,000 grams, Preterm delivery: GA <37 completed weeks, Postterm delivery: GA >=42 weeks, small-for-GA (SGA): FGR <0.85, large-for-GA (LGA): FGR >1.15.

3.4. Potential Determinants

The importance of the determinants (in terms of their prevalence and previously reported effect sizes), as well as the validity and reproducibility of their measurement, have been taken into consideration in choosing potential determinants for the current study. The determinants listed below are those meeting these criteria:

1) Genetic and constitutional factors: infant sex and maternal race and height.

2) Socioeconomic factors: maternal age, educational attainment, marital status, and country of current residence.

3) Behavioural factors: maternal cigarette smoking and alcohol and social drug use during pregnancy.

4) Nutritional factors: prepregnancy body mass index (BMI,

weight/height^2 in kg/m^2) and net gestational weight gain rate [(last weight before delivery - prepregnancy weight - BW)/GA in kg/week)].

5) Medical factors: parity, severe pregnancy-induced hypertension (PIH), and diabetes (either gestational or pre-existing).

Records of maternal educational attainment were incomplete in MOND, especially for earlier years of the data. Data for this variable on the Quebec provincial birth certificate, on the other hand, were fairly complete. To reduce missing values for this variable, Montreal metropolitan area birth certificate files (1978 to 1986 files only, after that the hospital code was removed from the birth certificate, which made it difficult to merge the birth certificate file with MOND) for births at the RVH were merged with MOND and matched by mother's name, baby's sex, delivery date, and BW.

3.5. Data Management and Quality Control

All of the data from MOND were retrieved from RVH's medical charts and computerized in the manner shown in Appendix C. Routine clinical and demographic measurements from MOND were taken by staff at the RVH or obstetricians' offices. Neither hospital nor office staff responsible for data collection were aware of the current study when they collected the data. To ensure comparability of data obtained from Montreal's RVH and Hefei's HMIH, not only was the data sheet for prospective data

collection in HMIH constructed in the same way as that used by the RVH, but the data collection procedure was kept the same as that used at Montreal's RVH as well. The only difference was that while all of the data in MOND were retrieved from RVH's medical charts, information on maternal educational attainment and cigarette smoking, alcohol, and social drug use during pregnancy in HMIH were obtained by interviews with the patients by a research nurse during the patient's postpartum hospital stay, since such information was not available in the medical charts at that hospital. There is no need to request the race for native Chinese mothers, since as in other Han-dominated cities in China, the likelihood of non-Chinese residents in Hefei is nil.

The distribution for each variable was first examined, and outliers were identified and assigned as missing according to the following criteria: BW <500 g, GA >322 days, FGR <0.4 or >1.4, height <130 cm, prepregnancy weight or last weight before delivery <30 kg, maternal age <15 or >50, completed years of schooling >35, cigarette smoking per day >50. Fewer than 1% of the variables were assigned as missing by these criteria.

3.6. Data Analyses

3.6.1. Comparisons of outcomes and determinants among Caucasian, immigrant Chinese, and native Chinese infants

3.6.1.1. Outcomes

Outcomes were compared using tables and graphs. Means, standard deviations (SDs), and coefficients of variation (CVs) of BW, and prevalences of LBW and HBW for Caucasian, immigrant Chinese, and native Chinese are presented in tabular form as follows: I. total study subjects; II. live births (to test the natural selection theory); III. singleton, non-malformed live births to mothers without severe PIH (to examine if differences in those maternal and infant conditions among the three study groups would change the BW distribution comparison); IV. 'risk-free I' subsample: singleton, non-malformed live births to mothers without severe PIH, who did not smoke, or drink regularly, or use social drug(s) during pregnancy, whose height ranged from 151cm-171cm, whose prepregnancy BMI ranged from 17.8-<26.0, and whose net gestational weight gain rate ranged from 0.15-<0.40 kg/week, including subjects with missing values for any of the above determinants. [The 'risk-free' ranges for maternal height, prepregnancy BMI, and net gestational weight gain rate are derived in part from previous studies on BW (1,63), which have shown that values beyond these ranges probably represent 'growth-inhibiting' ('growth-accelerating)') or 'gestation-

shortening' ('gestation-prolonging') levels. Statistical stability (sufficient sample size) has also been considered in choosing the cut-off points, however. Moreover, some "residual" risk in the 'risk-free' sample is still likely. However, since same criteria have been employed for the three study groups, such kind of trade-off should not affect our comparisons among the three study groups]; V. 'risk-free II' subsample: subjects with the same determinant range as defined in IV, but excluding those with missing values for any of these determinants. Since a substantial proportion of values for maternal height, prepregnancy BMI, and net gestational weight gain rate were missing in Caucasian and immigrant Chinese patients, using two 'risk-free' (I and II) subsamples in the comparison allows us to examine whether including or excluding subjects with one or more missing values for these determinants distorts the 'risk-free' subsample comparison.

One-way ANOVA was used to test differences in means, chi-square was used to test differences in proportions, and Bartlett's test (64) was used to test differences in variances among Caucasian, immigrant Chinese, and native Chinese.

The overall distribution of BW is presented graphically using traditional frequency plots. Graphic presentations follow the same scheme as the tabular presentations. In addition to visual inspection, skewness and kurtosis coefficients have also been calculated to facilitate the graphic comparisons.

The same tabular and graphic presentations were then followed for GA and FGR distributions, to assess whether the Chinese-Caucasian differences in BW distribution could be attributed to GA or FGR.

The prevalence of SGA at preterm, term, and postterm deliveries, and mean BW and mean FGR as a function of GA (in weeks), are also presented in tabular form for Caucasian, immigrant Chinese, and native Chinese infants.

Since outcome distributions in males and females in Caucasians, immigrant Chinese, and native Chinese showed similar patterns, and since sex ratios in the three study groups were similar, males and females were combined in all of the presentations to preserve a reasonable sample size. Elective cesarean section has a strong effect in shortening GA (and therefore in reducing BW). But since cesarean section rates were quite similar in the three study groups, and since a substantial proportion of women had a cesarean section (about 20% in each study group), the analyses were not further restricted to spontaneous births.

Multiple births, congenital malformation, and severe PIH are also strongly associated with GA and/or FGR. The prevalences of these conditions were quite different in native Chinese vs immigrant Chinese and in native Chinese vs Caucasians. Since we are not interested in the association between these conditions and BW, however, and since the diagnostic criteria and reporting for congenital malformations and the management

of severe PIH in China are likely to be different from those of in Canada, subjects with multiple births, congenital malformations, and severe PIH were also eliminated in subsample III comparisons, bivariate analyses, and multivariate analyses.

To reduce misclassification of GA and FGR, the results of principal analyses (those presented in the text, rather than the appendices) are based on subjects with concordant ultrasound- and LNMP-determined GAs. To assess if excluding subjects with discordant GAs and/or unavailable ultrasound-determined GA has created a biased sample, comparisons of distributions of outcomes were also made for subjects without exclusions for discordant ultrasound- and LNMP-determined GAs.

Finally, to obtain a more comparable sample of the three study groups in terms of parity, outcomes were also compared for primiparas separately.

3.6.1.2. Potential determinants

For this part of the analysis, distributions of potential determinants for all Caucasian, immigrant Chinese, and native Chinese infants are presented first. Principal analyses for the distributions of GA and FGR among Caucasian, immigrant Chinese, and native Chinese infants are based on subjects with concordant ultrasound- and LNMP-determined GA. To assess whether using subjects with concordant GAs creates a biased comparison of GA and FGR distributions in terms of

determinants, distributions of determinants in those subjects are described as well. Initial analysis showed that 88% of native Chinese were primiparas, while less than 50% of Caucasian and immigrant Chinese were primiparas. To obtain a more comparable picture of determinant distribution in terms of parity, distributions of determinants for the three groups are therefore compared for primiparas separately.

One-way ANOVA was used to test differences in means, chi-square was used to test differences in proportions, and Bartlett's test (64) was used to test differences in variances among Caucasian, immigrant Chinese, and native Chinese.

3.6.2. Bivariate analyses

Bivariate analyses were performed to examine the relationships between various determinants and outcomes, to assess if the previously reported determinant-outcome relationships were evident in our data, and to help us in selecting determinants and their categorizations in the multivariate models. Means of BW, GA, and FGR, and proportions of LBW, HBW, preterm delivery, postterm delivery, SGA, and LGA across various categories of the determinants are presented separately for Caucasian, immigrant Chinese, and native Chinese infants. The interpretation of the results of these analyses is based on the magnitude and consistency of the differences, rather than statistical significance, owing to two considerations. First, determinant-outcome relationships

are not considered one of the primary objectives of the thesis. Second, weak associations among Caucasian infants may be statistically significant because of the large sample size, while strong associations in the two Chinese groups may be not statistically significant because of their limited sample sizes. Thus in neither case would statistical significance be helpful in interpretation.

For reasons discussed above, bivariate analyses were restricted to singleton, nonmalformed live births to mothers without severe PIH. To avoid misclassification of GA and FGR, bivariate and multivariate analyses for these outcomes were based on subjects with concordant ultrasound- and LNMP-determined GAs.

3.6.3. Multivariate analyses

Multiple linear regression analyses for continuous outcome variables (BW, GA, and FGR) [SAS software (65)] were performed first for Caucasian, immigrant Chinese, and native Chinese infants separately, followed by multiple linear regression [SAS software (65)] and multiple logistical regression [BMDP software (66)] for all subjects in the three study groups combined.

Potential determinants included in the initial multiple linear regression models for the three study groups were infant sex, maternal age, educational attainment, marital status, cigarette smoking, alcohol consumption, social drug

use during pregnancy, height, prepregnancy BMI, and net gestational weight gain rate. The determinant variables were coded as follows: sex: male = 0, female = 1; marital status: currently married = 0, others = 1; cigarette smoking: none = 0, 1-10 = 1, 11-19 = 2, >=20 = 3; alcohol consumption: none = 0, occasional = 1, >=1 drink/d = 2; social drug use: none = 0, any = 1; all other determinants analyzed were based on the original values.

For the multiple logistic regression models, all of the determinants were entered as dummy variables. The categorization for determinant variable was based partly on previous published studies (1,63). However, some adjustment was made, to preserve a reasonable sample size in each category of the determinants, while maintaining a strong contrast in the determinant-outcome relationships. The categories for each determinant variable in the current multiple logistic regression models were thus: infant sex: male, female; maternal age (years): <20, 20-29, 30-34, >=35; maternal marital status: currently married vs unmarried; parity: primiparous vs multiparous; maternal educational attainment (years completed): 0-10, 11-12, 13-16, >=17; mother's smoking during pregnancy (cigarettes/day): 0, 1-9, 10-19, >=20; alcohol consumption during pregnancy: none, occasional, >=1 drink/day; social drug use during pregnancy: no vs yes; maternal height (cm): <151, 151-160, 161-169, >=170; prepregnancy BMI (weight/height^2 in kg/m^2): <17.8, 17.8-

<19.8, 19.8-<26.0, >=26.0; net gestational weight gain rate (kg/week): <0.15, 0.15-<0.30, 0.30-<0.40, >=0.40.

Since missing values for one or more of the potential determinants led to a large reduction in cases available for analysis, those variables failing to reach threshold significance ($p = 0.05$) in the models with the largest sample size (Caucasian) for any of the three main outcomes (BW, GA, and FGR) or their dichotomized measures were excluded from subsequent regressions. Maternal alcohol consumption reached a marginally significant level in initial analysis for Caucasian infants, but the effect was small (caused probably by poor measurement of this determinant). In addition, it was not possible to analyze this variable for our native Chinese sample (because all of them were nondrinkers). To avoid noncomparability of models among the three main study groups, maternal alcohol consumption was also excluded from subsequent regressions. The results presented in this thesis are based on the latter regression model.

To ensure that the same number of determinants remained in linear regression models for the three study groups, no stepwise procedure was used at this phase of analysis. For each potential determinant in each of the three study groups, the results are reported as the regression slope (b), its 95% confidence interval (CI), and its corresponding r^2. (As discussed in Chapter 2, the r^2 for a given determinant represents its EVF.)

In addition to the above-discussed determinant variables in the separate multiple linear regressions for each study group, maternal race (Chinese = 0, Caucasian = 1) and current country of residence (Canada = 0, China = 1) were also included in models combining study subjects from all three study groups for the purpose of assessing independent racial/ethnic effects. Two phases of analysis were performed for BW and FGR, and for their dichotomized indices: (1) models without controlling for GA, and (2) models in which the potential confounding and modification of GA on the racial/ethnic effect were examined simultaneously. To facilitate the interpretation of effect modification, GA was entered as a dummy variable (preterm vs term vs postterm) during the second phase of the analysis, with term delivery as the reference.

Considering the number of statistical analyses performed in the thesis, several safeguards were followed to avoid erroneous inferences (type I errors) stemming from multiple comparisons. First, the objectives and analytic strategies were established well before the data editing and analysis, and no change in strategy or omission of inconsistent results occurred. Second, the interpretation of the results is based largely on the magnitude of effects, internal and external consistency, and biological plausibility, rather than statistical significance alone.

Residuals analysis and collinearity assessment were performed for all of the linear regression models. For reasons

of space, only the results of regression models for BW in which GA was entered both as a confounding factor and an interaction term (with maternal race) are presented. The accuracy of logistic regression modelling was assessed by overall goodness-of-fit, consistency of results obtained from logistic regression with results obtained from bivariate analysis and linear regression analysis for underlying continuous measures, and consistency with the published literature.

To assess if excluding subjects with discordant ultrasound- and LNMP-determined GAs and/or unavailable ultrasound-determined GA has resulted in a biased sample, multivariate analyses were also performed for subjects without discordant GA exclusions.

CHAPTER 4. RESULTS

4.1. Distributions of Outcomes in Caucasian, Immigrant Chinese, and Native Chinese Infants

4.1.1. Overall BW, GA, and FGR distributions

Figures 1-3 and Tables 2-5 examine whether the lower mean BW, "tighter" overall BW distribution, similar LBW rate, and much lower HBW rate in ethnic Chinese infants reported in other studies are also observed in our study population, and whether such a different BW distribution pattern in ethnic Chinese infants is due to differences in the distribution of GA vs FGR. These tables and figures also demonstrate whether patterns among ethnic Chinese infants in the overall sample are also observed in live births (to test the natural selection theory) and 'risk-free' subsamples (to test the environmental determinants theory).

Table 1 shows the sample sizes in the Caucasian, immigrant Chinese, and native Chinese study groups. While the sample size for Caucasians was quite large, sample sizes for the two Chinese groups were limited, especially in the 'risk-free' subsamples.

Table 1. Sample size in all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V) among Caucasian, immigrant Chinese, and native Chinese subjects, concordant ultrasound- and LNMP-determined GA*

	Caucasian	Immigrant Chinese	Native Chinese
I	11,037 (100.0)	723 (100.0)	581 (100.0)
II	10,988 (99.6)	722 (99.9)	577 (99.3)
III	10,142 (91.9)	665 (92.0)	550 (94.7)
IV	3,986 (45.6)	408 (67.5)	309 (57.3)
V	2,291 (27.0)	148 (25.9)	305 (56.6)

* Results are given as number (percent)

Graphic presentations show that the distributions of BW in the two Chinese groups were nearly identical with one another, but that both differed from Caucasians, with a 'left-shifted' and 'peaked' distribution in the two Chinese groups (Figure 1). The GA distributions in the three study groups were different from those for BW: slightly 'left-shifted' in immigrant Chinese and slightly 'right-shifted' in native Chinese compared with Caucasians (Figure 2). FGR in the two Chinese groups was also 'left-shifted' compared with that of Caucasians, but the 'peaking' was less obvious than for the BW distribution (Figure 3). The graphic changes from the overall sample to 'risk-free' subsamples (subsample I to subsample V) were less obvious and difficult to detect by visual inspection for any of the outcome measures (BW, GA, and FGR).

The coefficients of skewness and kurtosis for BW and GA in immigrant Chinese infants were as large as those in Caucasian infants, whereas the coefficients for FGR in the two Chinese groups were larger than in Caucasian infants. Possible reasons for these inconsistent results will be discussed in Chapter 5.

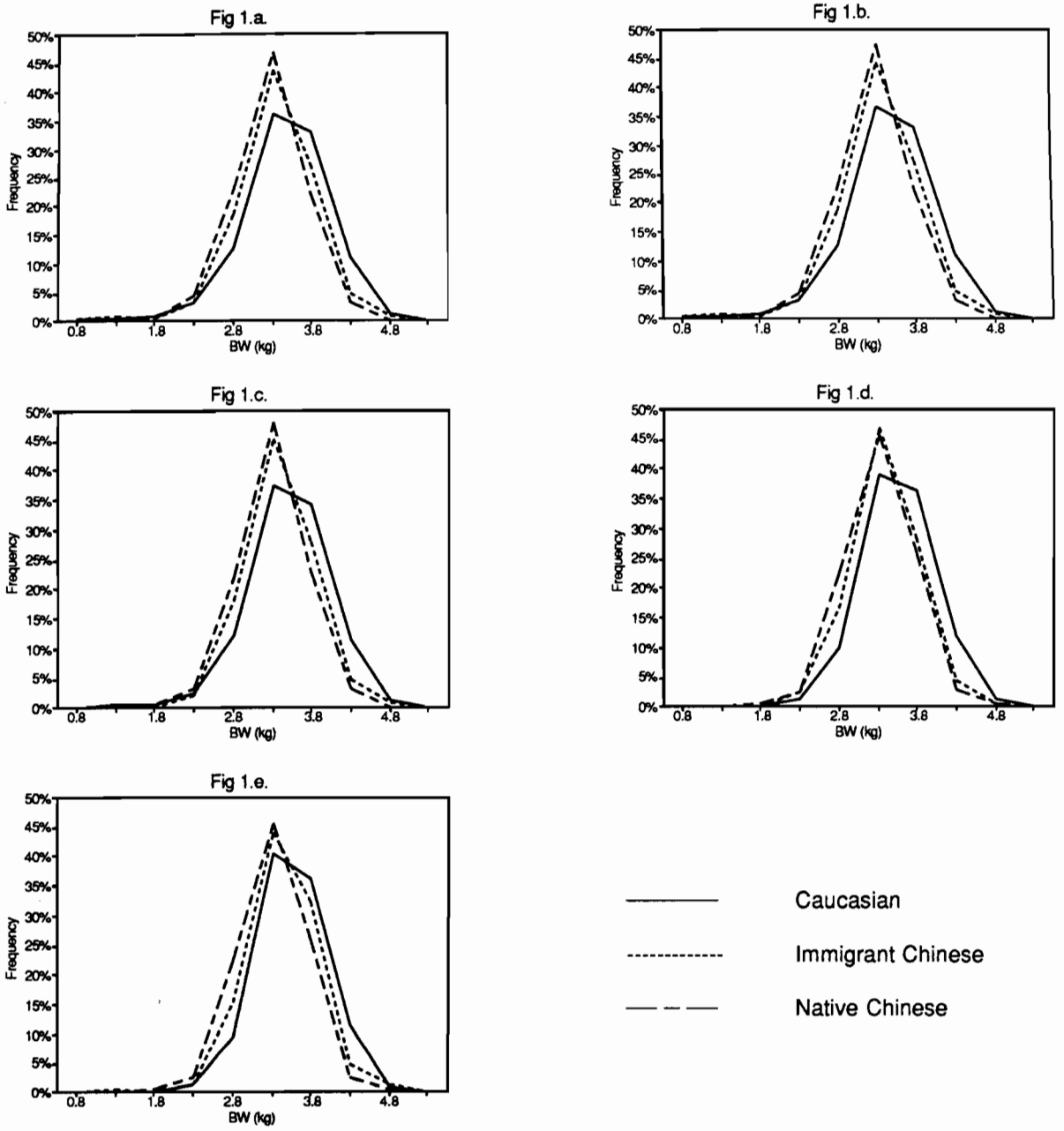


Figure 1. BW distribution in Caucasian, immigrant Chinese, and native Chinese infants, concordant ultrasound- and LNMP-determined GA: a. all births; b. live births; c. singleton, live, non-malformed births to mothers without severe PIH; d. 'risk-free I' births; e. 'risk-free II' births

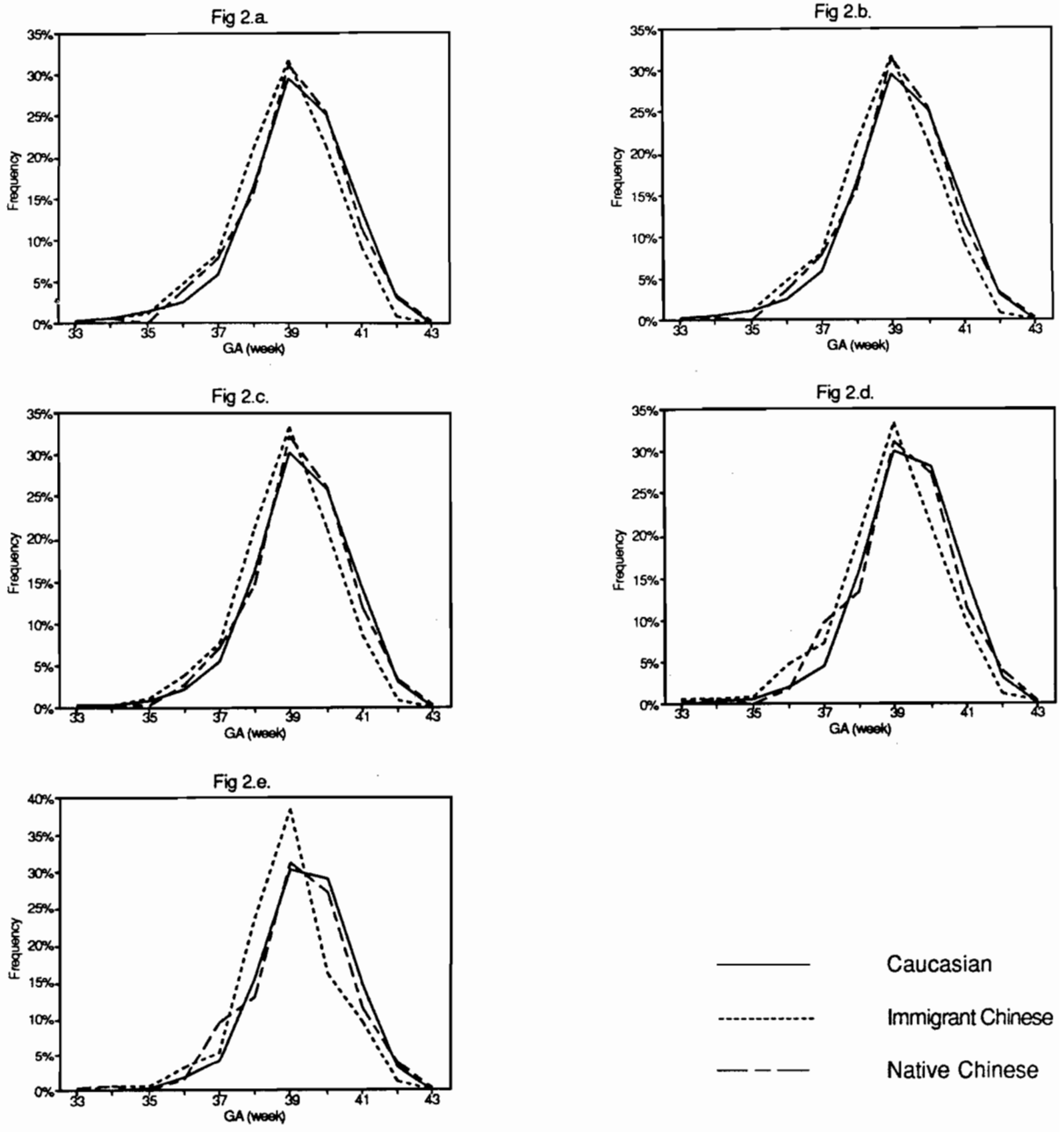


Figure 2. GA distribution in Caucasian, immigrant Chinese, and native Chinese infants, subjects with concordant ultrasound- and LNMP-determined GA: a. all births; b. live births; c. singleton, live, non-malformed births to mothers without severe PIH; d. 'risk-free I' births; e. 'risk-free II' births

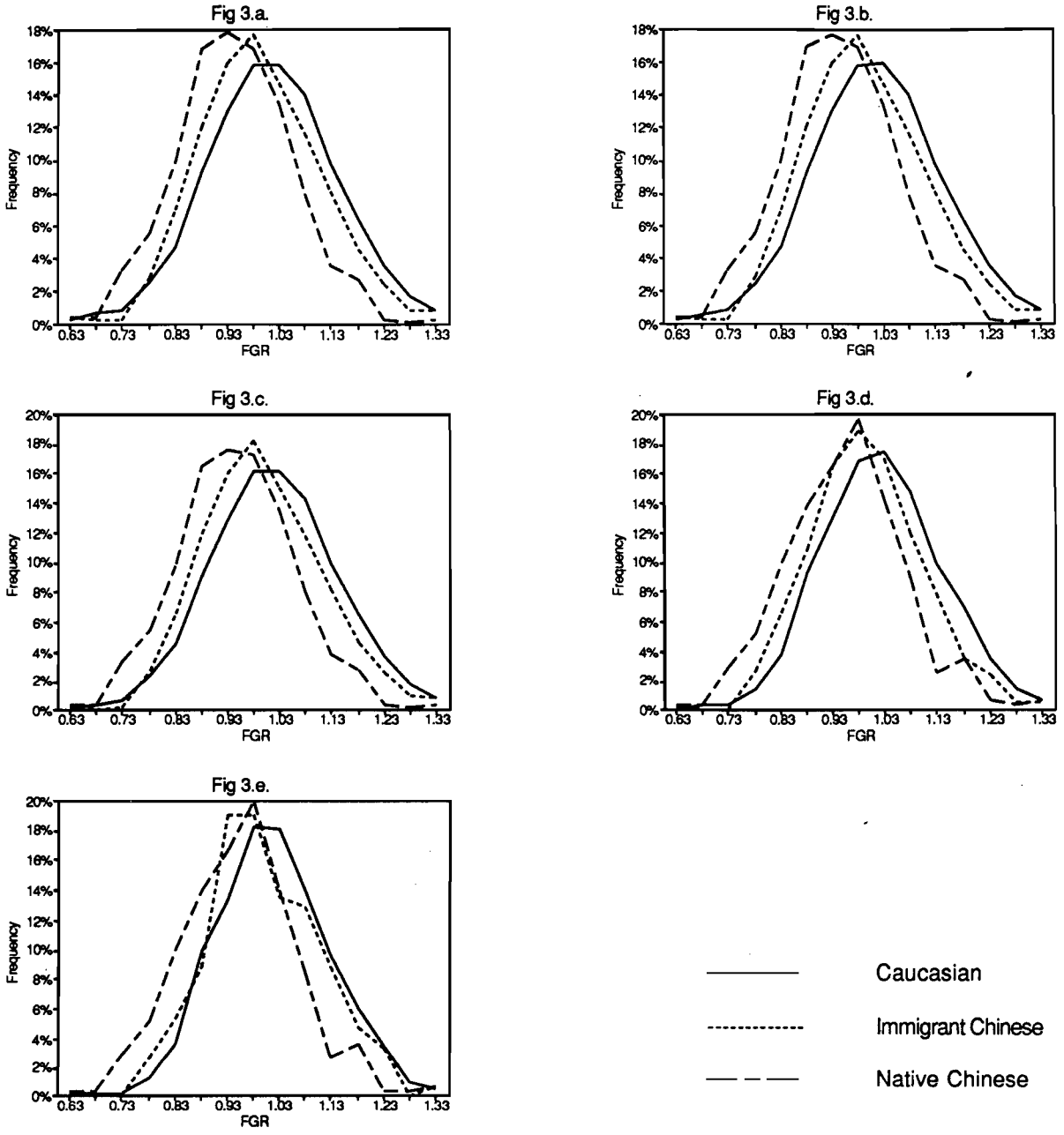


Figure 3. FGR distribution in Caucasian, immigrant Chinese, and native Chinese infants, concordant ultrasound- and LNMP-determined GA: a. all births; b. live births; c. singleton, live, non-malformed births to mothers without severe PIH; d. 'risk-free I' births; e. 'risk-free II' births

On the other hand, the comparison of skewness and kurtosis coefficients from the overall sample to 'risk-free' subsamples showed clearer changes; the absolute values decreased (indicating less skewness and less spread) in 'risk-free' subsamples, especially for BW and FGR, although some fluctuations were observed for the two Chinese groups because of limited sample sizes (Table 2).

Table 2. Comparison of skewness and kurtosis coefficients for BW, GA, and FGR distributions among Caucasian, immigrant Chinese, and native Chinese infants of all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V), concordant ultrasound- and LNMP-determined GA

	Caucasian		Immigrant Chinese		Native Chinese	
	Skewness	Kurtosis	Skewness	Kurtosis	Skewness	Kurtosis
BW, g						
I	-0.92	3.11	-0.88	3.42	-0.10	0.65
II	-0.79	2.69	-0.88	3.44	-0.00	0.42
III	-0.49	2.17	-0.53	2.90	0.05	0.51
IV	-0.41	2.31	-0.63	3.08	0.23	0.86
V	-0.34	1.81	-0.42	2.94	0.03	0.90
GA, d						
I	-2.90	16.18	-2.78	14.63	-1.12	4.07
II	-2.67	14.82	-2.79	14.67	-0.79	2.24
III	-2.41	15.24	-2.29	12.50	-0.87	2.74
IV	-2.11	14.01	-2.35	12.54	-1.02	3.15
V	-1.74	12.66	-2.90	18.91	-1.03	3.20
FGR						
I	-0.03	0.36	0.16	0.53	0.13	0.32
II	0.03	0.17	0.16	0.52	0.13	0.32
III	0.09	0.09	0.31	0.19	0.19	0.23
IV	0.10	0.02	0.30	0.30	0.21	0.47
V	0.12	0.04	0.40	0.28	0.21	0.51

Table 3 shows that Caucasian infants were about 150 g heavier, on average, than immigrant Chinese infants, and 250 g heavier than native Chinese infants. This discrepancy in mean BW was largely attributable to differences in mean FGR, although GA differences contributed a small portion of the gap

in BW between Caucasian and immigrant Chinese infants. For the comparison between native Chinese and immigrant Chinese infants, the difference in mean BW contradicted the findings for mean GA: while the mean BW in native Chinese infants was lower than immigrant Chinese infants, their mean GA was higher (Table 3). Mean BW, GA, and FGR changed little in subsamples excluding fetal deaths, but increased in subsamples III to V in all three study groups. As a result, mean BW, GA, and FGR remained significantly higher in Caucasian infants than in the two groups of Chinese infants, even in 'risk-free' subsamples (Table 3).

Table 3. Comparison of mean BW, GA, and FGR in Caucasian, immigrant Chinese, and native Chinese infants of all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V), concordant ultrasound- and LNMP-determined GA

	Caucasian	Immigrant Chinese	Native Chinese	F*
BW, g				
I	3410	3276	3178	64.4[a]
II	3418	3277	3185	69.2[a]
III	3453	3308	3204	87.7[a]
IV	3487	3302	3227	71.3[a]
V	3478	3356	3222	50.1[a]
GA, d				
I	276.0	273.7	276.6	10.3[a]
II	276.2	273.8	276.8	13.1[a]
III	277.0	274.4	277.3	16.2[a]
IV	277.9	274.5	277.1	20.4[a]
V	278.2	274.8	277.2	10.9[a]
FGR				
I	1.012	0.990	0.940	94.3[a]
II	1.012	0.990	0.940	98.1[a]
III	1.016	0.993	0.942	100.3[a]
IV	1.017	0.990	0.951	57.8[a]
V	1.021	1.000	0.949	45.9[a]

* One-way ANOVA for mean difference among Caucasian, immigrant Chinese, and native Chinese infants
[a] $P < 0.01$

Table 4 shows that the variation in BW, GA, and FGR was larger in Caucasian infants vs immigrant Chinese or (especially) native Chinese infants; all differences were statistically significant in comparisons of the overall study sample. But the magnitude of the difference for BW was larger than for GA or FGR. The SD and CV changed little in subsamples excluding fetal deaths, but decreased in subsamples III to V in all three study groups. But since the determinant-related decreases of SD and CV were larger in Caucasian infants, variation in BW, GA, and FGR was similar between Caucasian and Chinese infants in the 'risk-free' subsample comparisons.

Table 4. Comparison of variation in BW, GA, and FGR in Caucasian, immigrant Chinese, and native Chinese infants of all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V), concordant ultrasound- and LNMP-determined GA*

	Caucasian	Immigrant Chinese	Native Chinese	X2**
BW, g				
I	565, 0.166	503, 0.155	431, 0.136	46.7[a]
II	551, 0.161	503, 0.154	423, 0.133	40.0[a]
III	505, 0.146	462, 0.140	412, 0.129	25.6[a]
IV	464, 0.136	453, 0.138	414, 0.125	4.2[c]
V	451, 0.129	459, 0.144	413, 0.124	2.4[c]
GA, d				
I	13.7, 0.050	13.2, 0.048	11.0, 0.040	25.6[a]
II	13.0, 0.047	13.2, 0.048	10.5, 0.040	24.2[a]
III	11.5, 0.042	11.5, 0.042	10.3, 0.037	6.8[b]
IV	10.4, 0.039	12.2, 0.043	10.6, 0.038	10.7[a]
V	9.7, 0.036	11.1, 0.041	10.6, 0.038	4.5[c]
FGR				
I	0.129, 0.128	0.119, 0.120	0.111, 0.119	16.8[a]
II	0.127, 0.126	0.119, 0.120	0.112, 0.119	11.8[a]
III	0.125, 0.123	0.116, 0.116	0.111, 0.117	11.7[a]
IV	0.113, 0.112	0.107, 0.111	0.113, 0.118	1.2[c]
V	0.113, 0.111	0.112, 0.117	0.112, 0.117	0.6[c]

* Results are presented as SD, CV
** Bartlett's test for homogeneity among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$; [b] $P < 0.05$; [c] $P > 0.05$

Table 5 shows that in the overall study sample, the LBW rate was slightly lower in the immigrant Chinese, slightly higher in the native Chinese, than in Caucasian infants. LBW rates changed little in subsamples excluding fetal deaths (II), but decreased dramatically in 'risk-free' subsamples in all three study groups. But since the risk-related decrease in LBW rate was more substantial in Caucasian infants, the LBW rate was slightly lower in Caucasian infants than either immigrant Chinese or native Chinese infants in the 'risk-free' subsamples. This ethnic- and risk factor-related pattern of LBW rate distribution was also observed in the preterm delivery and SGA rates, although changes in the latter were smaller. HBW, postterm delivery, and LGA rates, on the other hand, changed little from the overall study sample to 'risk-free' subsamples. HBW and LGA rates in Caucasian infants were substantially higher than those of either immigrant Chinese or native Chinese infants, but the postterm rate was higher in native Chinese infants than in Caucasian or (especially) in immigrant Chinese infants.

Table 5. Comparison of dichotomized outcomes among Caucasian, immigrant Chinese, and native Chinese of all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V), concordant ultrasound- and LNMP-determined GA

	Caucasian	Immigrant Chinese	Native Chinese	X^{2*}
% LBW				
I	5.1	4.7	5.0	0.2[c]
II	4.8	4.7	4.7	0.0[c]
III	3.0	2.7	3.5	0.7[c]
IV	1.8	3.2	2.9	5.1[c]
V	1.6	2.0	3.0	3.1[c]
% HBW				
I	11.9	5.5	1.9	80.3[a]
II	12.0	5.5	1.9	81.1[a]
III	12.3	5.6	2.0	78.7[a]
IV	12.2	4.9	2.3	45.9[a]
V	11.1	6.1	2.3	26.6[a]
% Preterm delivery				
I	6.5	8.2	5.3	4.8[c]
II	6.3	8.2	4.9	6.2[b]
III	4.6	6.8	4.0	7.4[b]
IV	3.4	7.8	3.2	20.9[a]
V	2.8	5.4	3.3	3.3[c]
% Postterm delivery				
I	3.2	1.0	3.6	11.5[a]
II	3.2	1.0	3.6	11.9[a]
III	3.3	1.1	3.8	10.4[a]
IV	3.3	1.5	4.2	4.9[c]
V	3.3	1.4	4.3	2.6[c]
% SGA				
I	9.1	10.8	19.8	73.2[a]
II	8.9	10.8	19.8	77.6[a]
III	8.0	9.8	19.5	88.9[a]
IV	5.9	9.6	18.8	77.5[a]
V	5.6	8.2	19.0	72.0[a]
% LGA				
I	13.3	9.1	3.6	56.6[a]
II	13.4	9.1	3.6	56.4[a]
III	13.6	9.2	3.6	55.3[a]
IV	12.6	7.1	5.2	24.8[a]
V	11.1	9.6	4.9	11.5[a]

* Chi-square test for differences of prevalences among Caucasian, immigrant Chinese, and native Chinese [a] $P < 0.01$; [b] $P < 0.05$; [c] $P > 0.05$

Restricting the comparison to primiparas decreased the differences between the native Chinese and Caucasian, and between the native Chinese and immigrant Chinese. For example, the difference in mean BW between native Chinese and immigrant Chinese infants decreased to 24 g after restricting the comparison to primiparas (Table 6). More detailed comparisons

on primiparas are shown in Appendix F.

Table 6. Comparison of BW, GA, and FGR in Caucasian, immigrant Chinese, and native Chinese infants, primiparas with concordant ultrasound- and LNMP-determined GA*

	Caucasian	Immigrant Chinese	Native Chinese	F**
BW, g	3369 (567)	3195 (493)	3171 (428)	43.3[a]
GA, d	276.7 (14.0)	274.2 (13.7)	277.0 (10.8)	5.7[a]
GR	0.994 (0.124)	0.963 (0.114)	0.935 (0.112)	62.2[a]

* Results are presented as mean (SD)
** One way ANOVA for mean differences among Caucasian, immigrant Chinese, and native Chinese infants
[a] $P < 0.01$

4.1.2. Prevalence of SGA in preterm, term, and postterm deliveries

This section examines whether the "excess" SGA rate among Chinese infants originates from preterm, term, or postterm deliveries. This information should be helpful in understanding why the overall SGA rate was substantially higher in Chinese infants, while the overall LBW rate was not. It also bears on one of the hypothesized explanations for the "tight" overall BW distribution in Chinese infants.

Table 7 demonstrates that the prevalence of SGA was lower in preterm Chinese infants than in preterm Caucasian infants, but was higher among Chinese infants born at or after term. The observed differences were not statistically significant for preterm or postterm comparisons, however, because of limited sample sizes. For example, there were only seven cases of postterm deliveries, with two SGA births among them, in the

immigrant Chinese group.

Table 7. Percent SGA in preterm, term, and postterm Caucasian, immigrant Chinese, and native Chinese infants, concordant ultrasound- and LNMP-determined GA

	Caucasian (n=11,036) %	Immigrant Chinese (n=723) %	Native Chinese (n=581) %	X^{2*}
Preterm	14.8	10.2	12.9	1.0[c]
Term	8.5	10.7	19.9	80.1[a]
Postterm	16.0	28.6	28.6	2.9[c]

* Chi-square test for differences in SGA rates among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$
[c] $P > 0.05$

Restricting the analysis to primiparas generally decreased differences between native Chinese and immigrant Chinese and between native Chinese and Caucasian infants, although some fluctuations occurred for preterm and postterm deliveries, probably caused by further reduction of sample size after this restriction (Appendix F).

4.1.3. Mean BW and FGR as a function of GA

The purpose of this section is to assess whether the mean BW and FGR in Chinese infants differs in pattern with advancing GA from that of Caucasian infants. Here, too, the information should be helpful in interpreting the "tight" overall BW distribution in Chinese infants.

Table 8 shows that Chinese infants had a similar or slightly higher BW before 36 weeks of GA but were smaller after 36 weeks of GA, and substantially smaller after 39 weeks. Patterns for FGR were the same as for BW (Table 9).

Table 8. Mean BW (g) as a function of GA in Caucasian, immigrant Chinese, and native Chinese infants, concordant ultrasound- and LNMP-determined GA*

GA, wk	Caucasian (n=11,036)	Immigrant Chinese (n=723)	Native Chinese (n=581)
33	1972 (320)	2095 (7)	2400 (283)
34	2237 (437)	2486 (263)	2400 (346)
35	2523 (423)	2635 (266)	2400 (**)
36	2846 (429)	2760 (417)	2625 (364)
37	3032 (471)	3096 (389)	2900 (320)
38	3300 (432)	3208 (394)	3092 (357)
39	3469 (430)	3352 (385)	3198 (357)
40	3590 (406)	3503 (401)	3277 (401)
41	3687 (438)	3516 (325)	3439 (463)
42	3751 (475)	3763 (478)	3455 (286)

* Results are given as mean (SD)
** SD not calculable; n = 1

Table 9. Mean FGR as a function of GA in Caucasian, immigrant Chinese, and native Chinese infants, concordant ultrasound- and LNMP-determined GA*

GA, wk	Caucasian (n=11,036)	Immigrant Chinese (n=723)	Native Chinese (n=581)
33	0.979 (0.165)	1.063 (0.037)	1.206 (0.092)
34	0.998 (0.188)	1.099 (0.104)	1.090 (0.134)
35	1.017 (0.154)	1.070 (0.125)	0.991 (**)
36	1.033 (0.142)	1.012 (0.154)	0.966 (0.136)
37	1.007 (0.146)	1.021 (0.117)	0.968 (0.110)
38	1.014 (0.128)	0.983 (0.113)	0.954 (0.108)
39	1.015 (0.123)	0.982 (0.112)	0.936 (0.099)
40	1.013 (0.113)	0.990 (0.114)	0.925 (0.113)
41	0.998 (0.118)	0.953 (0.089)	0.930 (0.128)
42	0.977 (0.122)	0.987 (0.122)	0.899 (0.071)

* Results are given as mean (SD)
** SD not calculable; n = 1

Restricting the analysis to primiparas generally decreased the above-noted differences, although some fluctuations occurred for preterm and postterm deliveries, probably caused by further reduction of sample size after this restriction (Appendix F).

4.2. Distributions of Determinants in Caucasian, Immigrant Chinese, and Native Chinese Infants

We hypothesized that the lower mean BW in ethnic Chinese infants was caused by differences in (mean) determinant values, while the lower prevalence of extreme BWs was due (partly) to lower exposure to 'growth-inhibiting' (and 'growth-accelerating') or 'gestation-shortening' (and 'gestation-prolonging') levels of those determinants. The results presented in this part bear on this hypothesis.

Table 10 shows that Caucasian mothers were taller and heavier, gained more weight during pregnancy, and had more years of education. In addition, native Chinese mothers were slightly taller and heavier than immigrant Chinese mothers. Table 11 shows that the variability (as represented by the CV) in maternal age, height, and prepregnancy BMI in the two Chinese groups, and especially among the native Chinese, was smaller than that of Caucasians. The variation in net gestational weight gain rate, however, was greater in native Chinese. The variation in maternal educational attainment in both groups of Chinese mothers was larger than that of Caucasian mothers. Table 12 demonstrates that Caucasian mothers were more likely to be unmarried and to smoke, drink, and use social drugs during pregnancy than either immigrant Chinese or native Chinese mothers. Native Chinese mothers, on the other hand, were more likely to be primiparas and to experience severe PIH. The sex ratio in the three study groups

was quite similar.

Table 10. Comparison of means for determinants with continuous distributions among Caucasian, immigrant Chinese, and native Chinese, overall study samples

	Caucasian (n=18,665)	Immigrant Chinese (n=1,597)	Native Chinese (n=1,862)	F*
Age, y	28.7	29.1	26.0	301.3[a]
Education, y completed	13.4	12.0	10.2	910.7[a]
Height, cm	163.0	157.0	160.0	465.3[a]
Prepregnancy BMI, kg/m^2	22.3	20.2	20.5	313.7[a]
Net Wt gain, kg/week	0.29	0.26	0.26	92.6[a]

* One-way ANOVA for mean difference among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$

Table 11. Comparison of variation in determinants with continuous distributions among Caucasian, immigrant Chinese, and native Chinese, overall study samples*

	Caucasian (n=18,665)	Immigrant Chinese (n=1,597)	Native Chinese (n=1,862)	X^{2**}
Age, y	4.8, 0.167	4.3, 0.148	2.8, 0.108	432.7[a]
Education, y completed	3.1, 0.231	3.9, 0.325	3.0, 0.108	87.4[a]
Height, cm	6.5, 0.040	5.3, 0.034	4.7, 0.029	208.4[a]
Prepregnancy BMI, kg/m^2	3.9, 0.175	2.9, 0.144	2.2, 0.107	566.7[a]
Net Wt gain, kg/week	0.13, 0.431	0.11, 0.423	0.13, 0.500	37.2[a]

* Results are presented as SD, CV
** Bartlett's test for homogeneity among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$

Table 12. Comparison of categorical determinants among Caucasian, immigrant Chinese, and native Chinese, overall study samples

	Caucasian (n=18,665)	Immigrant Chinese (n=1,597)	Native Chinese (n=1,862)	X^{2*}
Infant sex, % female	48.8	49.9	49.0	0.7[c]
Parity, % primiparas	49.1	46.7	88.5	1075.1[a]
% Married	83.0	96.9	99.2	540.0[a]
% Severe PIH	0.5	0.6	2.7	121.9[a]
% Diabetes	4.1	3.2	**	3.2[c]
% Social drug use	0.9	0.0	0.0	31.7[a]
% >= 1 drink/d	0.5	0.0	0.0	17.3[a]
% Smoked	26.9	2.0	0.0	890.5[a]

* Chi-square test for differences of prevalences among Caucasian, immigrant Chinese, and native Chinese (between Caucasian and immigrant Chinese for diabetes)
** Not available
[a] $P < 0.01$; [c] $P > 0.05$

The comparison of distributions of determinants among Caucasian, immigrant Chinese, and native Chinese infants for study subjects with concordant ultrasound- and LNMP-determined GAs (Tables 13-15) showed similar results as the comparisons for the overall study samples.

Table 13. Comparison of means for determinants with continuous distributions among Caucasian, immigrant Chinese, and native Chinese, subjects with concordant ultrasound- and LNMP-determined GA

	Caucasian (n=11,036)	Immigrant Chinese (n=723)	Native Chinese (n=581)	F*
Age, y	29.1	29.7	26.1	122.2[a]
Education, y completed	13.5	12.2	10.7	255.6[a]
Height, cm	163.0	158.0	160.5	184.6[a]
Prepregnancy BMI, kg/m^2	22.4	20.4	20.4	127.6[a]
Net Wt gain, kg/week	0.30	0.26	0.28	16.2[a]

* One-way ANOVA for mean difference among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$

Table 14. Comparison of variation in determinants with continuous distributions among Caucasian, immigrant Chinese, and native Chinese, subjects with concordant ultrasound- and LNMP-determined GA*

	Caucasian (n=11,036)	Immigrant Chinese (n=723)	Native Chinese (n=581)	X^{2**}
Age, y	4.7, 0.162	4.3, 0.145	2.6, 0.100	166.2[a]
Education, y completed	3.1, 0.162	3.9, 0.320	2.8, 0.262	46.6[a]
Height, cm	6.4, 0.039	5.1, 0.032	4.5, 0.028	90.5[a]
Prepregnancy BMI, kg/m^2	3.8, 0.170	3.0, 0.147	2.3, 0.113	150.9[a]
Net Wt gain, kg/week	0.13, 0.433	0.10, 0.385	0.14, 0.500	267.6[a]

* Results are presented as SD, CV
** Bartlett's test for homogeneity among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$

Table 15. Comparison of categorical determinants among Caucasian, immigrant Chinese, and native Chinese, subjects with concordant ultrasound- and LNMP-determined GA

	Caucasian (n=11,036)	Immigrant Chinese (n=723)	Native Chinese (n=581)	X^{2*}
Infant sex, % female	47.5	48.8	48.0	0.5[c]
Parity, % primiparas	50.1	45.9	89.5	354.4[a]
% Married	86.2	97.8	98.6	153.7[a]
% Severe PIH	0.4	0.4	1.5	15.2[a]
% Diabetes	4.1	4.1	**	0.4[c]
% Social drug use	0.6	0.0	0.0	8.6[b]
% >= 1 drink/d	0.4	0.0	0.0	5.3[c]
% Smoked	25.5	2.1	0.0	392.9[a]

* Chi-square test for differences of prevalences among Caucasian, immigrant Chinese, and native Chinese (between Caucasian and immigrant Chinese for diabetes)
** Not available
[a] $P < 0.01$; [b] $P < 0.05$; [c] $P > 0.05$

To address the issue of residual "within-normal" differences in determinants, we compared the means of three important determinants: maternal height, prepregnancy BMI, and net gestational weight gain rate in 'risk-free II' subsamples for the three study groups. Table 16 shows that Caucasian mothers were still substantially taller, heavier, and had higher rates of net gestational weight gain than either immigrant Chinese or native Chinese mothers in the 'risk-free II' subsample, although the variability in these determinants became more comparable among the three study groups.

Table 16. Comparison of selected important determinants in Caucasian, immigrant Chinese, and native Chinese, 'risk-free II' subsamples*

	Caucasian (n=3,414)	Immigrant Chinese (n=282)	Native Chinese (n=972)	F**
Height, cm	162.0 (5.1)	158.7 (4.2)	160.5 (4.0)	88.8[a]
Prepregnancy BMI, kg/m^2	21.4 (1.9)	20.4 (1.8)	20.6 (1.7)	85.2[a]
Net Wt gain, kg/week	0.27 (0.06)	0.25 (0.06)	0.26 (0.07)	27.2[a]

* Results are given as mean (SD)
** One-way ANOVA for mean differences among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$

Restricting the comparison to primiparas decreased the differences between native Chinese and immigrant Chinese and between native Chinese and Caucasians (Appendix F).

4.3. Bivariate Analyses

Bivariate analyses showed similar determinant-outcome relationships in Caucasian infants to those reported in previous studies, except for alcohol assumption (probably owing to inadequate ascertaiment of this determinant) (Appendix G). Some categories in the two Chinese groups with few subjects (such as the unmarried or those who smoked during pregnancy), the results were not consistent with literature, probably owing to limited sample sizes (Appendix G).

4.4. Multivariate Analyses

4.4.1. Separate multiple linear regression analyses for the three study groups

The purpose of separate multiple linear regression analyses for the three study groups is to compare the effect (represented by *b*, the regression slope) and variance explained (represented by r^2, equivalent to EFV as discussed in Chapter 2) of various determinants on BW, GA, and FGR among Caucasian, immigrant Chinese, and native Chinese infants. The results obtained from these analyses should be useful in relating the overall BW distribution in the three study groups to their two major contributors, GA and FGR, and to important

maternal demographic, anthropometric, nutritional, and behavioral determinants.

Table 17 shows that for Caucasian infants, the mean BW in male infants was 125 g heavier than in females; infants born to unmarried mothers were about 49 g lighter than infants born to married mothers; BW increased 45 g for each birth, 12 g for each cm of height, 23 g for each kg/m^2 of prepregnancy BMI, and 44.3 g by each 0.1 kg/week in net gestational weight gain, and decreased 78 g for each 10 cigarettes/day smoked during pregnancy. Maternal prepregnancy BMI ranked first in terms of explained variance in BW; maternal height, cigarette smoking, infant sex, net gestational weight gain rate, parity, marital status, education, and maternal age were next, in that order. But only a small fraction of variance (11.6%) was explained by the determinants included in the model.

The results of the multiple linear regression analysis for GA in Caucasian infants were quite different from those for BW. The direction of effect for infant sex and parity was reversed, and the magnitude of effect for other determinants was smaller. For example, each 10 cigarettes/day reduced BW by about 2.5% (78/3380), but reduced GA by only about 0.2% (0.60/277, see Table 17). The amount of GA variance explained by the determinants was trivial (no determinant explained more than 0.5% of the variance, and the total variance explained by all determinants was only 1.5%, see Table 17).

Contrary to the results for GA, multiple linear regression

analysis for FGR in Caucasian infants showed similar results as for BW. Not only were the direction and magnitude of the effects similar, but the proportion of variance explained by the determinants was also comparable. Only the rank order for r^2s changed slightly. Prepregnancy BMI ranked first, infant sex, height, smoking, gestational weight gain rate, parity, maternal age, education, and marital status next, in that order (Table 17).

The results of multiple linear regressions for BW and FGR were similar in immigrant and native Chinese infants, but differed in some aspects from those in Caucasian infants. The direction of effect for maternal marital status among both immigrant and native Chinese, and for smoking among immigrant Chinese, was reversed, although neither effect was statistically significant and the amount of variance explained by these two determinants was virtually nil. The effect of other determinants (i.e., infant sex, maternal height, prepregnancy BMI, and net gestational weight gain rate) on BW and FGR in the two Chinese groups was similar to that for Caucasians, although there were some minor differences (for example, the direction of effect of parity on BW in immigrant Chinese was reversed, although the effect was not statistically significant, probably because of limited sample size in this group). The r^2 values for these determinants in the two Chinese groups were close to the corresponding Caucasian values (Table 17).

The results of the multiple linear regression analysis for GA in immigrant Chinese infants were quite similar to those in native Chinese infants. Contrary to the results in Caucasian infants, GA was higher in unmarried mothers in both Chinese groups. As in Caucasian infants, the magnitude of effects and amount of variance explained for all the determinants were very small. Virtually no determinant included in the models reached the statistically significant level ($p < 0.05$) for either immigrant Chinese or native Chinese infants (Table 17).

Table 17. Results of separate multiple linear regression analyses for Caucasian, immigrant Chinese, and native Chinese infants, concordant ultrasound- and LNMP-determined GA

	Caucasian		Immigrant Chinese		Native Chinese	
	b^*(95% C.I.)	r^2	b^*(95% C.I.)	r^2	b^*(95% C.I.)	r^2
BW, g						
A	-1(-4, +2)	.000	19(4, 33)	.019	-2(-16, +12)	.000
B	-125(-102,-148)	.017	-87(-207, +33)	.008	-107(-41,-173)	.017
C	5(1, 9)	.001	-4(-19, +11)	.001	-9(-21, +3)	.003
D	-49(-12, -86)	.001	67(-348,+482)	.000	165(-109,+429)	.002
E	45(36, 60)	.005	-10(-78, +58)	.000	54(-64,+170)	.001
F	-78(-66, -90)	.024	10(-212,+232)	.000	**	**
G	12(11, 14)	.026	18(7, 29)	.034	16(9, 23)	.029
H	23(20, 26)	.029	33(13, 53)	.034	49(24, 54)	.040
I	443(348, 538)	.013	328(-192,+848)	.005	373(110, 436)	.013
GA, d						
A	-0.09(-0.03,-0.15)	.001	0.26(-0.10,+0.62)	.007	0.13(-0.23,+0.49)	.001
B	0.62(0.08, 1.10)	.001	1.38(-1.28,+4.05)	.004	-1.36(-3.10,+0.38)	.004
C	0.10(0.03, 0.20)	.001	-0.23(-0.59,+0.13)	.006	-0.26(-0.58,+0.07)	.004
D	-1.38(-1.06,-1.70)	.002	2.64(-7.47,+12.8)	.001	-1.14(-8.33,+6.05)	.000
E	-0.76(-0.43,-1.09)	.003	-1.79(-2.74,-0.11)	.016	-3.10(-6.13,+0.01)	.007
F	-0.60(-0.35,-0.86)	.003	-1.40(-6.73,+3.93)	.004	**	**
G	0.09(0.05, 0.14)	.003	-0.03(-0.29,+0.24)	.000	0.19(-0.00,+0.39)	.007
H	0.02(-0.05,+0.09)	.000	0.14(-0.35,+0.64)	.001	0.16(-0.25,+0.56)	.001
I	-1.05(-3.11,+1.01)	.001	-0.80(-13.5,+11.9)	.000	3.13(-3.55,+10.0)	.001
FGR						
A	.001(-.000,+.001)	.001	.003(-.001,+.007)	.008	-.002(-.006,+.002)	.002
B	-.042(-.036,-.047)	.029	-.035(-.008,-.061)	.020	-.021(-.003,-.039)	.009
C	.000(-.001,+.001)	.001	.001(-.003,+.005)	.001	-.001(-.004,+.003)	.000
D	-.003(-.012,+.006)	.000	-.001(-.102,+.099)	.000	.053(-.021,+.127)	.003
E	.018(.014, .021)	.012	.012(-.004,+.019)	.006	.040(.009, .071)	.011
F	-.019(-.016,-.022)	.022	.013(-.004,+.066)	.001	**	**
G	.003(.003, .004)	.024	.006(.003, .008)	.055	.003(.001, .005)	.017
H	.006(.005, .007)	.036	.010(.004, .014)	.039	.010(.006, .015)	.041
I	.147(.124, .171)	.022	.088(-.037,+.214)	.006	.089(.018, .160)	.010

A. Maternal age: exact year
B. Infant's sex: female=1, male=0
C. Maternal education: completed years of schooling
D. Mother's marital status: unmarried=1, currently married=0
E. Parity: exact number of parity
F. Maternal smoking during pregnancy: none=0, 1-9=1, 10-19=2, equal or more than 20=3
G. Maternal height: in cm
H. Prepregnancy BMI: prepregnancy weight/height^2 in kg/m^2
I. Net gestational wt gain rate: (last weight before delivery - prepregnancy weight - BW)/GA in kg/week

* Regression slope
** Incalculable because all are nonsmokers

4.4.2. Linear regression and logistic regression analyses for all study subjects combined

The purpose of this part of the analysis is to assess if the Chinese-Caucasian differences in mean BW, GA, FGR, and prevalences of LBW, HBW, preterm delivery, postterm delivery, SGA, and LGA, as well as the Chinese-Caucasian differences in mean BW and FGR as a function of GA, could be explained by important maternal demographic, anthropometric, nutritional, and behavioral determinants.

The results of multiple linear regression analysis for BW in all infants (i.e., the three study groups combined) showed that infants born in China were 137 g lighter than infants born in Canada; female infants were 122 g lighter than males; infants born to unmarried mothers were about 45 g lighter than infants born to married mothers; BW increased 42 g for each birth, 13 g for each cm of height, 24 g for each kg/m^2 for prepregnancy BMI, and 42.2 g for each 0.1 kg/week in rate of net gestational weight gain; BW decreased 78 g for each 10 cigarettes/day smoked during pregnancy; and maternal race, age, and education attainment had no significant independent effect on BW (Table 18).

Results of multiple linear regression for GA were quite different from those for BW. The direction of effect for infant's birth place, sex and parity was reversed, and the magnitude of effect for other determinants was smaller. For example, each 10 cigarettes/day reduced BW by about 2.5%

(78/3350), but reduced GA by only about 0.2% (0.57/277). Moreover, while BW was 137 g lower in native Chinese infants, their GA was 2.09 day higher (see Table 18). More detailed discussion about this apparent "contradictory" betwwen BW and GA will be discussed in section 5.2.

Multiple linear regression analysis for FGR showed similar results as for BW. Both the direction and the magnitude of the effects for FGR for those determinants included in the model (except for maternal age and marital status) were similar to those for BW. Mother's marital status had no significant effects on FGR, while maternal age had a marginal effect (with an increase of FGR of 0.001 for each year of age, see Table 18).

Table 18. Slopes (*b*) and 95% CIs for effects on BW, GA, and FGR of various determinants obtained from multiple linear regression models in which GA was not included as a determinant or an interaction term (for BW and FGR), subjects with concordant ultrasound- and LNMP-determined GA

Determinant	BW, g	GA, d	FGR
A	-0(-3, +3)	-0.09(-0.03,-0.15)	.001(.000, .001)
B	-122(-100,-143)	0.53(0.03, 1.04)	-.039(-.034,-.044)
C	-45(-10, -81)	-1.32(-0.49,-2.15)	-.003(-.012,+.006)
D	4(0, 7)	0.09(0.01, 0.18)	.000(-.001,+.001)
E	42(28, 57)	-0.82(-0.48,-1.16)	.018(.014, .022)
F	-78(-66, -90)	-0.56(-0.29,-0.84)	-.019(-.016,-.022)
G	13(11, 15)	0.09(0.04, 0.13)	.003(.003, .004)
H	24(21, 27)	0.06(-0.01,+0.13)	.006(.005, .007)
I	422(334, 510)	-1.09(-3.13,+0.95)	.134(.112, .155)
J	53(-3,+108)	2.85(1.56, 4.14)	-.003(-.017,+.010)
K	-137(-71,-203)	2.09(0.54, 3.64)	-.052(-.036,-.068)

A. Maternal age: exact year
B. Infant's sex: female=1, male=0
C. Mother's marital status: unmarried=1, currently married=0
D. Maternal education: completed years of education
E. Parity: exact number of parity
F. Maternal smoking during pregnancy: none=0, 1-9=1, 10-19=2, >=20=3
G. Maternal height: in cm
H. Prepregnancy BMI: prepregnancy weight/height^2 in kg/m^2
I. Net gestational wt gain rate: (last wt before delivery - prepregnancy wt - BW)/GA in kg/week
J. Mother's race: Caucasian=1, Chinese=0
K. Mother's current country of residence: China=1, Canada=0

As shown in Table 19, GA showed the strongest effect on BW when it was included in the multiple linear regression model (both as main effect and as an interaction term with maternal race), even though it was merely categorized into preterm vs term vs postterm. But the effects of various other determinants on BW and FGR changed little in these expanded models. Preterm delivery reduced BW by 689 g, and postterm delivery increased BW by 227 g.

The effect of maternal racial/ethnic status on BW was modified by GA, even after controlling for other maternal demographic, anthropometric, nutritional, and behavioral determinants. For example, the slope (*b*) for the interaction between preterm and maternal race (preterm Caucasian = 1, else = 0) was -211, indicating that BW was further decreased by an additional 211 g in preterm Caucasian infants, beyond the 689 g decrease for all preterm infants (Table 19).

Table 19. Slopes (*b*) and 95% CIs for effects on BW and FGR of various determinants obtained from multiple linear regression models in which GA was included both as a determinant and an interaction term (with mother's race), subjects with concordant ultrasound- and LNMP-determined GA

Determinant	BW	FGR
A	1(-2, +3)	.001(-.000,+.001)
B	-125(-105,-144)	-.039(-.034,-.044)
C	-21(-54, +12)	-.004(-.013,+.005)
D	2(-1, +6)	.000(-.001,+.001)
E	46(32, 59)	.017(.013, .021)
F	-74(-63, -85)	-.019(-.016,-.022)
G	12(10, 14)	.003(.003, .004)
H	23(20, 26)	.006(.005, .007)
I	468(388, 548)	.132(.110, .154)
J	44(-8, +95)	.001(-.013,+.015)
K	-149(-88,-210)	-.050(-.033,-.066)
L	-689(-554,-824)	.089(.053, .125)
M	227(53, 401)	-.048(-.001,-.095)
N	-211(-65,-357)	-.054(-.015,-.093)
O	26(-157,+209)	.012(-.037,+.061)

A. Maternal age: exact year
B. Infant's sex: female=1, male=0
C. Mother's marital status: unmarried=1, currently married=0
D. Maternal education: completed years of schooling
E. Parity: exact number of parity
F. Maternal smoking during pregnancy: none=0, 1-9=1, 10-19=2, >=20=3
G. Maternal height: in cm
H. Prepregnancy BMI: prepregnancy weight/height^2 in kg/m^2
I. Net gestational wt gain: (last wt before delivery - prepregnancy wt - BW)/GA in kg/week
J. Mother's race: Caucasian=1, Chinese=0
K. Mother's current country of residence: China=1, Canada=0
L. GA I: preterm(<37 completed weeks)=1, else=0
M. GA II: Postterm(>= 42 completed weeks)=1, else=0
N. Interaction of preterm*mother's race
O. Interaction of postterm*mother's race

According to the regression model shown in Table 19, mean BW for preterm, term, and postterm Caucasian, immigrant Chinese, and native Chinese infants can be estimated as follows:

Table 20. Mean BW for preterm, term, and postterm Caucasian, immigrant Chinese, and native Chinese infants estimated from multiple linear regression model in which GA was included both as a determinant and an iteraction term (with mother's race), subjects with concordant ultrasound- and LNMP-determined GA

	Caucasian	Immigrant Chinese	Native Chinese
Preterm	2568	2735	2586
Term	3468	3424	3275
Postterm	3721	3651	3502

The results of linear regression diagnostics showed that the model assumptions were not violated (Appendix H).

The results of logistic regression analyses (Tables 21-23) of determinants and dichotomized outcome measures (LBW, HBW, preterm delivery, postterm delivery, SGA, and LGA) were generally consistent with those observed for the underlying continuous measures. Prevalences at the left end of the distributions (LBW, preterm delivery, and SGA) decreased, and prevalences at the right end of the distributions (HBW, postterm delivery, and LGA) increased as mean values of the corresponding underlying continuous outcome measures (BW, GA, and FGR) increased. Several surprising results, however, merit further comment. First, postterm delivery and SGA rates were substantially higher in native Chinese infants. Systematical over-estimation of GA, especially in postterm deliveries, might be at least part of the reasons; a detailed discussion of this finding is included in Chapter 5. Second, the LGA rate was substantially higher in preterm deliveries but substantially lower in postterm deliveries. This is probably caused by the fact that multiple logistic regression analyses were restricted to singleton, nonmalformed live births to mothers without severe PIH. Such a restriction might have resulted in a selective retention of fast-growing fetuses preterm (thus increasing the LGA rate) and a selective exclusion of fast-growing fetuses postterm (thus decreasing the LGA rate). Finally, there was less statistical stability

and fewer significant results in logistic regression analyses, probably owing to reduced statistical power due to dichotomization of the outcome measures.

Table 21. Odds ratios and 95% CIs for effects on LBW, preterm delivery, and SGA of various determinants obtained from multiple logistic regression models in which GA was not included as a determinant or an interaction term (for LBW and SGA), subjects with concordant ultrasound- and LNMP-determined GA

Determinant	LBW	Preterm delivery	SGA
A:			
1.	0.19(0.02,1.31)	0.60(0.21,1.70)	0.68(0.34,1.36)
2.	1.35(0.94,1.95)	0.95(0.70,1.29)	1.37(1.10,1.70)
3.	2.31(1.49,3.60)	1.62(1.12,2.34)	1.46(1.54,1.98)
B	1.41(1.05,1.91)	0.90(0.71,1.15)	1.83(1.54,2.19)
C	1.10(0.70,1.71)	1.61(1.14,2.29)	1.33(1.02,1.73)
D:			
1.	1.87(1.14,3.08)	1.40(0.93,2.13)	1.12(0.83,1.52)
2.	1.31(0.89,1.92)	1.12(0.83,1.51)	1.20(0.96,1.49)
3.	1.18(0.72,1.95)	0.91(0.61,1.37)	1.08(0.81,1.45)
E	1.55(1.12,2.16)	1.09(0.83,1.42)	2.08(1.69,2.54)
F:			
1.	2.22(1.28,3.86)	1.37(0.84,2.22)	1.66(1.14,2.41)
2.	3.10(1.98,4.84)	1.37(0.90,2.08)	3.48(2.64,4.60)
3.	2.00(1.24,3.23)	1.29(0.85,1.96)	2.66(2.00,3.53)
G:			
1.	2.55(1.21,5.38)	1.59(0.78,3.27)	2.28(1.42,3.66)
2.	1.78(1.28,2.49)	1.35(1.02,1.77)	1.39(1.14,1.68)
3.	0.65(0.37,1.14)	0.96(0.65,1.42)	0.66(0.48,0.90)
H:			
1.	2.28(1.32,3.93)	0.91(0.50,1.63)	2.59(1.90,3.55)
2.	1.72(1.21,2.44)	1.25(0.92,1.69)	1.60(1.30,1.97)
3.	0.57(0.32,1.02)	0.98(0.65,1.47)	0.57(0.40,0.82)
I:			
1.	2.17(1.35,3.48)	0.97(0.61,1.52)	1.92(1.43,2.59)
2.	1.03(0.71,1.49)	0.83(0.61,1.12)	1.25(1.01,1.55)
3.	1.02(0.63,1.63)	1.40(1.00,1.97)	0.71(0.52,0.96)
J	1.40(0.65,3.04)	0.71(0.40,1.24)	1.05(0.67,1.66)
K	1.39(0.58,3.35)	0.69(0.34,1.37)	2.74(1.67,4.30)

A. Maternal age (years): 1. <20; 2. 30-34; 3. >=35, 20-29 as the reference
B. Infant's sex: female=1 male=0
C. Mother's marital status: unmarried=1 currently married=0
D. Maternal education (years): 1. <11; 2.11-12; 3. 13-16, > 16 as the reference
E. Parity: first birth=1 second or higher births=0
F. Maternal smoking during pregnancy (cigarettes/day): 1. 1-9; 2. 10-19; 3. >=20, none as the reference
G. Maternal height (cm): 1. <151; 2. 151-160; 3. >=170, 161-169 as the reference
H. Prepregnancy BMI (prepregnancy weight/height^2 in kg/m^2: 1. <17.8; 2. 17.8-<19.8; 3. 26.0-29.0; 4. >=29.0, 19.8-<26.0 as the reference
I. Net gestational wt gain rate (last wt before delivery - prepregnancy wt - BW)/GA in kg/week: 1. <6.5; 2. 6.5-<12.5; 3. >=17.5, 12.5-<17.5 as the reference
J. Mother's race: Caucasian=1 Chinese=0
K. Mother's current country of residence: China=1 Canada=0

Table 22. Odds ratios and 95% CIs for effects on HBW, postterm delivery, and LGA of various determinants obtained from multiple logistic regression models in which GA was not included as a determinant or an interaction term (for HBW and LGA), subjects with concordant ultrasound- and LNMP-determined GA

Determinant	HBW	Postterm delivery	LGA
A:			
1.	0.83(0.38,1.78)	0.42(0.10,1.77)	1.27(0.64,2.50)
2.	1.05(0.88,1.26)	0.87(0.62,1.22)	1.05(0.88,1.25)
3.	1.22(0.96,1.55)	0.89(0.55,1.44)	1.51(1.20,1.89)
B	0.57(0.48,0.66)	0.88(0.68,1.15)	0.52(0.44,0.60)
C	1.05(0.80,1.37)	0.77(0.49,1.21)	1.03(0.79,1.34)
D:			
1.	0.85(0.62,1.18)	1.13(0.68,1.89)	0.80(0.59,1.09)
2.	0.89(0.74,1.06)	0.97(0.71,1.34)	0.91(0.76,1.09)
3.	0.97(0.78,1.21)	1.17(0.79,1.73)	0.78(0.62,0.98)
E	0.71(0.60,0.84)	2.82(2.04,3.88)	0.60(0.51,0.71)
F:			
1.	0.73(0.51,1.03)	1.14(0.66,1.97)	0.68(0.48,0.97)
2.	0.54(0.39,0.75)	0.98(0.58,1.66)	0.43(0.30,0.61)
3.	0.51(0.37,0.71)	1.34(0.85,2.13)	0.55(0.40,0.76)
G:			
1.	0.24(0.09,0.58)	1.02(0.40,2.56)	0.51(0.28,0.95)
2.	0.70(0.58,0.84)	0.82(0.61,1.11)	0.76(0.63,0.90)
3.	1.66(1.37,2.02)	1.09(0.75,1.57)	1.50(1.23,1.83)
H:			
1.	0.38(0.22,0.65)	1.00(0.54,1.83)	0.43(0.26,0.69)
2.	0.58(0.46,0.73)	0.84(0.59,1.19)	0.57(0.45,0.71)
3.	1.79(1.44,2.23)	0.86(0.54,1.37)	1.83(1.48,2.26)
I:			
1.	0.48(0.34,0.67)	0.99(0.59,1.67)	0.55(0.40,0.75)
2.	0.74(0.62,0.89)	1.07(0.78,1.47)	0.80(0.67,0.96)
3.	1.31(1.06,1.62)	0.91(0.61,1.36)	1.42(1.15,1.76)
J	1.31(0.80,2.15)	4.91(1.19,20.3)	0.83(0.56,1.24)
K	0.31(0.14,0.68)	3.90(0.90,17.0)	0.35(0.19,0.65)

A. Maternal age (years): 1. <20; 2. 30-34; 3. >=35, 20-29 as the reference
B. Infant's sex: female=1 male=0
C. Mother's marital status: unmarried=1 currently married=0
D. Maternal education (years): 1. <11; 2.11-12; 3. 13-16, > 16 as the reference
E. Parity: first birth=1 second or higher births=0
F. Maternal smoking during pregnancy (cigarettes/day): 1. 1-9; 2. 10-19; 3. >=20, none as the reference
G. Maternal height (cm): 1. <151; 2. 151-160; 3. >=170, 161-169 as the reference
H. Prepregnancy BMI (prepregnancy weight/height^2 in kg/m^2: 1. <17.8; 2. 17.8-<19.8; 3. 26.0-29.0; 4. >=29.0, 19.8-<26.0 as the reference
I. Net gestational wt gain rate (last wt before delivery - prepregnancy wt - BW)/GA in kg/week: 1. <6.5; 2. 6.5-<12.5; 3. >=17.5, 12.5-<17.5 as the reference
J. Mother's race: Caucasian=1 Chinese=0
K. Mother's current country of residence: China=1 Canada=0

Table 23. Odds ratios and 95% CIs for effects on LBW, HBW, SGA, and LGA of various determinants obtained from multiple logistic regression models in which GA was included both as a determinant and an interaction term, subjects with concordant ultrasound- and LNMP-determined GA

Determinant	LBW	HBW	SGA	LGA
A:				
1.	0.16(0.02,1.51)	0.82(0.38,1.77)	0.69(0.34,1.38)	1.28(0.65,2.53)
2.	1.57(1.03,2.39)	1.06(0.89,1.28)	1.38(1.11,1.71)	1.06(0.88,1.26)
3.	2.17(1.29,3.65)	1.27(1.00,1.61)	1.46(1.07,1.98)	1.49(1.18,1.86)
B	1.58(1.12,2.23)	0.56(0.47,0.65)	1.84(1.54,2.21)	0.52(0.44,0.60)
C	0.73(0.43,1.26)	1.10(0.84,1.44)	1.35(1.03,1.75)	1.00(0.77,1.32)
D:				
1.	1.72(0.97,3.06)	0.88(0.64,1.22)	1.12(0.83,1.51)	0.78(0.57,1.06)
2.	1.34(0.87,2.08)	0.89(0.74,1.07)	1.19(0.96,1.49)	0.90(0.76,1.08)
3.	1.37(0.78,2.40)	0.97(0.78,1.21)	1.08(0.80,1.44)	0.78(0.62,0.97)
E	1.76(1.21,2.57)	0.68(0.58,0.81)	2.02(1.64,2.47)	0.61(0.52,0.72)
F:				
1.	2.30(1.20,4.41)	0.73(0.51,1.04)	1.65(1.13,2.40)	0.67(0.47,0.96)
2.	3.33(1.95,5.68)	0.54(0.39,0.74)	3.52(2.66,4.65)	0.43(0.30,0.60)
3.	2.07(1.18,3.63)	0.50(0.36,0.70)	2.64(1.99,3.51)	0.55(0.40,0.75)
G:				
1.	2.46(1.01,5.98)	0.24(0.09,0.59)	2.29(1.42,3.69)	0.51(0.28,0.95)
2.	1.68(1.14,2.47)	0.71(0.59,0.85)	1.40(1.16,1.70)	0.74(0.62,0.88)
3.	0.59(0.31,1.12)	1.67(1.37,2.03)	0.66(0.48,0.90)	1.51(1.23,1.84)
H:				
1.	3.11(1.66,5.83)	0.36(0.21,0.62)	2.60(1.90,3.56)	0.43(0.27,0.70)
2.	1.67(1.11,2.51)	0.59(0.47,0.74)	1.61(1.31,1.99)	0.56(0.44,0.70)
3.	0.55(0.29,1.05)	1.83(1.47,2.28)	0.57(0.40,0.82)	1.83(1.48,2.27)
I:				
1.	3.06(1.77,5.28)	0.48(0.34,0.67)	1.92(1.43,2.59)	0.54(0.40,0.74)
2.	1.19(0.77,1.84)	0.73(0.60,0.87)	1.25(1.01,1.55)	0.81(0.67,0.97)
3.	0.91(0.53,1.56)	1.36(1.10,1.69)	0.71(0.53,0.96)	1.40(1.13,1.73)
J	1.44(0.56,3.68)	1.23(0.75,2.02)	1.02(0.64,1.62)	0.97(0.63,1.49)
K	1.69(0.65,4.42)	0.30(0.14,0.66)	2.73(1.66,4.48)	0.38(0.20,0.70)
L	38.9(15.7,96.1)	0.00(0.00,>100)	0.87(0.32,2.37)	6.57(2.82,15.3)
M	0.00(0.00,>100)	1.59(0.20,13.0)	1.81(0.67,4.95)	0.01(0.00,>100)
N	1.43(0.54,3.81)	62.0(0.00,>100)	0.96(0.31,2.97)	0.34(0.14,0.84)
O	1.65(0.00,>100)	1.69(0.20,14.1)	1.23(0.42,3.65)	>100(0.00,>100)

A. Maternal age (years): 1. <20; 2. 30-34; 3. >=35, 20-29 as the reference
B. Infant's sex: female=1 male=0
C. Mother's marital status: unmarried=1 currently married=0
D. Maternal education (years): 1. <11; 2.11-12; 3. 13-16, > 16 as the reference
E. Parity: first birth=1 second or higher births=0
F. Maternal smoking during pregnancy (cigarettes/day): 1. 1-9; 2. 10-19; 3. >=20, none as the reference
G. Maternal height (cm): 1. <151; 2. 151-160; 3. >=170, 161-169 as the reference
H. Prepregnancy BMI (prepregnancy weight/height^2 in kg/m^2: 1. <17.8; 2. 17.8-<19.8; 3. 26.0-29.0; 4. >=29.0, 19.8-<26.0 as the reference
I. Net gestational wt gain rate (last wt before delivery - prepregnancy wt - BW)/GA in kg/week: 1. <6.5; 2. 6.5-<12.5; 3. >=17.5, 12.5-<17.5 as the reference
J. Mother's race: Caucasian=1 Chinese=0
K. Mother's current country of residence: China=1 Canada=0
L. GA I: preterm(<37 completed weeks)=1 else=0
M. GA II: Postterm(>= 42 completed weeks)=1 else=0
N. Interaction of preterm*mother's race
O. Interaction of postterm*mother's race

4.5. Comparability of Data Obtained From Different Sources

Data obtained from different sources were generally comparable. The results of these assessments are given in Appendix I (the magnitude and consequences of missing values for outcomes and determinants), Appendix J (comparability of terminal digit preference in BW records between the two study institutions), Appendix K (comparability of immigrant Chinese mothers with 'certain' and 'uncertain' Chinese names), and Appendix L (comparability of data collected in different years). Although some of the comparisons showed statistically significant differences, the magnitude of the differences was usually quite small. For those comparisons showed large differences, their consequences on the study conclusions will be discussed in Chapter 5.

Potential selection bias caused by excluding subjects with discordant GAs and/or unavailable ultrasound-determined GA was also assessed. The distributions of BW, GA, and FGR were examined, and bivariate and multivariate analyses were performed for subjects without exclusions. The results of these analyses generally agreed with analyses for subjects with concordant ultrasound- and LNMP-determined GAs (Appendix M).

To assess the possible systematic overestimation of GA in native Chinese infants despite $\pm$ 10 days criterion has been applied, mean difference (in days) between ultrasound- and LNMP-determined GA (LNMP GA - ultrasound GA) and the

proportion (%) of infants in whom LNMP-determined GA is larger than ultrasound-determined GA by >= 7 days with or without application of $\pm$ 10 days criterion were also compared among the three study groups (Appendix N).

Although cesarean section tends to shorten GA (and therefore decrease BW), cesarean section rates were quite similar in the three study groups (Appendix O).

Multiple birth and congenital malformation are strongly associated with BW, GA, and FGR. The prevalences of these conditions were quite different between native Chinese and immigrant Chinese and between native Chinese and Caucasians (Appendix P). Potential bias caused by differences in these conditions will be discussed in detail in Chapter 5. The fetal death rate was much higher in native Chinese infants (Appendix P); the effect of this difference on the ethnic difference in BW distribution (as natural selection theory would dictate) will also be discussed in Chapter 5.

CHAPTER 5. DISCUSSION

5.1. Distribution of BW in Caucasian, Immigrant Chinese, and Native Chinese Infants

Although our study samples were taken from two tertiary obstetric care centers, and were therefore not representative of national or even provincial samples, the ethnic-specific BW and GA distributions are strikingly comparable with vital statistical data (9,67). The mean BW and LBW rate of U.S. Caucasian babies in 1983 were 3,414 g and 4.8%, respectively (9), and in 1984 were 3,417 g and 5.6% (67), compared with our Caucasian infants' figure of 3,414 g and 5.5%. The mean BW and LBW rate of U.S. Chinese babies in 1983 were 3,278 g and 4.4%, respectively (9), and in 1984 were 3,281 g and 5.1% (67), compared with our immigrant Chinese infants' figure of 3,245 g and 5.3%, and native Chinese infants' figure of 3,159 g and 6.8%. The mean BW and LBW rate of Canadian infants (predominantly Caucasians) in 1983 were 3,431 g and 5.2% respectively (68), which is also similar to our Caucasian infants' figure.

Mean BW in immigrant Chinese infants was about 150 g lower than that of Caucasian infants; potential reasons for this difference will be discussed later. Native-born Chinese infants had a mean BW about 100 g lighter vs Canadian-born Chinese infants (Tables 3, F.3, M.3, and M.8). The prevalence of LBW was higher and the prevalence of HBW was lower in

native-born Chinese infants than in Canadian-born Chinese infants (Tables 5, F.5, M.5, and M.10). Much of the difference in mean BW and prevalence of LBW and HBW between immigrant and native Chinese infants was caused by the unbalanced parity distribution (mainly primiparas) among native Chinese; the differences diminished considerably when comparisons were restricted to primiparas (Tables 3, 5, 6, F.3, F.5, M.3, M.5, M.8, and M.10). Remaining differences in mean BW and prevalences of LBW and HBW between native-born and Canadian-born Chinese infants might be caused by differences between Canada and China in determinants that were not measured in our study, such as maternal diabetes and other maternal morbidity. For example, a lower rate of maternal diabetes and/or a higher rate of other maternal illnesses in the native Chinese sample might be sufficient to produce a difference of this magnitude (less than 50 g in mean BW).

A lower mean BW would ordinarily be expected to increase the percentage of the sample in the left tail of its distribution (LBW), and to decrease the percentage in the right tail (HBW), since the entire curve should shift to the left. The LBW rate in ethnic Caucasian infants, however, was not lower than the Chinese values. A 3- to 5- fold higher HBW rate in Caucasian infants compared to Chinese infants, on the other hand, was consistently observed (Tables 5, F.5, M.5, and M.10).

The overall BW distribution in the two Chinese groups was "tighter," i.e., more centered, than in Caucasians. This can

be judged by the fact that the SDs, CVs, and kurtosis coefficients for BW were generally smaller in the two Chinese groups than in Caucasians in the overall sample comparisons (Tables 2, 4, F.2, F.4, M.2, M.4, M.7, and M.9). The "tight" BW distribution observed in Chinese infants in this study and other studies (9-13) probably explains the observed discrepancy in mean BW and LBW. The 'would-be' higher LBW rate caused by a left-shifted mean BW among Chinese infants was counteracted by the "tight" BW distribution, and the Chinese-Caucasian difference in LBW was thereby diminished; while the 'would-be' lower HBW rate among Chinese infants was accentuated by the "tight" BW distribution, and the Chinese-Caucasian difference in HBW was thereby increased.

The comparison of kurtosis coefficients for BW yielded inconsistent results: the kurtosis coefficients in immigrant Chinese infants were as large as Caucasian infants, while the kurtosis coefficients in native Chinese infants were substantially smaller than either immigrant Chinese or Caucasian infants (Tables 2, F.2, M.2, and M.7). The kurtosis coefficient is not a very reliable satistical parameter and hence is often difficult to interpret (69). Since the results of other comparisons (e.g., means, SDs, prevalences, and graphs of distributions) of BW were consistent and interpretable, the inconsistent findings from the comparison of kurtosis coefficients should not alter our conclusions.

Can these Chinese-Caucasian differences in BW be attributed

to Chinese-Caucasian differences in GA or FGR? Are they genetically or environmentally determined? These questions will be addressed in the following sections.

5.2. Distribution of GA in Caucasian, Immigrant Chinese, and Native Chinese Infants and Its Relative Contribution to Chinese-Caucasian Differences in BW Distributions

Mean GA was 1.8 days higher among the native Chinese, and was 1.1 days lower among the immigrant Chinese, than among the Caucasian infants. Although these differences are statistically significant, they are small compared with total GA (Tables 3, F.3, M.3, and M.8). Variation in GA was modest in all three study groups, with CVs of about 5% (Tables 4, F.4, M.4, and M.9). The preterm rate was higher in immigrant Chinese infants, while the postterm rate was higher in native Chinese infants (Tables 5, F.5, M.5, and M.10).

Part of the differences between immigrant and native Chinese infants in mean GA and prevalence of preterm and postterm delivery was caused by the unbalanced parity distribution (mainly primiparas) among native Chinese. The magnitude of the differences thus diminished when comparisons were restricted to primiparas (Tables 6, F.3, F.5, M.8, and M.10). But part of the differences between immigrant and native Chinese infants might also be caused by overestimation of LNMP-determined GA in the native Chinese group. Although the main analyses were restricted to subjects with concordant ultrasound- and LNMP-

determined GA, ultrasound-determined GA has only been used as a confirmation of LNMP GA. Since the LNMP-determined GA was the actual value used in the analysis, some residual misclassification (with after application of the $\pm$ 10 days criterion) is still likely. This issue will be further discussed in section 5.6.3.

The ethnic GA difference contributed little to the observed BW difference between Caucasian and Chinese infants. Not only were the ethnic differences in mean GA, variation in GA (as expressed by CV), and prevalence of preterm and postterm deliveries small and inconsistent, but the r^2 (EFV) obtained from multiple linear regression models for GA for all of the determinants were trivial as well. No single determinant explained more than 0.5% of total variance in GA in any of the three study groups. Moreover, no substantial and consistent ethnic differences in GA distribution or prevalence of preterm or postterm delivery were observed with changes in 'risk' levels (from level I to level V).

The modestly (1 - 3 days) but consistently lower mean GA, higher prevalence of preterm delivery, and lower prevalence of postterm delivery observed in immigrant Chinese infants compared with either Caucasian and native Chinese infants is interesting. Part of the difference between immigrant and native Chinese infants might be caused by systematic overestimation of LNMP-determined GA in the native Chinese group (see section 5.6.3). A meta-analysis of reports

published in English and French from 1970 to 1984 concluded that gestational duration is fairly stable across racial/ethnic groups (1). GA has also been reported to remain stable over time in Taiwan (70). An analysis based on 1983 U.S. birth certificates, on the other hand, found a shorter gestational duration based on mother's recall of LNMP in U.S. immigrant Chinese infants than in white infants (9). Several studies comparing GA between black and white infants have reported shorter average gestations in blacks than in whites (71,72). In a study assessing prenatal risk factors in an indigent population in Alabama, Wen et al found an increased rate of preterm delivery in black infants than white infants, after controling for several maternal demographic, smoking, and prenatal and gestational nutrition status (33). But in a study in which sociodemographic and medical factors were more completely controlled, the black-white difference in prevalence of preterm delivery substantially decreased (73).

A difference in the frequency of elective cesarean section is an unlikely explanation for the shorter gestational duration in immigrant Chinese infants, since the cesarean section rate in immigrant Chinese women was not higher (Table O.1). Genetic factors related to ethnic origin are obviously not the explanation, since otherwise we would expect GA to be similar in immigrant and native Chinese infants and different in Caucasian infants. Potential environmental determinants of GA such as demographic, anthropometric, nutritional factors,

and toxic exposures, are also unlikely explanations. Since these determinants have weak effects on GA (1), large differences in the distributions of these determinants among the three study groups (i.e., more frequent exposure to gestation-shortening levels of these determinants in immigrant Chinese infants than in either native Chinese or Caucasian infants) would be necessary to produce an appreciable difference in GA.

Stressful life events produced by immigration to a culturally different country in immigrant Chinese mothers, on the other hand, might provide an explanation. This argument is especially important in this group, because most Chinese immigrant mothers were recent immigrants (Table B.1) who might suffer more from 'culture-shock' than later (e.g., second-generation) immigrants. Previous studies have shown no consistent effect of maternal stress and anxiety on intrauterine growth but a possible effect on preterm delivery (1). It also makes biological sense that stress and anxiety may provoke preterm labour (perhaps mediated through hormones, e.g., catecholamines) in some susceptible women, although firm conclusions about such an effect require further investigation.

A recent analysis of gestational duration in Chinese, Caucasian, and mixed-race infants in the United State found that the GA for the immigrant Chinese group was slightly shorter than for U.S. Caucasians and that this racial GA

difference was predominantly determined by maternal race, while paternal race was not related (13). Since the paternal contribution can be considered genetic, while the maternal contribution is both genetic and environmental, the results of this study further support the hypothesis that the slightly decreased GA in immigrant Chinese infants is probably environmentally-related. Because the hypothesized environmental determinants (particularly maternal stress and anxiety, which may be more prevalent in recent immigrants) were not considered in our analysis, it is not surprising to find a difference of 2.9 day in mean GA between ethnic Caucasian and Chinese infants in linear regression analysis.

5.3. Distribution of FGR in Caucasian, Immigrant Chinese, and Native Chinese Infants and Its Relative Contribution to Chinese-Caucasian Differences in BW Distribution

Caucasian infants had a significantly higher mean FGR than either immigrant Chinese or native Chinese infants (Tables 3, F.3, M.3, and M.8). The variation (represented by CV) in FGR was also higher in Caucasians (Tables 4 and F.4).

Differences in mean FGR between ethnic Chinese and Caucasian infants largely explain the observed ethnic difference in mean BW. Differences in the variation in FGR between ethnic Chinese and Caucasian infants in the overall sample comparison also explain most of the ethnic difference in BW variation.

As with HBW, the prevalence of LGA in Chinese infants was

much lower (Tables 5, F.5, M.5, and M.10) than among Caucasians. But unlike LBW, the prevalence of SGA was much higher in Chinese infants than in Caucasian infants in the overall sample comparison (Tables 5, F.5, M.5, and M.10). Part of the reason for the high prevalence of SGA in native Chinese infants might be a systematic overestimation of LNMP-determined GA among the native Chinese (see sections 5.3 and 5.6.3). However, since the prevalence of SGA was also much higher in immigrant Chinese infants despite their lower GA, interpretations other than misclassification of GA must be considered. As discussed in Chapter 1, BW is determined by two main factors: gestational duration and fetal growth rate. If ethnic BW differences are determined mostly by ethnic differences in FGR rather than GA, then one should expect to see the same pattern for the entire distribution of FGR as for BW. If GA is similar across ethnic groups, the lower mean BW, smaller variation in BW, similar prevalence of LBW, and much lower prevalence of HBW seen in ethnic Chinese infants should be reflected in a lower mean FGR, smaller variation of FGR, similar prevalence of SGA, and much lower prevalence of LGA in the same group of infants. The observed discrepancy between LBW and SGA was caused by a different growth pattern with advancing GA in Chinese infants and will be discussed in detail in section 5.5.2.

5.4. Hypothesized Explanations for Chinese-Caucasian Differences in BW

5.4.1. Natural selection

Differential selective forces on fetal death between Caucasian and Chinese infants do not appear to explain our findings, although the fetal death rate in native Chinese was much higher than in either Caucasians or immigrant Chinese (Tables P.1-P.3). The higher fetal death rate in native Chinese is likely to be caused by the lack of advanced technology for prenatal care in Hefei (see section 5.6.1. for more detailed discussion). However, the differences in BW, GA, and FGR distributions between Caucasian and Chinese infants changed little when the comparison was restricted to live births (Figures 1-3, F.1-F.3, M.1-M.6; Tables 2-5, F.2-F.5, M.2-M.5, M.7-M.10). As a result, natural selection appears to play little role in Chinese-Caucasian differences in BW, at least for the current generation.

A step-by-step adaptation resulting from selection over many generations might have operated in Chinese populations, however. The results of such an accumulated selection effect would perhaps be a faster growth rate at early GAs, a slower growth rate at later GAs. A faster growth at early GAs combined with a slower growth at later GAs would protect infants from the risks of insufficient or excessive size. Both extremes of size are associated with an increased risk of death before, during, or after birth. Although the increased

risk for large babies is a less important current public health problem, it was a major problem a century ago, because of the increased maternal mortality associated with large fetuses.

It is unclear why and how such an adaptation may have occurred. Is it because the Chinese population has had a longer history, because Chinese infants are more sensitive to selection pressures, or because the Chinese population confronted greater environmental pressures in the past? It would be difficult to answer these questions without data accumulated through many generations. Since a comparison of growth patterns between blacks and Caucasian reported similar results (74), it would be of great interest to further explore the reasons for such a racial/ethnic group difference in growth pattern. In section 5.4.2, I will further discuss the Chinese-Caucasian difference in growth pattern with advancing GA, but from less theoretical stand point.

5.4.2. Difference in growth pattern with advancing GA

Our data demonstrate a different pattern of growth with advancing GA in Chinese infants. Before 35 weeks, BW and FGR were even higher in Chinese infants than in Caucasian infants, while Caucasian infants appeared to "catch up" to and overtake Chinese infants at about 36-37 weeks (Tables 8, 9, F.7, F.8, M.13, and M.14). The more advanced the GA beyond 36-37 weeks, the greater the gap between Chinese and Caucasian infants,

although some inconsistencies were observed, probably owing to small sample sizes at the two extremes of the GA distribution, especially in the two Chinese groups. Systematic overestimation of LNMP-determined GA might provide part of the explanation for the lower BW in term and (especially) postterm native Chinese infants. However, since immigrant Chinese infants showed a similar pattern despite their lower GA, interpretations other than misclassification of GA must be considered.

In the multiple linear regression model containing an interaction term for maternal ethnic group and GA, BW and FGR for preterm Caucasian infants (compared with preterm Chinese infants) were reduced 211 g and 0.05, respectively, but in postterm Caucasian infants (compared with postterm Chinese infants) were increased 26 g and 0.01 (Table 19). It should also be emphasized that to facilitate the interpretation of the race-GA interaction, we grouped GA into three categories: preterm, term, and postterm. By lumping GAs with large variation into a single group, a substantial amount of information was lost. For example, term delivery contains GAs ranging from 37 to 41 completed weeks, during which time Chinese-Caucasian differences in BW and FGR increased substantially, thus reducing the power to detect such effect modification. The weight of the evidence therefore suggests that Chinese infants are heavier at earlier GAs but lighter at later GAs than Caucasian infants, and this pattern of fetal

growth was not explained by the covariates studied.

There are two possible interpretations for the observed pattern of fetal growth in Chinese infants. First, it might be caused by the fact that faster-growing fetuses tend to be delivered earlier, while slower-growing fetuses tend to stay longer in utero in Chinese infants as compared with Caucasian infants. Second, Chinese fetuses might actually grow faster at earlier GAs, but slower at later GAs. The truth cannot be unravelled without reliable longitudinal intrauterine measurements of fetal growth.

Several mechanisms are possible if Chinese fetuses truly grow faster at early GAs but slower at later GAs. First, as discussed above, this pattern might result from natural selection over many generations. Second, it might conceivably be caused by a different diet among Chinese pregnant women that is particularly helpful in promoting fetal growth early in the third trimester.

Regardless of the reasons, however, the heavier BW at earlier GAs probably explains (at least partially) why the LBW rate in Chinese infants was not higher despite a much higher overall SGA rate. The comparison of SGA prevalence in preterm, term, and postterm deliveries clearly demonstrates that the majority of the "extra" SGA in the two Chinese groups occurred in term and postterm infants (Tables 7, F.6, M.11, and M.12). Although many of the race-GA interaction terms were statistically nonsignificant in multiple logistic regression

models, the direction of the effects was usually consistent with the crude comparison. Since the "extra" SGAs in Chinese infants occur only in term and postterm deliveries, LBW, which occurs mostly at earlier GAs (24,25), might not be more frequent.

Because the BW was heavier in Caucasian infants at or after term, a higher mean BW is expected, since unlike LBW, mean BW is calculated from all births, and the vast majority births occur at or after term (>=37 weeks).

The higher SGA rate in term and postterm Chinese infants thus appears to reflect the Caucasian-dominated mean BW (obtained from RVH's population, see Appendix E) used to calculate FGR for Chinese infants in whom the "expected" BW at these later periods of gestation is substantially lower.

In a study comparing U.S.-born Chinese infants (with both parents Chinese) and Caucasian infants, Yip et al (10) raised the question of whether a different fetal growth standard should be used for Chinese infants. They suggested that the same cutpoints be used for both groups (Chinese and Caucasian) when defining SGA infants, since similar 10th BW percentiles were observed, but that lower 90th BW percentiles cutpoint values were required for defining LGA. Unfortunately, GAs in their data were based solely on mother's recall of LNMP. Besides, they did not calculate GA-specific SGA rates. Instead, they based their conclusions on visual inspection of graphs. Their Figure 3 shows that at most GAs (from 32 weeks

to 38 weeks), BW 10th percentiles in Chinese and Caucasians were quite similar, but beginning at 40 weeks of GA, the 10th percentiles in Chinese became statistically significantly lower (no overlaps in 95% CIs). But the impression obtained from this figure is misleading, because most deliveries occur around term, and significantly lower 10th percentile BWs at term GAs would cause a substantial proportion of "excess" SGAs in Chinese infants. In our data, a 1.5- to 2.5-fold higher SGA rate was observed in term and postterm Chinese infants, based on a standard from a Caucasian-dominated population. A different standard might be needed for Chinese infants. While waiting for a new standard, clinicians might prefer to use a lower cutpoint value (e.g., 5th percentile) for defining SGA Chinese infants at later GAs.

Black U.S. infants have been reported to show a similar pattern of mean BW with advancing GA as seen in our Chinese infants, with heavier BWs at earlier GAs but substantially lighter BWs at later GAs, compared with Caucasian infants (74). Yet the variation in BW is higher, and the prevalence of LBW is much higher, in black U.S. infants than in Caucasian infants (75,76). The distribution of determinants in black infants is quite heterogeneous, with frequent exposure to 'growth-inhibiting' and/or 'gestation-shortening' levels, such as poor maternal prepregnancy and gestational nutrition, smoking, drinking, and drug use (74-78). Thus any benefit of heavier BWs at earlier GAs is probably offset by greater

exposure to adverse levels of determinants in black infants, so that they maintain a higher variation in BW and higher prevalence of LBW. More importantly, the prevalence of preterm delivery is much higher in U.S. blacks than U.S. Caucasians (71-73). Therefore, the left tail of the BW distribution, i.e., LBW, is much larger in blacks.

The striking differences in BW distribution among Chinese, Caucasian, and black infants, as well as the observations made in this study, merit further investigation. Comparing distributions of BW, GA, FGR, and their determinants among Chinese, Caucasian, and black infants simultaneously would be helpful not only in suggesting reasons for differences in BW distribution among the three ethnic groups, but also in providing insight into the mechanisms by which determinants affect fetal growth and gestational duration.

5.4.3. Differences in genetic determinants

The evidence obtained in this study and reported in previous studies suggests that genetic influences probably explain at least part of the Chinese-Caucasian difference in mean BW and LBW rate.

Regardless of data source and restriction criteria, a 150-250 g difference in mean BW was constantly observed. The 'risk-free' subsample approach adopted in our study created subsamples with a 'normal' range of determinants of fetal growth and/or gestational duration. But even within this

'normal' range of determinants, substantial Chinese-Caucasian mean differences remained for determinants with continuous distributions. Chinese mothers were shorter, lighter, and gained less weight during gestation than Caucasian mothers, even in the 'risk-free' subsamples (Table 16). Since these three determinants have a strong positive relationship with BW, the larger mean BW in Caucasian infants in the 'risk-free' subsample comparison is not surprising.

Some studies comparing the BW distribution in U.S. blacks and Caucasians have shown a lower mean BW and a higher prevalence of LBW in black infants even after adjusting for confounding factors (74-78). But it is usually the case that only those factors with rather weak independent effects on fetal growth or gestational duration (such as demographic factors) are accounted for in these studies. One study managed to adjust for one of the important maternal anthropometric determinants, i.e., prepregnancy weight-for-height (78). But the coding for this determinant (<25th percentile vs 25th-75th percentile) may not have been sufficient to control adequately for its potential confounding effect. In addition, the study investigators did not control for other important maternal anthropometric (maternal height) and nutritional (gestational weight gain) factors. A recent study comparing the prevalences of intrauterine growth retardation (IUGR, or SGA) and preterm delivery between black and Caucasian infants in an indigent population in Alabama reported that the odds ratios for IUGR

and preterm delivery in black vs Caucasian infantof 1.70 and 1.35, respectively (34). These higher IUGR and preterm delivery rates observed in black infants were statistically significant and were adjusted for parity, previous preterm delivery, infant sex, maternal age, education, marital status, height, prepregnancy weight, pregnancy weight gain, as well as maternal smoking, alcohol consumption, and drug use during pregnancy, suggesting an independent genetic (racial) effect on black-Caucasian differences in both fetal growth and gestational duration (34). But some of the covariates included in the multiple logistic models could not be controlled optimally. For example, only dichotomized information (yes vs no) was available on maternal smoking, alcohol consumption, and drug use during pregnancy (34). As a result, some residual confounding is likely. In addition, a substantial proportion of variation in both fetal growth and (especially) gestational duration remains (e.g., less than 20% and 5%, respectively, in the thesis). More sophisticated studies with more complete control for important confounding factors are needed, therefore, before declaring that the black-Caucasian BW distribution difference is substantially genetically determined.

Multivariate regression analyses in our study showed quite different results. While the main effect of maternal race on BW was substantially reduced, the interaction of maternal race and GA remained significant, with heavier BW in Caucasians at

or after term (see Tables 3, 18, 19, F.3, M.3, M.8, M.22, and M.23). The interaction term (maternal race) is a partial proxy for genetic effect, and some of the covariables (e.g., maternal height) included in the model contain genetic components. Since Caucasian infants were heavier at or after term, and since the vast majority of infants are born at or after term, a higher mean BW in them is expected. On the other hand, since Chinese infants were not lighter during earlier GAs, and since most LBW occurs at earlier GAs (24,25), a lower-than-expected LBW in Chinese infants is also expected. Thus the evidence suggests that the Chinese-Caucasian differences in mean BW and LBW rate can be explained, at least in part, by genetic mechanisms.

However, genetic potential on growth might have not been expressed fully in uterio. Consider birth length, which is the measure of fetal growth perhaps most susceptible to genetic influence. Correlation of length and midparental height is very small at birth (0.2), but increases rapidly over the subsequent 18 months or so, when it reaches its adult value of 0.5 (79). Correlation of an individual's length at birth with its later adult height is also small (0.3), but by age 3 it has risen to 0.8 (79). These improvements in height correlations with time demonstrate that even for anthropometric measurements highly subject to genetic control, much of the genetic effects are relatively weak in utero.

5.4.4. Differences in environmental determinants

The "tighter" overall BW distribution in Chinese infants appears to be largely environmentally mediated, and the lower-than-expected LBW rate in them is at least partly environmentally mediated. These inferences are supported by the fact that many of the determinants used to define the 'risk-free' subsample have substantial environmental components. Moreover, the Chinese-Caucasian difference of variation in BW disappeared, and the LBW rate in Caucasian infants became lower than the Chinese rate in the 'risk free' subsample comparisons.

Consistent with previous studies (9,26-28), few Chinese mothers were unmarried or smoked, drank, or used social drugs during pregnancy (Tables 12, 15, and F.11). Cigarette smoking during pregnancy, for example, occurred in 27% of Caucasian mothers, but in none of native Chinese mothers, and only 2% of immigrant Chinese mothers. Morever, the variation (represented by CV) in maternal age, height, and prepregnancy BMI was lower among Chinese mothers than among Caucasian mothers (Tables 11, 14, and F.10).

The variation in net gestational weight gain rate among Caucasian mothers was also higher than among immigrant Chinese mothers, but was lower than among native Chinese mothers. It will be recalled that net gestational weight gain rate was calculated from four directly ascertained measures: last maternal weight before delivery, prepregnancy weight, BW, and

GA. The variation of indices obtained from multiple original measures is likely to be larger than the variation of single direct measures, because each direct measure contributes some measurement error. It is clear from Tables 11, 14, and L.10 that the variation in net gestational weight gain rate was larger than the variation for any other determinant in all three study groups. It is possible that the measurement error for each of the four original measures was larger in native Chinese subjects. Larger error for each measure taken alone might not change the overall picture of a more homogenous distribution in native Chinese. But when all four measures are combined, greater measurement error might have obscured the underlying homogeneous distribution among the native Chinese, i.e., rendered it 'more' variable.

The only determinant for which Caucasian mothers had a definitely lower variation than Chinese mothers was maternal education, which, however, was only a weak independent determinant of fetal growth.

The relative reduction in number of study subjects from the overall sample to 'risk-free' subsamples in the two Chinese groups was much lower (Tables 1, F.1, M.1, and M.6), which further illustrates that the Chinese groups contain more subjects whose determinant values fall within the 'normal' range.

Thus the distributions of determinants among the two Chinese groups (combined with the tendency for Chinese mothers not be

exposed to smoking, drinking, drug use, and other hazardous activities) are more homogeneous ("tighter") than among Caucasians. This homogeneity in distribution of determinants is consistent with the literature (9,21,26,28). Reduced exposure to 'growth-inhibiting' and 'growth-accelerating' levels of determinants might therefore provide a partial explanation for the "tighter" BW distribution in ethnic Chinese infants.

The greater variation in BW among Caucasian infants in the overall sample was reduced in 'risk-free' subsamples (Tables 4, F.4, M.4, and M.9). Thus, when the comparison of BW variation was based on comparable samples in terms of homogeneity of maternal demographic, anthropometric, nutritional, and maternal behavioral (including smoking) determinants, Caucasian and Chinese infants had similar BW variation, suggesting that the extra variation in BW among Caucasians was caused (at least partially) by greater exposure to 'growth-inhibiting' and 'growth-accelerating' levels of determinants.

Maternal smoking was the only determinant in which the adjusted r^2 (EFV) for Caucasian infants was strikingly higher than for Chinese infants. The adjusted r^2 for maternal height was moderately higher, and for maternal prepregnancy BMI and net gestational weight gain rate moderately lower, in Caucasian infants compared with Chinese infants. The differences in adjusted r^2 for infant sex, parity, and

maternal marital status were small and inconsistent (Tables 17 and M.21).

Since we wanted a direct comparison of r^2 for a common set of determinants among the three study groups, we did not remove those determinants which were nonsignificant in the multiple regression models in the two Chinese groups. Forced inclusion of some nonsignificant determinants may have reduced the precision of parameters estimated from the models, however (80). Although it is possible to calculate a confidence interval for r^2 using a jackknife (81) or bootstrap (82) approach, the computation is time-consuming, and these approaches were therefore not used. The modest differences in r^2 for some determinants (such as maternal height, prepregnancy BMI, and net gestational weight gain rate) between Caucasian and Chinese infants, unlike the large differences for maternal smoking, may thus to be attributable to modelling imprecision and/or sampling variation.

Unlike the case in the overall sample comparison, the LBW rate in Caucasian infants in 'risk-free' subsamples was consistently and statistically significantly lower than the Chinese LBW rate (Tables 5, F.5, M.5, and M.10), indicating that the 'would-be' lower LBW rate in Caucasian infants in the overall sample comparison was obscured, at least in part, by more frequent exposure to 'growth-inhibiting' levels of environmentall determinants.

As discussed in Chapter 2, a quantitative estimation of

environmental contribution by the 'risk-free' subsample comparison and by multivariate analyses depends on the contribution of each environmental determinant studied. Since the true magnitude of effect for each individual determinant has not yet been established, only a semi-quantitative estimation of environmental contribution can be obtained by our approach.

The similarity of maternal demographic, anthropometric, and behavioral characteristics between immigrant and native Chinese mothers, and the differences between both Chinese groups and Caucasian mothers, indicate that common cultural influences from the motherland are stronger than the cultural influence of the adoptive country, at least in this group of immigrants in which the majority were born outside of their adoptive country (Table B.1.)

5.5. Alternative Interpretations of the Study Findings

5.5.1. Geographic, socioeconomic, and medical care differences between Montreal and Hefei

Both Montreal and Hefei are at sea level, so the influence of altitude on fetal growth does not pose a problem. There is no doubt, however, that economic development in Hefei is much behind that of Montreal. In 1988, the annual per capita income in mainland China was U.S.$ 320 (83), while in Canada it was about U.S.$ 18,500 (84).

In any case, the per capita income may not be a good

socioeconomic index for international comparisons. Though per capita income is low in Hefei, there is no shortage of food or other everyday necessities of life, and there is universal access to both basic health care and primary education (85). One previous study showed that despite marked differences in economic status in mainland China, Taiwan, and the United States (the 1988 annual per capita income was 320, 4,325, and 19,800 U.S. dollars in the three areas respectively), the BW distributions of Chinese infants from these three areas were similar (10).

The 'one couple, one child' policy in China during the study period was quite strict, especially in urban areas where the majority of the population are government employees who are more easily controlled (86). Generally speaking, only those couples whose first baby dies or is handicapped can have two or more babies. The punishment for breaking the regulation varies from paying a fine to losing a job or apartment. The desire for more children for some Chinese people is so strong that they may still want more babies despite such disincentives, however, and better-off couples who can afford the fine, or self-employed persons who are not afraid of being fired by the government, can manage to do this.

The 'one couple, one child' policy not only created an unbalanced parity distribution in our native Chinese sample, but also affected the distribution of other determinants that are associated with parity. It is therefore expected that

differences in the distributions of some determinants (e.g., maternal age and severe PIH) and pregnancy outcomes (e.g., cesarean section) between native Chinese and immigrant Chinese, and between native Chinese and Caucasians, diminished when the comparison was restricted to primiparas (Tables F.9, F.10, F.11, and O.1).

Several obstetric conditions and pregnancy outcomes other than BW, GA, and FGR, such as severe PIH, multiple births, and congenital malformation, remained different in native Chinese vs immigrant Chinese or Caucasians, even after restriction to primiparas. The rates of severe PIH and multiple birth were higher, while the rate of congenital malformation was much lower, among the native Chinese (Tables 12, F.11, and P.1-P.3).

The prevalences of severe PIH and congenital malformations observed in two recent national surveys in China were 2.2% and 1.3%, respectively (87,88). These figures are quite comparable with our native Chinese figures, but substantially different from those for immigrant Chinese and Caucasians. Differences between China and Canada in diagnostic criteria for PIH and in availability and accessibility of required technologies, extensiveness of screening, and reporting for congenital malformation might provide a partial explanation, although differences in unmeasured environmental exposures might also have played a role.

Severe PIH and congenital malformations were two criteria

for excluding study subjects from 'risk-free subsample' outcome presentations and multiple regression analyses. Differences in diagnoses for these conditions between Hefei and Montreal might therefore affect these analyses. But since our step-by-step presentations show that differences in these conditions did not change the comparisons of outcomes in native Chinese vs immigrant Chinese vs Caucasians, our results appear valid despite the possible diagnostic and reporting differences between Hefei and Montreal.

Montreal and Hefei might be different in some unmeasured socioeconomic and perinatal care factors that could affect BW, GA, and FGR. If this were true, however, one would expect the BW, GA, and FGR distributions to be more similar between immigrant Chinese and Caucasian infants than between immigrant Chinese and native Chinese infants. In fact, we observed just the opposite.

5.5.2. Differences between Montreal's historical data and Hefei's contemporary data

In immigrant Chinese mothers, mean maternal age, educational attainment, height, prepregnancy BMI, net weight gain rate, and marital status changed from the late 1970s to the late 1980s: from 27.6 to 30.0 years for maternal age, from 9.8 to 12.8 years for completed schooling, from 157.4 to 159.2 cm for height, from 19.9 to 20.5 kg/m^2 for prepregnancy BMI, from 0.24 to 0.29 kg/week for net weight gain rate, and from 99.2

to 95.4% for percent currently married (Tables L.1 and L.2). In Caucasian mothers from 1983 to 1989, mean maternal age increased from 28.0 to 29.1 years, completed schooling increased from a mean of 12.9 to 13.8 years, height increased from a mean of 163.1 to 163.2 cm, prepregnancy BMI increased from a mean of 21.9 to 22.8 kg/m^2, net weight gain rate increased from a mean of 11.3 to 11.7/kg/week, the cesarean section rate increased from 20.2 to 22.8%, but the percent of currently married decreased from 87.1 to 80.5% (Tables L.4 and L.5). These temporal trends in maternal determinants were all small but statistically significant. The temporal trend for GA and FGR in Caucasian and immigrant Chinese infants was also statistically significant, with a decreased mean GA and an increased mean FGR in later years compared with earlier years in both Caucasian and immigrant Chinese infants (Tables L.3 and L.6). If increased maternal height, prepregnancy BMI, and net gestational weight gain caused these trends in GA and FGR, one would expect corresponding changes in BW over the same time period. However, BWs remained constant both in Caucasian and immigrant Chinese infants. As a result, other interpretation must be considered.

One possibility is that the effect of increased maternal height, prepregnancy BMI, and net gestational weight gain in recent years was offset by the increased cesarean section rates and other interventions in recent years. The increase in elective cesarean section rate in recent years is also a

likely explanation for the temporal trend toward a shortened GA and an increased FGR observed both in Caucasian and immigrant Chinese infants, because some of the cesarean sections are carried out to effect early delivery of a growth-retarded fetus. We have not been able to examine interventions other than cesarean section, such as induced labour. However, those interventions are correlated with cesarean section, and if obstetricians applied cesarean sections more frequently in recent years, they probably applied other interventions as well.

Another possible explanation is a change in misclassification of GA over time, since no ultrasound validation was applied for temporal trend assessment (because of limited sample size). Namely, a reduction in "falsely" prolonged GA and/or an increase of "falsely" shortened GA would lead to a decrease in GA in recent years compared with earlier years. Since the outcome that is relatively free of misclassification, namely, BW, remained the same in recent years as compared with earlier years both in Caucasian and immigrant Chinese infants (Tables L.3 and L.6), a change in misclassification of LNMP-determined GA over time is a possible explanation, although why and how such a temporal trend in misclassification occurred is unknown.

Shortened GA and increased FGR in recent years compared with earlier years observed in both Caucasian and immigrant Chinese infants. If caused by increased cesarean section rates, these

trends did not appear to distort the Caucasian-native Chinese or immigrant Chinese-native Chinese comparison of GA and FGR, since the cesarean section rates in the three study groups were quite comparable after adjustment for parity (Table O.1). Changes in misclassification of LNMP-determined GA (and therefore FGR) over time in Montreal's data is also unlikely to have distorted our comparisons for GA and FGR distributions among Caucasian, immigrant Chinese, and native Chinese infants, since the main analyses for these two outcomes were based on subjects with concordant ultrasound- and LNMP-determined GAs. As a result, there should be no serious problem in combining Montreal's historical data and comparing it with Hefei's contemporary data.

5.5.3. Misclassification of GA and FGR

There is no doubt that LNMP-determined GA (and therefore the FGR calculated from it) is prone to error. In addition to biological errors, there is legitimate concern about the accuracy of study mothers' recall of LNMP, especially in native Chinese mothers. Tables N.1 and N.2 show that the mean difference (LNMP GA minus ultrasound GA) was usually higher, and the proportion (%) with an LNMP-determined GA >= 7 days longer than the ultrasound-determined GA was substantially higher, in native Chinese infants, especially in postterm deliveries. Comparison of study subjects with concordant ultrasound- and LNMP-determined GA did not completely remove

the differences between native Chinese and Caucasian or native Chinese and immigrant Chinese (Tables N.1 and N.2).

There are two possible explanations for this phenomenon: a systematic overestimation of LNMP-determined GA or a systematic underestimation of ultrasound-determined GA in native Chinese infants.

In the study sample, three native Chinese mothers used lunar-based calendars to report their LNMP, which were later corrected by the hospital staff (85). Since in 1990 and 1991 the lunar-based calendar was about 1 month behind the western calendar (so that February 1 1991 in the western calendar was January 1 1991 in the lunar-based calendar), and since the hospital staff always use the western calendar to estimate the delivery date, the LNMP-determined GA for native Chinese reporting their LNMP based on the lunar calendar would be artificially higher. Suppose a pregnant woman's LNMP according to the western calendar was November 1, 1990, while according to the lunar-based calendar was October 1, 1990. Further suppose that the woman delivered on August 1, 1991 (western calendar). GA calculated from LNMP according to the western calendar would be one month lower than according to the lunar-based calendar. A few of the native Chinese mothers might have reported lunar-based LNMPs that were not detected by the hospital staff (85).

Biological reasons for overestimating LNMP-determined GA (i.e., delayed ovulation or missed abortion) might have also

occurred more frequently in native Chinese women. Since the LNMP-determined GA was the actual value used in the analyses in this thesis, one should be cautious about the impressively high rates in postterm delivery and postterm SGA in native Chinese infants (Tables 5, F.5, M.5 and M.10).

It would be inappropriate to say that GA estimated by ultrasonographic examination of the fetal biparietal diameter (BPD) early in the second trimester is entirely free of error. Apart from random measurement errors, there is a possibility that some fetuses were already growth-retarded early in gestation and had smaller BPDs at that time, which resulted in lower ultrasound-determined GA.

There should be no major concern about systematic errors in the ultrasound GA estimate, although modest random measurement error is inevitable. Both study hospitals are university-affiliated, tertiary obstetric care centers. Obstetric ultrasonography has been practiced in HMIH for 5 years (85). The ultrasound machine was imported from Japan, and, as at the RVH, the measurement of the fetal BPD is computerized (85).

Timing of the ultrasound examination is also an important factor affecting the accuracy of the GA estimate (2). For native Chinese mothers, ultrasound data obtained after 20 weeks of gestation were initially used for part of the ultrasound-determined GA calculation (85), but were later discovered and excluded from our analysis. Although there is no record of the timing of ultrasound examination in MOND, the

majority of the RVH patients had this procedure done at 16-18 weeks gestation (62).

Besides, the actual GA value used in this thesis was that estimated from mother's recall of LNMP. Ultrasound has been used only as a confirmating tool. Even if systematic underestimation of GA occurred by ultrasound measurement of fetal BPD in the native Chinese, it should not cause measurement bias in GA estimation. It would create, instead, selection bias. This issue will be addressed in section 5.6.7.

5.5.4. Misclassification of mother's race

Because of the extremely stable status of the native Chinese population, the possibility of misclassification of race for native Chinese mothers is nil. For immigrant Chinese mothers, an indirect approach using the mothers' maiden names was used to define their racial/ethnic status, because no racial/ethnic information is available in MOND. Although no further validation was performed, we believe these Chinese family names are unique enough to distinguish them from Caucasian and other ethnic groups, except perhaps for ethnic Vietnamese (Appendix A). There is no doubt that a small portion of ethnic Vietnamese have been classified as Chinese by our family names approach. The consequence of this misclassification is limited, however, since both determinant and outcome distributions were very similar in immigrant Chinese mothers with 'certain Chinese names' and those with 'uncertain names,

possibly mixed with Vietnamese' (Tables K.1 and K.2). The mean BW of 3,278 g reported in a group of singleton, live U.S. ethnic Chinese infants (defined by maternal race; see reference 9) is only slightly higher than our similar immigrant Chinese infants' figure of 3,245 g.

Using mothers born in Canada or other Caucasian-dominated countries as our Caucasian sample should have created an ethnic group with little misclassification, since non-Caucasian immigration to Montreal has occurred only in recent years. Although we could not validate the maternal ethnic group for Caucasian infants directly, comparison with external sources may be helpful in this regard. The mean BW of 3,414 g in a well-defined group of singleton, live U.S. ethnic white infants (9) is exactly the same as our similar Caucasian sample. The mean BW of Canadian infants (predominantly Caucasian) in 1983 was 3,431 g (68), which is also similar to our Caucasian infants' figure.

5.5.5. Misclassification of other outcome and determinant measures

BW, maternal anthropometric, demographic, obstetric, and neonatal measurements are routine and straightforward. Although some nondifferential misclassification due to measurement errors is inevitable, differential misclassification is unlikely, because the hospital physician and office staffs were unaware of the current study when they

made these measurements.

We are not sure, however, to what extent recall bias may have occurred in obtaining maternal smoking, drinking, and drug use during pregnancy. But since the distributions of these determinants observed in Caucasian and Chinese mothers in our study are quite similar with those reported in the literature (9,21,26-28,36), as are the observed determinant-outcome relationships (Tables G.1.-G.6, M.15-M.20) (1,34), recall bias, if any, should pose no serious problem for our study conclusions.

The stronger 0 terminal digit preference seen in the native Chinese data (Table J.1) might have caused less precise estimation of mean BW in this group (89). But for a variable like BW with a wide range of values, the effect should be extremely small, because the extra variance caused by such rounding is trivial. Although stronger 0 digit preference among the native Chinese could have had a substantial effect on the observed prevalence of LBW and HBW (Table J.2), it is obvious that this has altered neither the direction nor the clinical meaning of differences in LBW and HBW rates among Caucasian, immigrant Chinese, and native Chinese infants (Table J.2).

5.5.6. Selection bias caused by missing ultrasound-determined GAs

A substantial proportion of the mothers (22% Caucasian, 36%

immigrant Chinese, and 53% native Chinese) had no available early ultrasound-determined GA estimate (Table I.1). During the study period, early ultrasound examination was routinely performed in almost all women giving birth at the RVH (6). Most of the otherwise available ultrasound data were missing because the ultrasound results were not routinely computerized in MOND, especially during the early years of the database (6). For the native Chinese data, the situation is more complicated. Obstetric ultrasound fees are not covered by the government health care program, and an ultrasound examination costs Yuan 50.00, which is one-fourth the average monthly income for ordinary working women in Hefei city (85). In addition, during the study period, a local newspaper published an article about the potential fetal hazards of ultrasound (85). Both factors may have played some role in discouraging pregnant native Chinese women from having ultrasound examinations.

The potential for selection bias becomes a concern in using subjects with concordant ultrasound- and LNMP-determined GA for the analyses of GA and FGR distributions, because a significant portion of subjects had no ultrasound-determined GA records, and the proportions of women missing ultrasound data in the three study groups were rather different (Table I.1).

From Table I.2, it is clear that missing ultrasound measurement records in Caucasian mothers most likely occurred

randomly, since the distributions of determinants and outcomes in subjects with or without ultrasound estimates were quite similar. Although some comparisons were statistically significant, the differences are clinically negligible. As a result, it is unlikely that selecting subjects with ultrasound-determined GA records would create a biased sample.

A small degree of selection bias might have occurred in the participation and/or registration of ultrasound measurements for immigrant and native Chinese mothers, however, because BW, GA, and FGR distributions in subjects with ultrasound-determined GA records were shifted slightly to the right compared to subjects without such records (Table I.2).

The mechanism of selective participation and/or registration of immigrant Chinese mothers is unclear. Poorer access to prenatal care programs for less educated or lower socio-economic status immigrant Chinese mothers (90) might provide an explanation. Among native Chinese mothers, it is likely that the economically less fortunate would have had fewer ultrasound examinations. Regardless of the reasons, using subjects with available ultrasound-determined GA might have biased the BW, GA, and FGR distributions to the right in immigrant and native Chinese infants. But whether such a selection bias distorted the Chinese-Caucasian comparison needs further assessment.

The kurtosis coefficients for BW, GA, and FGR in subjects without exclusions showed some differences compared with the

results obtained from subjects with concordant GAs (Tables 2, F.2, M.2, and M.7). The kurtosis coefficient is highly variable in small samples and hence is often difficult to interpret (69). Such a change in kurtosis coefficients from the overall study sample to subsamples with concordant GAs (especially in native Chinese infants, see Tables 2, F.2, M.2, and M.7) might reflect (at least partially) the instability caused by substantial reduction of sample size occassioned by the concordant GA restriction. The results of other statistical comparisons (e.g., means, SDs, prevalences, and graphs of distributions) of BW, GA, and FGR among Caucasian, immigrant Chinese, and native Chinese infants without exclusions generally agreed with comparisons for subjects with concordant GAs (except for variation in FGR, in which slightly different results were obtained for the comparison without exclusions; see Tables 4, F.4, M.4, and M.9), indicating that such exclusions did not create serious selection bias.

5.5.7. Selection bias caused by exclusion of subjects with discordant ultrasound- and LNMP-determined GAs

The outcomes in subjects with concordant ultrasound- and LNMP-determined GAs were significantly different from subjects with discordant GAs in all three study groups. Subjects with concordant GAs had heavier BWs (80-110 grams), higher FGRs (0.05-0.07), shorter GAs (5-8 days), much lower prevalences of SGA and postterm delivery, somewhat lower prevalences of LBW

and preterm delivery (except for native Chinese infants, in which a slightly higher preterm delivery rate was observed), a higher prevalence of HBW, and marginally (and inconsistently) higher LGA rates compared to subjects with discordant GAs (Table I.4).

Most of the determinants, however, did not show important and consistent differences between subjects with concordant vs discordant GAs (Table I.5). This discrepancy in comparisons of outcomes and determinants indicates that the unfavourable BW, GA, and FGR distributions in subjects with discordant GAs might be caused by some artifact(s) or pathological process(es) unrelated to the determinants studied.

"False preterm" errors are most likely caused by nonmenstrual bleeding episodes in early gestation that are mistakenly interpreted by the gravida as normal menses (91). "False postterm" errors are caused largely by delayed ovulation (92), although missed spontaneous abortions might also provide a partial explanation (91,93). The frequency of delayed ovulation plus missed spontaneous abortion exceeds the frequency of nonmenstrual bleeding. As a result, the decrease in postterm delivery observed in our study after restriction to women with concordant GA estimates is most striking. The mean GA also decreased significantly after this restriction, despite some reduction in preterm delivery. A previous study carried out in an indigent U.S. population using GA based on LNMP, but modified by ultrasonography and other clinical

information, shifted the mean GA approximately 1 week to the left, compared with the use of LNMP data alone (34); this is entirely consistent with our findings.

Since FGR is a function of BW and GA, a shift in mean GA to the left should cause both a shift in mean FGR to the right and a reduction in SGA. Fetal growth appeared to slow at later GAs when GA was based on LNMP-determined estimates alone (2). A recent study showed that the tendency of slowed growth at later GAs is partially caused by erroneous inclusion of some smaller babies at (falsely) postterm dates (94). When GA is validated by ultrasound measurement of fetal BPD early in the second trimester, the prevalence of SGA at postterm deliveries becomes similar to that of term deliveries, and BW continues to increase with advancing GA (94). All of these previous findings are borne out in our data. Although the prevalence of SGA in postterm deliveries is still higher than that in term deliveries after GA validation by early ultrasound in the two Chinese groups, the difference becomes much smaller. The remaining higher SGA rates in postterm Chinese infants is probably caused by applying a mean BW obtained from RVH's Caucasian-dominated population (see Appendix E) to calculate FGR for Chinese infants whose "expected" BW at postterm GA is substantially lower.

The substantial reduction of BW in subjects with discordant ultrasound- and LNMP-determined GAs suggests that pathological processes may have been involved in these pregnancies,

however. As discussed above, biological explanations of preterm and postterm errors in LNMP-determined GA are related to some adverse obstetric events. Nonmenstrual bleeding episodes at early gestation are often seen in threatened abortion (95). When bleeding is slight and resolves, the fetus may survive to the delivery, but birth outcomes may be adversely affected (94). Missed spontaneous abortion usually occurs during the first trimester. First-trimester abortion is associated with maternal immunological abnormalities, endocrine disorders and other maternal diseases, abnormalities of the uterus, and fetal chromosomal anomalies (95). It is clear that many of these conditions are likely to recur (or continue) in the next pregnancy and thus affect the subsequent birth outcomes. Delayed ovulation might also be associated with abnormalities of menses, which, in turn, might adversely affect the fetus. But how and how much these obstetric events shortened the 'true' GA (the actual duration of the fetus in utero) and/or inhibited fetal growth is not clear.

Regardless of the explanations, significant differences in outcome distributions between subjects with concordant and discordant ultrasound- and LNMP-determined GA creates a potential for selection bias when results are based only on subjects with concordant ultrasound- and LNMP-determined GAs. But since outcome differences between subjects with concordant and discordant GAs were similar both in direction and magnitude in all three study groups, these differences seem

unlikely to bias the comparison among Caucasian, immigrant Chinese, and native Chinese infants.

5.5.8. Selection bias caused by missing values for determinants

A substantial proportion of values for maternal education, height, prepregnancy BMI, and net gestational weight gain rate were missing in Caucasian and immigrant Chinese subjects. In addition, BW, GA, and FGR were 'left-shifted' and more 'variable' in Caucasian subjects with missing values for determinants compared with Caucasian subjects without missing values (Tables I.6 and I.7).

But it is unlikely that difference in missing values for determinants would substantially change the Chinese-Caucasian comparisons. For example, given the (highly unlikely) worst case scenario, i.e., that missing one determinant value would predict an absence of missing other determinants, the reduction in mean BW among 'risk-free I' Caucasian infants caused by missing values would be 50 g*, which is only a fraction of the observed Chinese-Caucasian difference in mean BW.

* Calculated as follows: (0.12*127 g)[1] + (0.25*37 g)[2] + (0.32*32 g)[3] + (0.25*60 g)[4] = 50 g
[1] proportion of subjects with missing maternal education values*difference in mean BW between overall study sample and subjects with missing maternal education values)
[2] proportion of subjects with missing maternal height values*difference in mean BW between overall study sample and subjects with missing maternal height value)
[3] proportion of subjects with missing maternal BMI values*difference in mean BW between overall study sample and subjects with missing maternal BMI values)
[4] proportion of subjects with missing maternal wt gain rate values*difference

in mean BW between overall study sample and subjects with missing maternal net weight gain values)

5.6. Limitations of the Study

There are several limitations in our study, which not only prevent us from a more thorough and powerful analysis, but also create difficulties in interpreting the results.

a) Race

Only the mother's race was used for this study. The father's race does have some effect on gestational duration and fetal growth, although the paternal contribution appears much smaller than the maternal one (1,13). The absence of paternal data not only prevented us from analysing the effect of the father's race, but also decreased our power to distinguish a genetic from environmental effect; using both maternal and paternal race would have provided a better analysis of this aspect (13).

b) Time since immigration

Time since immigration may be crucial in unravelling the effect of the shift in the distributions of environmental determinants and their consequences on outcomes. Lack of this information prevented us from exploring this issue further. Although using the mother's country of birth could provide an opportunity to compare first- and second-generation immigrants, the small number of second-generation immigrants among Chinese mothers in our sample did not permit adequate

analysis.

c) Missing values for outcomes and determinants

A substantial portion of ultrasound-determined GAs were missing in our data set. This reduced statistical power in analyses for subjects with concordant ultrasound- and LNMP-determined GA, and created difficulties in interpreting the results, especially in the two Chinese groups for which the sample sizes are limited.

Very few determinant values were missing in the native Chinese group, while a substantial portion of values were missing for some important determinants in both Caucasian and immigrant Chinese infants. These missing values reduced the power to detect statistically significant associations between those determinants and outcomes in immigrant Chinese infants and created unstable estimates in the 'risk-free' subsample analyses for this group of infants. Since the sample size for Caucasian infants was very large, missing determinant values were a less severe problem for that group.

5.7. Summary, Relevance, and Implications

The main purpose of the current study is to examine possible explanations for the frequently observed "tight" BW distribution in Chinese populations. Two data sources have been used to address this issue: (1) MOND for Chinese immigrants and Caucasians delivering at Montreal's RVH; (2)

prospective information on native Chinese women delivering at Hefei's HMIH. Mother's family name and country of birth have been used to identify the maternal racial/ethnic group for Caucasian and immigrant Chinese women in MOND. This approach of classifying maternal racial/ethnic status has been assessed using external data sources and appears to be valid. The validity of ultrasound-confirmed GA, as well as other measures of outcomes and determinants obtained from routine clinical practice in the two hospitals, has also been assessed and appears acceptable. Various statistical approaches, including simple tabular and graphic presentation, live birth and 'risk-free' subsample comparisons, etiologic fraction for variance (r^2) analysis for attributes with continuous distributions, and multivariate analyses, have been utilized to assess Chinese-Caucasian differences in BW, gestational duration, fetal growth, and to test plausible hypotheses for explaining the observed differences.

The main findings from this study are as follows:

a) In immigrant and native Chinese infants, the distributions of BW and its major determinants were similar, but differed from those in Caucasian infants.

b) Mean BW in immigrant and native Chinese infants was about 150-250 grams lower than that of Caucasian infants, but the "tighter" overall BW distribution in the two Chinese groups of infants led to a prevalence of LBW that was no higher than that of Caucasian infants.

c) Although the rates of fetal death and severe PIH were higher, and the rate of congenital malformations lower, among the native Chinese, these differences could not explain the observed Chinese-Caucasian differences in BW distributions.

d) The Chinese-Caucasian differences in BW and FGR diminished after adjustment for the covariates studied.

e) Chinese infants exhibited more rapid growth preterm but slower growth at and after term.

f) Most of the "excess" SGA (based on a predominantly Caucasian standard) observed in Chinese infants occurred at or after term. In fact, SGA was less common among preterm Chinese infants than among preterm Caucasian infants.

g) Restricting the study sample to a 'normal' range of maternal determinants substantially reduced the prevalences of LBW, preterm delivery, and SGA (especially in Caucasian infants), but the prevalences of HBW, postterm delivery, and LGA remained the same in all three study groups.

h) All but one (marital status) of the determinants studied had a stronger effect on fetal growth than on gestational duration.

i) Since a substantial Chinese-Caucasian mean BW difference remained even in the 'risk-free' subsample comparison, and since the interaction term containing maternal race remained significant in the multivariate regression analyses, we conclude that the higher mean BW in Caucasian infants is determined largely by genetic mechanisms.

j) Based on the fact that the Chinese-Caucasian difference in the variation of BW disappeared in the 'risk free' subsample comparison, we conclude that the "tighter" BW distribution in Chinese infants is caused primarily by their reduced exposure to 'growth-inhibiting' and 'growth-accelerating' levels of environmental determinants.

k) Since the Caucasian LBW rate became lower than the Chinese LBW rate in the 'risk-free' subsample comparison, and since BWs in Chinese infants at earlier GAs were not lighter, we conclude that the lower-than-expected LBW rate in Chinese infants is caused partly by their reduced exposure to 'growth-inhibiting' levels of environmental determinants, and partly by their different temporal pattern in fetal growth (mediated largely by genetic mechanisms).

l) Because of the genetically-mediated fetal growth pattern, most extra SGA in Chinese infants occurred at or after term. Therefore the substantially higher overall SGA rate observed in Chinese infants was caused by inappropriately applying the Caucasian-dominated standard to define Chinese term and postterm SGA infants, at which time Chinese BWs were substantially lower.

The results of our study have several important implications relevant to clinical practice, public health policy, and future research:

a) For health-related attributes with a continuous distribution (such as BW in this study), analyses focused on

the mean are insufficient, as are those based solely on dichotomized indices. An adequate analysis for these kinds of attributes should examine the mean, variation, prevalence of dichotomized indices, and the entire distribution.

b) A discrepancy in the comparison of means and dichotomized values for a continuously distributed attribute (such as mean BW and the LBW rate in this study) often indicates an unusual distribution pattern. Exploring possible explanations for such a distribution pattern might be helpful in identifying some theoretically and practically important causal mechanisms.

c) In epidemiologic studies involving international (or interregional and interethnic) comparisons of distributions of diseases and other health-related attributes, it is important to assess not only the consequences of differences in diagnostic procedures (such as the potential differences in diagnostic criteria for PIH between Hefei and Montreal) and data registration and reporting (such as the differences in recording BW between Hefei and Montreal), but also the influence of culture and policy (e.g., the current 'one couple, one child' policy in China).

d) Measuring the distribution of major determinants among immigrants, residents of the homeland, and native residents of the adoptive country simultaneously, and assessing the contribution of these determinants in race-specific patterns of diseases or attributes, appear to be useful approaches to

estimating relative genetic vs environmental contributions.

e) Determinants in this study explained a relatively small portion of FGR variance, and explained almost none of the variance in GA. There is still much room, therefore, for etiologic research for both FGR and (especially) GA.

f) To further improve the pregnancy outcomes in developed countries such as Canada, clinical and public health efforts should be aimed at reducing behavioural risk factors such as smoking, drinking and drug use during pregnancy, and optimizing the individual woman's prepregnancy and pregnancy nutrition. To further improve pregnancy outcomes in developing countries (such as China) that meet basic health and nutritional needs for adequate fetal growth, clinical and public health efforts should be aimed at supplying adequate facilities for perinatal care and promoting optimal prepregnancy and pregnancy nutrition.

g) When applying standards obtained from one population to calculate FGR and the prevalences of SGA and LGA for a different population, it is important to examine the pattern of fetal growth during different periods of gestation in the new population and compare it with the standard. If the patterns are substantially different, it might be wise to search for or develop a new (race-specific) standard. While waiting for the new standard, clinicians might prefer to use a lower cutpoint value (e.g., 5th percentile) for defining SGA Chinese infants at later GAs.

h) Clinicians should not necessarily be concerned about otherwise normal Chinese infants born at term or postterm who are classified as mildly SGA based on a Caucasian-dominated standard.

i) Public health workers should not be alarmed by a higher SGA rate observed in Chinese populations based on a Caucasian-dominated standard, for the same reasons discussed in h).

j) It is clear from our results that the BW distribution and the growth pattern with advancing GA in ethnic Chinese infants are quite different from those in Caucasian infants. Our analyses provide part of the explanation for these Chinese-Caucasian differences. To better understand the mechanisms, further research is required. First, the sample size for Chinese infants (especially for immigrant Chinese infants) should be expanded, with inclusion of reasonable numbers of second-generation immigrants, to examine the potential shift in distribution of determinants and the effect of such a shift on outcomes. Second, studies comparing outcomes and determinants in Caucasian and immigrant Chinese infants with native Chinese infants in a society with more comparable medical care systems (such as in Hong Kong or Singapore) would ensure greater comparability of ultrasound examinations and other aspects of prenatal care, and the recording and coding of various pregnancy outcomes.

k) Similar research in other racial groups, such as

blacks, Japanese, Arabs, East Indians, etc., should examine whether the different race-specific BW distribution and pattern of fetal growth during different periods of gestation observed among the ethnic Chinese in our study, as well as the hypothesized explanations, are applicable to other races. Information obtained from such research would be helpful for clinicians and public health workers concerned with those racial groups. Such information would also be helpful for international agencies (such as the World Health Organization) in deciding whether a universal or a race-specific standard should be used in defining SGA and which interventions or research programs should receive highest priority in the effort to improve the BW distribution in different populations.

REFERENCES

1. Kramer, M.S. Determinants of low birth weight: methodological assessment and meta-analysis. Bull WHO 1987;65:663-737.

2. Little, G.A. Fetal growth and development. In: Eden, R.D. & Boehm, F.H. Ed. Assessment and care of the fetus: Physiological, clinical, and medicolegal principles. PP 1-5. Connecticut:Appleton & Lane, 1990.

3. Lubchenco, L.O., Homesman, C., Boyd, E. Intrauterine growth in length and head circumference as estimated from live births at gestational age from 26 to 42 weeks. Pediatrics. 1966;37:403.

4. Ott, W.J. & Doyle, S. Normal ultrasonic fetal weight curve. Obstet Gynecol 1982;59:603-606.

5. Widdowson, E.M., Southgate, D.A.T. & Hey, E. Fetal growth and body composition. In: Lindblad, B.S. Ed. Perinatal nutrition. PP. 3-14. San Diego:Academic Press INC, 1988.

6. Kramer, M.S., McLean, F.H., Boyd, M.E., Usher, R.H. The validity of gestational age distribution by menstrual dating in term, preterm and postterm gestations. JAMA 1989;260:3306-3308.

7. World Health Organization. The incidence of low birth weight: a critical review of available information. World Health Statistics Quarterly 1980; 33:197-224.

8. World Health Organization. The incidence of low birth weight: an update. Weekly Epidemiological Record. 1984;59:205-

211.

9. Wen, S.W. An analysis of the differences in birth weight patterns of Chinese and white babies in the United States. Master's thesis. University of Washington Health Science Library, 1987.

10.Yip, R., Li, Z. & Chong, W-H. Race and birthweight: the Chinese example. Pediatrics. 1991;87:688-693.

11.Lin, C. & Emanuel, I. A comparison of American and Chinese intrauterine growth standard:Are American babies really smaller? Am J Epi 1972;95:418-430.

12.Ip, H.M.H. Intrauterine growth in Hong Kong Chinese. Biol Neonatal 1978;33:253-263.

13.Moceri, V.M., Wen, S.W. & Emanuel I. Gestational duration and birth weight in Chinese, white and mixed race babies. Pediatric and Perinatal Epidemiology (in processing).

14.Helsel, D., Petitti, D.B. & Kunstandter, P. Pregnancy in the Hmong: Birthweight, age, and parity. Am J Public Health 1992;82:1361-4.

15.Hughes, K., Tan, N.R., & Lun, K.C. Low birthweight of live singletons in Singapore, 1964-1974. International J Epidemiology. 1984;13:465-471.

16.Davis, D.P. Size at birth of Asian and white Caucasian babies born in Leicester: implications for obstetric and paediatric practices. Early Human Development. 1982;6:257-263.

17.Yudkin, P.L., Harlap, S. & Baras, M. High birthweight in an ethnic group of low socioeconomic status. Br J Obstet Gynecol.

1983;90:291-296.

18.Chase, H.C. A study of risks, medical care, and infant mortality. AJPH 1973;63(suppl):1-56.

19.Hoffman, H.J., Stark, C.R. & Lundin, F.E.Jr. Analysis of birth weight, gestational age, and fetal viability, U.S. births, 1968. Obstetrics Gynecology Survey. 1974;29:651-681.

20.Niswander, K.R. & Gordon, M. The Collaborative Perinatal study of the National Institute of Neurological Diseases and Stroke: the women and their pregnancies. Washington, D.C, U.S. Government Printing Office, 1972 (DHEW Publication No. 73-379).

21.Schumacher, L.B., Pawson, I.G., Green, J.R., Partridge, J.C. & Kretchmer, N. Ethnic variation in the size of infant at birth. Am J Human Bio 1990;2:695-702.

22.Falconer, D.S. Introduction to quantitative genetics. 3ed. New York: John Wiley & Sons, Inc, 1989.

23.Vogel, F. & Motulsky, A.G. Human genetics. 2ed. Berlin:Springer-Verlag, 1986.

24.Goldenberg, R.L., Nelson, K.G., Koski, J.F. & Cutter, G.R. Low birth weight, intrauterine growth retardation, and preterm delivery. Am J Obstet Gynecol 1985;152:980-984.

25.Kline, J., Stein, Z. & Susser, M. Conception to birth: epidemiology of prenatal development. New York:Oxford University Press, 1989.

26.Fung, K.P., Wong, T.W. & Lau, S.P. Ethnic determinants of perinatal statistics of Chinese: demography of China, Hong

Kong and Singapore. International J Epidemiol 1989;18:127-131.

27.Wen, S.W. Smoking habits of 1008 young couples during pregnancy in Changsha city. Chinese J Prevent Med 1986;20:320-321.

28.Yu, E. The low mortality rates of Chinese infants: some plausible explanatory factors. Social Science and Medicine 1982;16:253-265.

29.Cattanach, B.M. & Kirk, M. Differential activity of maternally and paternally derived chromosome regions in mice. Nature 1985;315:496-498.

30.Walton, A. & Hammond, J. The maternal effects on growth and conformation in Shire horse-Shetland pony crosses. Proc. R. Soc. Lond. B. 1938;125:311-335.

31.Morton, N.E. The inheritance of human birth weight. Ann. Hum. Genet. 1955;200:125-134.

32.Magnus, P. Causes of variation in birth weight: A study of offspring of twins. Clin. Genet. 1984;25:15-24.

33.Little, R.E. & Sing, C.F. Genetic and environmental influences on human birth weight. Am. J. Hum. Genet. 1987;40:527-536.

34.Wen, S., Goldenberg, R., Cutter, G.R., Hoffman, H.J. & Cliver, S.P. Intrauterine growth retardation and preterm delivery: prenatal risk factors in an indigent population. Am J Obstet Gynecol. 1990;162:213-218.

35.Kramer, M.S., McLean, F.H., Eason, E. & Usher, R.H. Maternal nutrition and spontaneous preterm birth. Am J

Epidemiol. 1992;136:574-83.

36.Migone, A., Emanuel, I., Muller, B., Daling, J., & Little, RE. Gestational duration and birth weight in white, black, and mixed-race babies. Pediatric and Perinatal Epidemiology 1991;5:378-391.

37.Hackman, E., Emanuel, I. Van Belle, G. & Daling, J. Maternal birth weight and subsequent pregnancy outcome. JAMA 1983;250:2016-2019.

38.Klebanoff, M.A., Graubard, B.I., & Kessel, S.S. Low birth weight across generations. JAMA 1984;252:2423-2427.

39.Johnstone, F. & Inglis, L. Familial trends in low birth weight. Br Med J 1974;3:659-661.

40.Leff, M., Orleans, M., Haverkamp, A.D., Baron, A.E., Alderman, B.W. & Freedman, W.L. The association of maternal low birthweight and infant low birthweight in a racially mixed population. Paediatric & Perinatal Epidemiol 1992;6:51-61.

41.Alberman, E., Emanuel, I., Filakti, H. & Evans, S.W. The contrasting effects of parental birthweight and gestational age on the birthweight of offspring. Pediatric and Perinatal Epidemiology 1992;6:134-144.

42.Kramer, M.S. Balanced protein/energy supplementation in pregnancy. In: Chalmers, I. ed. Oxford Database of Perinatal Trials. Version 1.2, Disk Issue 8, Autumn 1992.

43.Kramer, M.S. The effects of energy and protein intake on pregnancy outcome: an overview of the research evidence from controlled clinical trials (Submitted for publication).

44.Blackwell, R.Q., Chow, B.F., Chinn, K.S.K., Blackwell, B.N. & Hsu, S.C. Prospective maternal nutrition study in Taiwan: rational, study design, feasibility and preliminary findings. Nutr Rep Intl 1973;7:517-532.

45.Zuckerman, B., Frank, D.A., Hingson, R. Amaro, H., Levenson, S.M., Kayne, H., Parker, S., Vinci, R., Aboagye, K. & Fried, L.E. Effects of maternal cocaine use on fetal growth. N Engl J Med 1989;321:762-768.

46.Petitti, D.B. & Coleman, C. Cocaine and the risk of low birth weight. Am J Public Health 1990;80:25-28.

47.Cavalli-Sforza, L.L. & Bodmer, W.F. The genetics of human populations. San Francisco:W.H.Freeman and Company (1971).

48.Rao, D.C. & Morton, N.E. Path analysis of quantitative inheritance. In: Mielke, J.H. & Crawford, M.H. et al. Current developments in anthropological genetics. PP 355-372 (1980).

49.Karlin, S., Cameron, E.C. & Chakraborty, R. Path analysis in genetic epidemiology: A critique. Am J Hum Genet 1983;35:695-732.

50.Rao, A.C. & Morton, N.E. IQ as a paradigm in genetic epidemiology. In: Morton, N.E. & Chung, C.S. Ed. Genetic epidemiology PP 145-195 (1978).

51.Rice, J., Cloninger, C.R. & Reich, T. Analysis of behavioral traits in the presence of cultural transmission and assortative mating: applications to IQ and SES Behav Genet 1980;10:73-92.

52.Cloninger, C.R., Rao, D.C. & Rice, J. A defense of path

analysis in genetic epidemiology Am J Hum Genet 1983;35:733-756.

53.Miettinen, O.S. Proportion of disease caused or prevented by a given exposure, trait or intervention. Am J Epidemiol 1974;99:325-332.

54.MacMahon, B. & Paul, T. Epidemiology: principles and methods. Boston:Little, Brown and Company, 1970.

55.Haenszel, W., & Kurihara, M. Studies of Japanese migrants. I. Mortality from cancer and other diseases among Japanese in the United States. J. Nat. Cancer Inst. 1968;40:43-68.

56.Trulson, M., Clancy, R.E., Jessop, W.J.E., Childers, R.W., & Share, F.J. Comparison of siblings in Boston and Ireland. J Am Diet Ass. 1964;45:225-229.

57.Alter, M., Leibouitz, U. & Speer, J. Risk of multiple sclerosis related to age at immigration to israel. Arch. Neurol. 1966;15:234-239.

58.Rothman, KJ. Modern epidemiology. Bosten:little, Brown and Company, 1986.

59.Sussar, M. Separating heredity and environment. Am J Prev Med 1985;1:5-23.

60.Smith, L.P., Deleon, A., Fumell, W.R., Lalonde, A.B., McLean, F.H., Usher, R.H. A research-oriented system for McGill obstetrical and neonatal data (MOND). Acta Obstet Gynecol Scand. 1989;109(suppl):49-50.

61.Usher, R., McLean, F. Intrauterine growth of live-born Caucasian infants at sea level: standards obtained from

measurements in 7 dimensions of infants born between 25 and 44 weeks of gestation. J Pediatr. 1969;74:901-910.

62.Kramer, M.S., McLean, F.H., Olivier, M.O., Willis, D.M. & Usher, R.H. Body proportionality and head and length 'sparing' in growth-retarded neonates: A critical reappraisal. Pediatrics 1989;84:717-723.

63.Subcommittee on nutritional status and weight gain during pregnancy, food and nutrition board, U.S. Institute of Medicine/National Academy of Sciences. Nutrition during pregnancy. Washington, D.C.: National Academy Press, 1990, PP 96-120 and 176-211.

64.Armitage, P. Statistical methods in medical research. Oxford:Blackwell Scientific Publications; 1971.

65.SAS User's Guide, Version 5 Ed. Cary, N.C.:SAS Institue Inc; 1985.

66.BMDP Statistical Software Manual. 1985 reprinting. Berkeley, CA:University of California Press; 1983.

67.National Center for Health Statistics: Advanced report of final natality statistics, 1984. In: Monthly Vital Statistical Report. Vol 35, No.4 (Suppl), 1986.

68.Statistics Canada: Births and deaths. In Vital statistics Volume 1, 1983.

69.Kleinbaum, D.G., Kupper, L.L., & Muller, K.E. Applied regression analysis and other multivariate methods. Boston:PWS-KENT Publishing Company, 1988.

70.Yan, J.S. & Yin, C-S. No decline in preterm birth rate over

three decades. Int. J. Gynecol. Obstet. 1990;34:1-5.

71.Garn, S.M., Shaw, H.A. & McCabe, K.D. Effects of socioeconomic status and race on weight-defined and gestational prematurity in the United States. In: Reed, D.M. & Stanley, F.J. Eds. The epidemiology of prematurity. Baltimore:Urban & Schwarzenberg, 1977:127-43.

72.Fedrik, J. & Anderson, A.B.M. Factors associated with spontaneous pre-term birth. Br J Obstet Gynecol 1976;83:342-50.

73.Lieberman, E., Ryan, K.J., Monson, R.R. & Schoenbaum, S.C. Risk factors accounting for racial differences in the rate of premature birth. N Engl J Med 1987;317:743-748.

74.Taffel, S. Factors associated with low birthweight, United States, 1976. Washington D.C.: U.S. Government Printing Office 1980 (Vital Health Statistics Series 21 (37), DHEW Publication No. (PHS) 80-1915).

75.Institute of Medicine. Preventing low birth weight. Washington D.C.:National Academic Press, 1985.

76.Kleinman, J.C. & Kessel, S.S. Racial differences in low birth weight, trends and risk factors. N Engl J Med 1987;317:749-753.

77.Carlson, E.D. Social determinants of low birth weight in a high-risk population. Demography 1984;21:207-15.

78.Shiono, P.H., Klebanoff, M.A., Graubard, B.I., Berendes, H.W. & Rhoads, G.G. Birth weight among women of different ethnic groups. JAMA 1986;255:48-52.

79.Tanner, J.M. Physical growth and development. In:Forfar, J.O. & Amei, G.C. eds. Textbook of pediatrics; vol. 1. 3rd ed. London:Churchill Livingstone, 1984:278-329.

80.Walter, S.D., Feinstein, A.R., & Wells, C.K. A comparison of multivariable mathematical methods for predicting survival-II. Statistical selection of prognostic variables. J Clin Epidemiol. 1990;43:349-359.

81.Fleiss, J.L. & Davies, M. Jackknifing functions of multinomial frequences, with an application to a measure of concordance. Am J Epidemiol 1982;115:841-845.

82.Efron, B. & Tibshirani, R. Statistical data analysis in the computer age. Science 1991;253:390-395.

83.Central Intelligence Agency (CIA): Per capita income. The World Fact Book. Washington D.C.:Central Intelligence Agency; 1989.

84.System of national accounts: National income and expenditure accounts, Annual estimates 1978-1989. Statistics Canada, 1990.

85.Ni, JF. Personal communications

86.Greenhalgh, S., & Bongaarts, J. Fertility policy in China: future options. Science. 1987;235:1167-1172.

87.National Pregnancy-Related-Hypertension Study Co-operative Group: A national survey of pregnancy-related-hypertension in China. Chinese J Obstet Gynecol. 1991;26:67-70.

88.Xiao, K.Z. A survey of the constitutional status of perinates in China. National Med J China. 1989;69:185-188.

89.Browner, W.S., Black, D., Newman, T.B., & Hulley, S.B. Estimating sample size and power. In: Hulley, S.B., & Cummings, S.R. ed. Designing clinical research. Baltimore:Williams & Wikins. 1988:139-150.

90.Chan-Yip, A. & Wen, SW. A cultural specific perinatal program for Chinese immigrant women (to be submitted)

91.Treloar, A.E., Behn, B.G., & Cowan, D.W. Analysis of gestational interval. Am J Obstet Gynecol. 1967;99:34-45.

92.Saito, M., Yazawa, K., & Hashiguchi, A. Time of ovulation and prolonged pregnancy. Am J Obstet Gynecol. 1972;112:31-38.

93.Boyee, A., Mayaux, M.J., Schwartz, D. Classical and 'true' gestational postmaturity. Am J Obstet Gynecol. 1976;125:911-914.

94.McLean, F.H., Boyd, M.E., Usher, R.H., & Kramer, M.S. Postterm infants: too big or too small? Am J Obstet Gynecol. 1991;164:619-624.

95.Turnbull, A. Spontaneous abortion, In: Turnbull, A. & Chamberlain, G. Eds. Obstetrics. Edinburgh:Churchill livingstone, 1989. PP. 401-418.

APPENDIX A. CHINESE FAMILY NAMES FROM MOND

1. CHINESE FAMILY NAMES WITH CERTAINTY:

AH, AU, AU YEUNG, AH SEN, AH-CHONG, AH-LAN, AH-YOU, BEI, BI, CHAN, CHAN 1, CHAN 2, CHAN HING QU, CHAN WAI, CHAN SUI HIN, CHA, CHAI, CHAO, CHANG, CHANG ALLOY, CHAU, CHEN, CHENG, CHEONG, CHEUNG, CHEUNG 1, CHEUNG 2, CHEW, CHHOUNG, CHIN, CHIANG, CHIN-KOON-SI, CHIN PO KOI, CHING, CHIU, CHO, CHOI, CHOI 1, CHOI 2, CHONG, CHOU, CHOW, CHOY, CHU, CHU FUNG LEU, DAO, DAO CONG, FAN, FANG, FONG, FU, FUNG, FUNG TING, GAN, GAO, GUAN, HO, HO CHIN SUN, HO-CHIN-SU, HONG, HU, HUANG, HUI, HUI-YU, LEE WAI YIN, LEE-PING-KEE, LEE-YEUNG, LEI, LI, LI TIEN CHEO, LI TSANG WAN, LI-MOORE, LI-WAN-PO, LIN, LIU, MA, MAI, MIN, MING, MINH, MOK, MOK-SIU-HING, NG, NG CHEONG TO, NG FUK CHONG, NG YUM LOONG, NG-NGOK, NG-THOW-HING, NI, NING, SHEA, SI, SITU, SU, TAN, TANG, WAN, WANG, WEN WANG, WON, WONG, WU, XU, XU 1, XU 2, YAN, YAN SUN YUEN, YANG, YANG-WU, YAO, YIP, YUAN.

2. 'UNCERTAIN, PROBABLY MIXED WITH VIETNAMESE NAMES' CHINESE FAMILY NAMES:

BANG, BANH, CHUAH, CHUAM, CHUANG, CHUN, CHUNG, CHUNG WAH CH, DANG, DIEP, DIHN, DUONG, HA, HA-KOW, HAN, HANG, HOANG, HOANG TRUNG, HSIEH, HSIUNG, HSU, HSUEH, HUA, HUISH, HUM, HUNG, HUYNH, HUYNH-THI, KONG, KONG-WIN-CHA, KWAN, KWONG, LA, LAC LAI, LAI LUN, LAM, LAM 1, LAM 2, LAM HEUNG KO, LAM PO YUEN,

LAM-HUANG, LAU, LAW, LE, LO, LO(LAW), LOI, LOK, LONG, LONG 1, LONG 2, LOO, LUI, LUNG, LUONG, LUU, LY, NGAI, ANGAN, NGO, NGUON, NGUY, NGUYEN, NGUYEN TU TH, NGUYEN-DINH, NGUYEN-HUU, NGUYEN-NGOC, NGUYEN-PHUON, NGUYEN-THI, ONG, ONG-SING, ONG-TONE, PANG, PHAM, PHAM-THI, PHAM-DANG, PHAN, PHANG, PHUNG, QUACH, QUACH-TINH, QUAN, QUANG, TA, TAI, TAING, TAM, THAI, TONG, TRAN, TRAN NGUYET, TRAN-QUANG, TRAN-THI, TRAN-TUYET, TRIEU, TRINH, TRUONG, TSANG, TSUI, TU, TUNG, VIEN, VIEN-HUCHETT, VU, VUONG, WOO, YEE, YEE SUI CHU, YEE SUI CHUN, YEE-SUI-CHUN.

3. CHINESE FAMILY NAMES THAT OVERLAP WITH OTHER ETHNIC GROUPS AND EXCLUDED:

GO, LANG.

4. CHINESE FAMILY NAMES THAT OVERLAP WITH OTHER ETHNIC GROUPS AND THE ETHNIC GROUPS WERE ASSIGNED ACCORDING TO THE MOTHER'S PLACE OF BIRTH:

LEE, YOUNG, LEUNG.

APPENDIX B. DISTRIBUTIONS OF MOTHER'S BIRTH PLACE FOR CAUCASIAN AND IMMIGRANT CHINESE

Table B.1 Distribution of birth place in Caucasian and immigrant Chinese mothers

	Caucasian		Immigrant Chinese	
	#	%	#	%
Quebec	14167	75.9	51	3.2
Ontario	945	5.1	4	0.3
New Brunswick	161	0.9	1	0.1
Other provinces of Canada	674	3.6	2	0.1
United States of American	618	3.3	2	0.1
England	386	2.1	1	0.1
Scotland	40	0.2	0	0.0
Poland	135	0.7	2	0.1
Russia	15	0.1	0	0.0
Hungary	29	0.2	1	0.1
Rumania	21	0.1	0	0.0
Italy	918	4.9	1	0.0
Greece	435	2.3	2	0.1
Germany	120	0.6	0	0.0
Other countries	0	0.0	1078	67.5
Missing	0	0.0	452	28.3

APPENDIX C. OBSTETRIC AND NEONATAL INFORMATION SHEET

1. Baby's case number:
2. Delivery date (year/month/date):
3. Mother's birth date (year/month/date):
4. Baby's sex:
5. Parity:
6. Mother's marital status (single, married, widowed, divorced or separated):
7. Mother's education (completed years of schooling):
8. Maternal smoking (amount/day):
9. Maternal alcohol consumption (amount & frequency):
10. Maternal social drug use (amount & frequency):
11. Delivery method:
12. Maternal hypertension (type and severity):
13. Congenital malformation (yes or no):
14. Multiple births (singleton, twin, triple and so on)
15. LNMP-determined GA (days):
16. Ultrasound-determined GA (days):
17. Maternal height (cm):
18. Maternal prepregnancy weight (kg):
19. Maternal weight before delivery (kg):
20. Birth outcome (live, fetal death or still birth):
21. Birth weight (g):

APPENDIX D. GESTATIONAL AGE BY BPD FROM RVH OBSTETRIC LAB

BPD (mm)	GEST.AGE (Wks.& days)	BPD (mm)	GEST.AGE (Wks.& days)	BPD (mm)	GEST.AGE (Wks.& days)
16	11.0	45	19.0	72	28.0
17	11.2	46	19.2	73	28.2
19	11.3	47	19.5	74	28.5
20	12.0	48	20.0	75	29.0
21	12.2	49	20.2	76	29.2
22	12.4	50	20.5	77	29.5
23	12.5	51	21.0	78	30.0
24	13.0	52	21.2	79	30.3
25	13.2	53	21.5	80	31.0
26	13.3	54	22.0	81	31.4
27	13.5	55	22.2	82	32.0
28	14.0	56	22.5	83	32.3
29	14.2	57	23.0	84	33.0
30	14.4	58	23.2	85	33.4
31	14.5	59	23.5	86	34.0
32	15.0	60	24.0	87	34.4
33	15.2	61	24.2	88	35.0
34	15.3	62	24.5	89	35.4
35	15.5	63	25.0	90	36.0
36	16.0	64	25.2	91	36.3
37	16.2	65	25.5	92	37.0

38	16.5	66	26.0	93	38.0
39	17.0	67	26.2	94	39.0
40	17.2	68	26.5	95	40.0
41	17.5	69	27.0	96	41.0
42	18.0	70	27.2	97	42.0
43	18.2	71	27.5	98	43.0
44	18.5				

APPENDIX E. MEAN BIRTH WEIGHT (GRAMS) BY PREGNANCY TIME (DAY) FROM RVH (140 DAYS TO 301 DAYS OF GESTATION)

400	406	411	417	422	428	434	440	449
457	466	474	483	492	500	510	520	530
540	551	561	571	582	594	605	617	628
639	651	664	676	689	702	715	727	740
755	769	784	799	814	828	843	860	878
895	913	930	947	965	983	1002	1020	1038
1056	1075	1093	1113	1133	1153	1174	1194	1214
1234	1256	1278	1300	1322	1344	1366	1388	1412
1436	1460	1484	1507	1531	1555	1581	1606	1632
1658	1684	1709	1735	1763	1790	1818	1845	1873
1900	1928	1958	1987	2017	2046	2076	2105	2135
2166	2198	2229	2261	2292	2323	2355	2388	2422
2455	2488	2522	2556	2589	2629	2669	2709	2748
2788	2828	2868	2906	2944	2982	3019	3057	3095
3133	3165	3198	3230	3263	3295	3328	3360	3377
3394	3411	3429	3446	3463	3480	3503	3525	3548
3571	3593	3616	3639	3661	3684	3707	3730	3752
3775	3798	3820	3843	3866	3888	3911	3934	

APPENDIX F. OUTCOMES AND DETERMINANTS IN PRIMIPARAS

Table F.1. Sample size in all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V) among Caucasian, immigrant Chinese, and native Chinese infants, primiparas with concordant ultrasound- and LNMP-determined GA*

	Caucasian	Immigrant Chinese	Native Chinese
I	5,530 (100.0)	332 (100.0)	520 (100.0)
II	5,507 (99.6)	332 (100.0)	517 (99.4)
III	5,071 (91.7)	303 (91.3)	494 (95.0)
IV	1,983 (42.8)	192 (64.2)	280 (57.9)
V	1,127 (25.5)	73 (25.3)	279 (57.7)

* Results are given as number (percent)

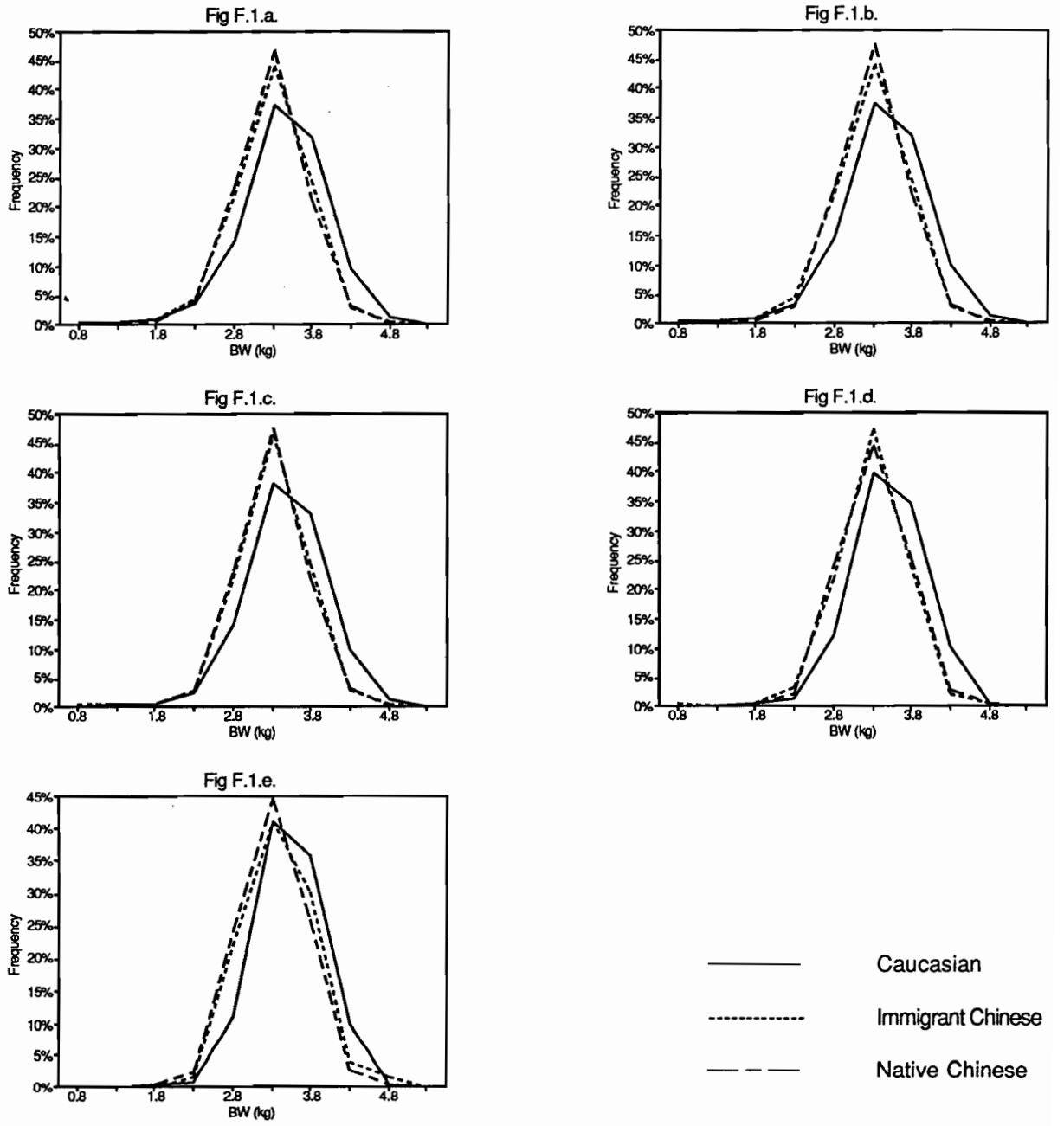


Figure F.1. BW distribution in Caucasian, immigrant Chinese, and native Chinese infants, primiparas with concordant ultrasound- and LNMP-determined GA: a. all births; b. live births; c. singleton, live, non-malformed births to mothers without severe PIH; d. 'risk-free I' births; e. 'risk-free II' births

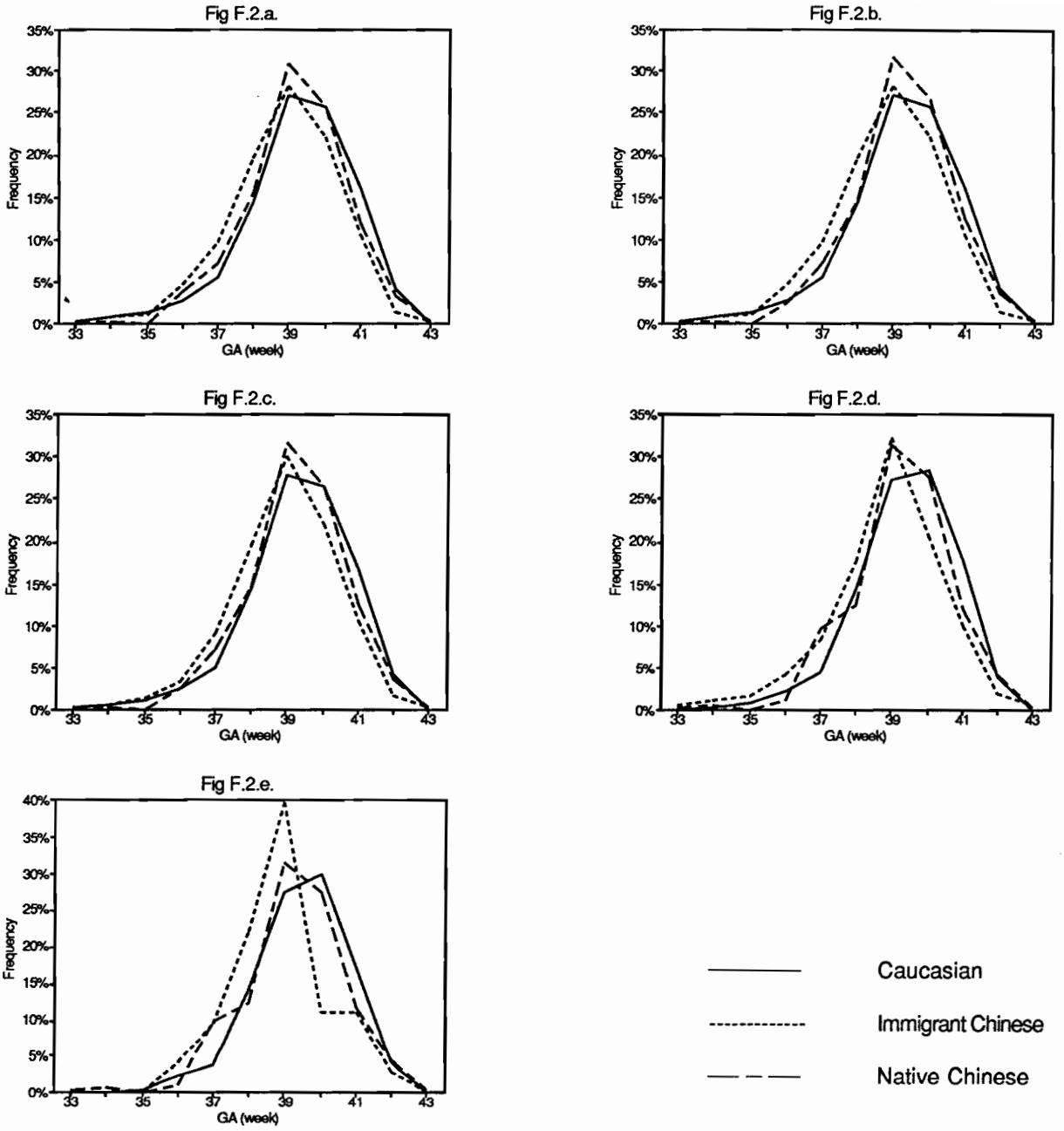


Figure F.2. GA distribution in Caucasian, immigrant Chinese, and native Chinese infants, primiparas with concordant ultrasound- and LNMP-determined GA: a. all births; b. live births; c. singleton, live, non-malformed births to mothers without severe PIH; d. 'risk-free I' births; e. 'risk-free II' births

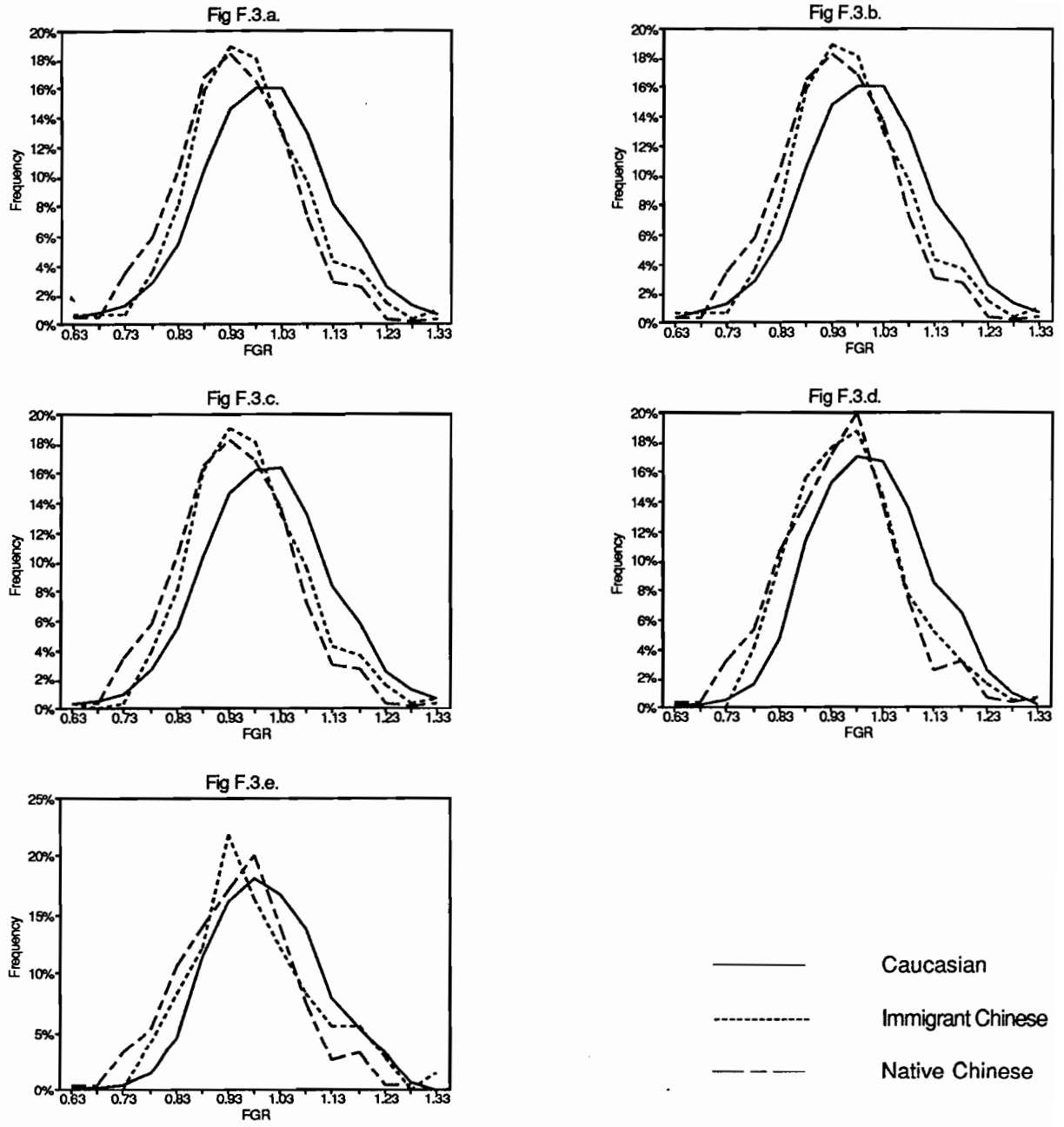


Figure F.3. FGR distribution in Caucasian, immigrant Chinese, and native Chinese infants, primiparas with concordant ultrasound- and LNMP-determined GA: a. all births; b. live births; c. singleton, live, non-malformed births to mothers without severe PIH; d. 'risk-free I' births; e. 'risk-free II' births

Table F.2. Comparison of skewness and kurtosis coefficients for BW, GA, and FGR distributions among Caucasian, immigrant Chinese, and native Chinese infants of all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V), primiparas with concordant ultrasound- and LNMP-determined GA

	Caucasian		Immigrant Chinese		Native Chinese	
	Skewness	Kurtosis	Skewness	Kurtosis	Skewness	Kurtosis
BW, g						
I	-0.94	3.08	-1.00	3.96	-0.05	0.71
II	-0.85	2.85	-1.00	3.96	0.04	0.47
III	-0.54	2.26	-0.74	3.84	0.10	0.58
IV	-0.45	1.89	-0.80	3.98	0.09	0.85
V	-0.21	1.00	0.25	0.20	0.09	0.89
GA, d						
I	-2.80	15.06	-2.64	15.01	-1.09	4.36
II	-2.70	14.83	-2.64	15.01	-0.72	2.11
III	-2.35	14.31	-2.11	11.27	-0.77	2.54
IV	-1.89	10.44	-2.27	11.74	-0.90	2.88
V	-0.92	2.97	0.03	-0.24	-0.91	2.90
FGR						
I	-0.02	0.40	0.22	1.48	0.18	0.45
II	0.04	0.26	0.22	1.48	0.18	0.45
III	0.10	0.21	0.52	0.87	0.24	0.35
IV	0.08	-0.08	0.68	0.85	0.28	0.61
V	0.09	0.01	0.78	0.86	0.26	0.62

Table F.3. Comparison of mean BW, GA, and FGR in Caucasian, immigrant Chinese, and native Chinese infants of all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V), primiparas with concordant ultrasound- and LNMP-determined GA

	Caucasian	Immigrant Chinese	Native Chinese	F*
BW, g				
I	3369	3195	3171	43.3[a]
II	3375	3195	3176	46.2[a]
III	3413	3226	3196	60.0[a]
IV	3441	3211	3221	47.4[a]
V	3451	3307	3219	36.4[a]
GA, d				
I	276.7	274.2	277.0	5.7[a]
II	276.8	274.2	277.1	6.4[a]
III	277.8	275.0	277.6	8.5[a]
IV	278.5	274.6	277.6	11.2[a]
V	279.1	275.6	277.6	6.0[a]
FGR				
I	0.994	0.963	0.935	62.2[a]
II	0.995	0.963	0.935	65.6[a]
III	0.998	0.965	0.938	67.8[a]
IV	1.001	0.966	0.946	37.9[a]
V	0.998	0.982	0.945	27.5[a]

* One-way ANOVA for mean difference among Caucasian, immigrant Chinese, and native Chinese infants
[a] $P < 0.01$

Table F.4. Comparison of variation in BW, GA, and FGR in Caucasian, immigrant Chinese, and native Chinese infants of all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V), primiparas with concordant ultrasound- and LNMP-determined GA*

	Caucasian	Immigrant Chinese	Native Chinese	X^{2**}
BW, g				
I	567, 0.168	493, 0.154	428, 0.135	40.0[a]
II	555, 0.164	493, 0.154	422, 0.133	37.9[a]
III	505, 0.148	450, 0.140	409, 0.128	22.7[a]
IV	458, 0.136	445, 0.145	412, 0.123	3.2[c]
V	429, 0.131	428, 0.147	410, 0.123	1.3[c]
GA, d				
I	14.0, 0.051	13.7, 0.050	10.8, 0.039	30.9[a]
II	13.6, 0.049	13.7, 0.050	10.3, 0.037	34.9[a]
III	11.9, 0.043	12.3, 0.045	10.2, 0.037	11.7[a]
IV	10.7, 0.040	13.4, 0.049	10.3, 0.036	10.2[a]
V	10.5, 0.037	9.0, 0.038	10.3, 0.036	2.7[c]
FGR				
I	0.124, 0.135	0.114, 0.119	0.112, 0.120	6.6[b]
II	0.123, 0.124	0.114, 0.119	0.112, 0.120	6.2[b]
III	0.121, 0.121	0.108, 0.112	0.111, 0.118	6.8[b]
IV	0.111, 0.112	0.108, 0.114	0.114, 0.119	0.7[c]
V	0.111, 0.111	0.122, 0.127	0.113, 0.118	2.5[c]

* Results are presented as SD, CV
** Bartlett's test for homogeneity among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$; [b] $P < 0.05$; [c] $P > 0.05$

Table F.5. Comparison of dichotomized outcomes among Caucasian, immigrant Chinese, and native Chinese infants of all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V), primiparas with concordant ultrasound- and LNMP-determined GA

	Caucasian	Immigrant Chinese	Native Chinese	X^{2*}
% LBW				
I	5.5	6.3	4.8	0.9[c]
II	5.2	6.3	4.6	1.2[c]
III	3.3	3.6	3.2	0.1[c]
IV	2.0	4.2	2.5	4.0[c]
V	1.4	1.4	2.5	1.7[c]
% HBW				
I	10.2	3.0	1.7	57.3[a]
II	10.3	3.0	1.7	58.0[a]
III	10.5	3.0	1.8	55.4[a]
IV	9.9	2.6	2.1	28.5[a]
V	9.4	5.5	2.2	16.6[a]
% Preterm delivery				
I	7.0	8.4	5.0	4.2[c]
II	6.8	8.4	4.6	5.3[c]
III	4.9	6.6	3.6	3.9[c]
IV	3.8	8.3	2.5	11.1[a]
V	3.1	4.1	2.5	0.6[c]
% Postterm delivery				
I	4.4	1.8	3.8	5.5[c]
II	4.3	1.8	3.9	5.0[c]
III	4.4	2.0	4.0	4.1[c]
IV	3.9	2.6	4.6	1.2[c]
V	4.4	2.7	4.7	0.6[c]
% SGA				
I	11.1	13.6	21.2	46.5[a]
II	11.0	13.6	21.1	47.6[a]
III	10.0	12.9	20.6	52.8[a]
IV	7.3	14.1	20.0	52.8[a]
V	6.8	12.3	20.1	46.3[a]
% LGA				
I	10.5	6.6	3.5	30.4[a]
II	10.5	6.6	3.5	30.1[a]
III	10.7	8.4	3.6	26.2[a]
IV	10.4	6.2	5.0	10.9[a]
V	9.2	11.0	4.7	6.5[b]

* Chi-square test for differences of prevalences among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$; [b] $P < 0.05$; [c] $P > 0.05$

Table F.6. Percent SGA in preterm, term, and postterm Caucasian, immigrant Chinese, and native Chinese infants, primiparas with concordant ultrasound- and LNMP-determined GA

	Caucasian (n=5,530) %	Immigrant Chinese (n=332) %	Native Chinese (n=520) %	X^{2*}
Preterm	17.9	14.3	11.5	0.9[c]
Term	10.3	13.1	21.3	52.8[a]
Postterm	17.3	33.3	30.0	2.5[c]

* Chi-square test for differences of SGA rates among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$; [c] $P > 0.05$

Table F.7. Mean BW (g) as a function of GA in Caucasian, immigrant Chinese, and native Chinese infants, primiparas with concordant ultrasound- and LNMP-determined GA*

GA, wk	Caucasian (n=5,530)	Immigrant Chinese (n=332)	Native Chinese (n=520)
33	1942 (298)	2100 (**)	2400 (283)
34	2149 (442)	2398 (239)	2600 (**)
35	2460 (397)	2549 (132)	*** (***)
36	2796 (408)	2684 (470)	2635 (320)
37	2964 (466)	3015 (401)	2869 (320)
38	3247 (430)	3112 (347)	3059 (347)
39	3408 (428)	3289 (410)	3187 (349)
40	3540 (397)	3367 (356)	3274 (405)
41	3651 (397)	3479 (275)	3409 (455)
42	3709 (463)	3731 (527)	3439 (455)

* Results are given as mean (SD)
** SD can not be calculated because only one in sample
*** Both mean and SD can not be calculated because no subject in this cell

Table F.8. Mean FGR as a function of GA in Caucasian, immigrant Chinese, and native Chinese infants, primiparas with concordant ultrasound- and LNMP-determined GA*

GA, wk	Caucasian (n=5,530)	Immigrant Chinese (n=332)	Native Chinese (n=520)
33	0.964 (0.141)	1.089 (**)	1.206 (0.092)
34	0.965 (0.202)	1.055 (0.065)	1.167 (**)
35	1.001 (0.154)	1.032 (0.067)	*** (***)
36	1.020 (0.141)	0.986 (0.180)	0.971 (0.141)
37	0.989 (0.150)	1.003 (0.127)	0.954 (0.108)
38	0.997 (0.126)	0.957 (0.106)	0.944 (0.105)
39	0.997 (0.123)	0.962 (0.118)	0.933 (0.101)
40	0.999 (0.112)	0.949 (0.101)	0.925 (0.114)
41	0.988 (0.115)	0.942 (0.072)	0.921 (0.126)
42	0.968 (0.122)	0.977 (0.133)	0.894 (0.070)

* Results are given as mean (SD)
** SD can not be calculated because only one in sample
*** Both mean and SD can not be calculated because no subject in this cell

Table F.9. Comparison of means for determinants with continuous distributions among Caucasian, immigrant Chinese, and native Chinese, primiparas

	Caucasian (n=9,036)	Immigrant Chinese (n=746)	Native Chinese (n=1,647)	F*
Age, y	27.2	27.7	25.7	92.5[a]
Education, y completed	13.5	12.5	10.3	762.9[a]
Height, cm	163.3	158.1	160.2	293.6[a]
Prepregnancy BMI, kg/m^2	22.0	19.7	20.4	207.5[a]
Net Wt gain, kg/week	0.31	0.27	0.26	109.4[a]

* One-way ANOVA for mean difference among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$

Table F.10. Comparison of variation in determinants with continuous distributions among Caucasian, immigrant Chinese, and native Chinese, primiparas*

	Caucasian (n=9,166)	Immigrant Chinese (n=746)	Native Chinese (n=1,647)	X^{2**}
Age, y	4.7, 0.173	4.1, 0.148	2.5, 0.097	483.6[a]
Education, y completed	3.0, 0.222	3.8, 0.304	2.9, 0.282	45.2[a]
Height, cm	6.5, 0.040	5.2, 0.033	4.5, 0.028	149.7[a]
Prepregnancy BMI, kg/m^2	3.7, 0.168	2.8, 0.142	2.2, 0.108	364.9[a]
Net Wt gain, kg/week	0.13, 0.419	0.10, 0.370	0.13, 0.500	45.4[a]

* Results are presented as SD, CV
** Bartlett's test for homogeneity among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$

Table F.11. Comparison of categorical determinants among Caucasian, immigrant Chinese, and native Chinese, primiparas

	Caucasian (n=9,166)	Immigrant Chinese (n=746)	Native Chinese (n=1,647)	X^{2*}
Infant sex, % female	48.2	50.3	49.5	2.0[c]
% Married	77.7	93.7	99.1	506.7[a]
% Severe PIH	0.8	1.2	2.8	51.6[a]
% Diabetes	3.6	2.8	**	1.4[c]
% Social drug use	1.1	0.0	0.0	27.3[a]
% >= 1 drink/d	4.3	0.0	0.0	107.7[a]
% Smoked	28.0	1.8	0.0	825.2[a]

* Chi-square test for differences of prevalences among Caucasian, immigrant Chinese, and native Chinese (between Caucasian and immigrant Chinese for diabetes)
** Not available
[a] $P < 0.01$
[c] $P > 0.05$

APPENDIX G. ASSESSMENT OF DETERMINANT-OUTCOME RELATIONSHIPS IN SINGLETON, NONMALFORMED LIVE BIRTHS TO MOTHERS WITHOUT SEVERE PIH

Table G.1 Relationship between selected maternal and infant determinants and BW (g) in Caucasian, immigrant Chinese, native Chinese, subjects with concordant ultrasound- and LNMP-determined GA*

	Caucasian	Immigrant Chinese	Native Chinese
Infant sex			
Male	3511 (515)	3368 (455)	3263(382)
Female	3390 (486)	3249 (461)	3141(433)
Age, y			
< 20	3366 (462)	3110 (**)	***
20 - 29	3438 (496)	3237 (492)	3207(412)
30 - 34	3480 (499)	3372 (423)	3098(353)
>= 35	3461 (553)	3386 (421)	3286(564)
Marital status			
Married	3471 (495)	3305 (462)	3202(412)
Unmarried	3338 (548)	3500 (433)	3306(401)
Parity			
Nulliparous	3413 (505)	3226 (450)	3196(409)
Multiparous	3493 (501)	3377 (460)	3272(432)
Education, y completed			
0 - 10	3345 (537)	3315 (455)	3229(403)
11 - 12	3432 (506)	3258 (484)	3169(410)
13 - 16	3487 (486)	3312 (462)	3199(438)
>= 17	3507 (477)	3344 (415)	3104(366)
Smoking, cigarette/d			
0	3506 (490)	3310 (461)	***
1 - 9	3375 (520)	3334 (373)	***
10 - 19	3268 (515)	2810 (269)	***
>= 20	3284 (515)	3732 (137)	***
Alcohol consumption			
No	3450 (503)	3323 (451)	***
Occasionally	3463 (502)	3265 (493)	***
>= 1 drink/d	3225 (642)	***	***
Social drug use			
No	3455 (503)	***	***
Yes	3178 (548)	***	***
Diabetes			
No	3449 (502)	3304 (452)	***
Yes	3537 (545)	3416 (646)	***
Height, cm			
< 151	3200 (510)	3258 (451)	2985 (430)
151 - 160	3385 (490)	3292 (444)	3143 (401)
161 - 169	3481 (484)	3437 (502)	3290 (408)
>= 170	3591 (508)	3625 (707)	3345 (456)
Prepregnancy BMI			
< 17.8	3271 (502)	3165 (362)	3031 (423)
17.8 - < 19.8	3351 (482)	3278 (500)	3169 (364)
19.8 - < 26.0	3484 (481)	3387 (430)	3265 (400)
>= 26.0	3554 (512)	3609 (530)	3200 (370)
Net Wt gain rate, kg/week			
< 0.15	3388 (517)	3252 (528)	3180 (382)
0.15 - < 0.30	3437 (467)	3309 (449)	3159 (419)
0.30 - < 0.40	3478 (495)	3338 (479)	3234 (425)
>= 0.40	3533 (511)	3467 (556)	3275 (382)

* Results are given as mean (SD)

** SD is incalculable because only one subject in the category

*** Both mean and SD are incalculable (no subjects in this category) or calculation meaningless (no subjects in the comparison category)

Table G.2 Relationship between selected maternal and infant determinants and BW as dichotomized variables in Caucasian, immigrant Chinese, native Chinese infants, subjects with concordant ultrasound- and LNMP-determined GA*

	Caucasian		Immigrant Chinese		Native Chinese	
	LBW	HBW	LBW	HBW	LBW	HBW
Infant sex						
Male	2.8	15.1	2.4	6.7	1.8	2.5
Female	3.3	9.1	3.0	4.5	5.2	1.5
Age, y						
< 20	2.3	6.7	**	**	**	**
20 - 29	2.8	11.4	4.0	3.7	3.7	1.9
30 - 34	2.9	13.5	1.6	7.6	0.0	0.0
>= 35	4.9	13.6	1.1	6.5	0.0	14.3
Marital status						
Married	2.7	12.7	2.8	5.5	3.5	2.0
Unmarried	5.1	9.3	0.0	8.3	0.0	0.0
Parity						
Nulliparous	3.3	10.5	3.6	3.3	3.2	1.8
Multiparous	2.8	14.0	1.9	7.7	5.4	3.6
Education, y completed						
0 - 10	5.3	9.0	2.6	6.3	3.0	2.6
11 - 12	3.3	11.4	4.6	5.4	3.5	1.4
13 - 16	2.1	13.1	3.2	4.5	4.9	1.6
>= 17	2.1	13.9	0.0	6.2	0.0	0.0
Smoking, cigarettes/d						
0	2.2	13.8	2.6	5.6	**	**
1 - 9	4.0	10.7	0.0	0.0	**	**
10 - 19	6.6	7.1	0.0	0.0	**	**
>= 20	5.2	6.7	0.0	16.7	**	**
Alcohol consumption						
No	3.0	12.0	2.3	5.5	**	**
Occasionally	3.0	12.8	2.4	7.3	**	**
>= 1 drink/d	9.5	11.9	**	**	**	**
Social drug use						
No	3.0	12.3	**	**	**	**
Yes	8.5	6.8	**	**	**	**
Diabetes						
No	3.0	12.0	2.5	5.0	**	**
Yes	3.9	18.5	7.1	17.9	**	**
Height, cm						
< 151	6.9	4.0	2.6	5.3	10.0	0.0
151 - 160	3.8	9.5	2.7	4.0	4.9	1.3
161 - 169	2.5	12.4	2.2	9.7	1.4	3.2
>= 170	2.1	19.4	0.0	40.0	0.0	0.0
Prepregnancy BMI						
<17.8	5.8	6.6	0.0	1.6	9.2	0.0
17.8-<19.8	3.8	8.3	5.7	3.0	3.2	0.0
19.8-<26.0	2.4	12.8	1.6	8.4	2.4	3.8
>=26.0	2.8	18.9	7.1	21.4	0.0	0.0
Net Wt gain, kg/week						
<0.15	5.2	10.0	5.3	5.3	3.5	1.2
0.15-<0.30	2.4	10.7	2.6	7.0	4.5	1.4
0.30-<0.40	2.3	13.6	1.1	3.4	3.2	3.2
>=0.40	2.6	16.4	2.3	11.6	1.2	2.4

* Conventional definition (< 2500 and > 4000 for LBW and HBW respectively)
** Incalculable (no subjects in this category) or calculation meaningless (no subjects in the comparison category)

Table G.3 Relationship between selected maternal and infant determinants and GA (d) in Caucasian, immigrant Chinese, native Chinese, subjects with concordant ultrasound- and LNMP-determined GA*

	Caucasian	Immigrant Chinese	Native Chinese
Infant sex			
Male	276.7 (11.9)	274.0 (10.9)	278.0 (9.7)
Female	277.4 (11.0)	274.9 (12.0)	276.5 (10.9)
Age, y			
< 20	277.0 (9.5)	280.0 (**)	***
20 - 29	277.4 (11.6)	274.4 (13.7)	277.3 (10.5)
30 - 34	277.1 (10.5)	275.0 (9.0)	276.1 (5.3)
>= 35	275.3 (13.4)	273.0 (8.5)	280.3 (5.6)
Marital status			
Married	277.3 (11.1)	275.0 (12.3)	277.6 (10.2)
Unmarried	276.3 (11.1)	274.0 (10.7)	274.7 (11.3)
Parity			
Nulliparous	277.8 (11.9)	275.0 (12.3)	277.6 (10.2)
Multiparous	276.3 (11.1)	274.0 (10.7)	274.7 (11.3)
Education, y completed			
0 - 10	274.9 (13.4)	275.4 (11.5)	277.6 (10.3)
11 - 12	276.8 (11.2)	273.2 (12.2)	276.3 (11.1)
13 - 16	277.5 (11.3)	273.8 (10.9)	277.7 (9.4)
>= 17	278.1 (10.1)	274.9 (10.2)	276.8 (8.2)
Smoking, cigarette/d			
0	277.4 (11.2)	274.5 (11.5)	***
1 - 9	276.8 (11.7)	274.3 (6.3)	***
10 - 19	275.6 (11.7)	265.5 (6.4)	***
>= 20	275.6 (13.0)	282.0 (4.6)	***
Alcohol consumption			
No	276.8 (11.6)	274.7 (11.7)	***
Occasionally	277.5 (11.2)	271.7 (10.9)	***
>= 1 drink/d	274.9 (17.8)	***	***
Social drug use			
No	277.1 (11.4)	***	***
Yes	275.6 (13.4)	***	***
Diabetes			
No	277.2 (11.5)	274.6 (11.5)	***
Yes	272.5 (10.2)	271.3 (11.6)	***
Height, cm			
< 151	273.4 (11.7)	275.4 (6.7)	278.4 (12.7)
151 - 160	276.8 (11.3)	274.2 (11.4)	276.0 (10.8)
161 - 169	277.4 (11.0)	275.0 (11.8)	279.0 (9.4)
>= 170	277.5 (11.5)	271.6 (8.4)	275.1 (8.7)
Prepregnancy BMI			
<17.8	276.4 (11.3)	273.9 (8.8)	276.1 (10.2)
17.8-<19.8	276.4 (11.1)	273.9 (10.7)	277.1 (9.9)
19.8-<26.0	277.7 (10.7)	275.1 (11.7)	277.6 (10.7)
>=26.0	276.6 (10.3)	276.1 (8.9)	276.0 (9.4)
Net Wt gain, kg/week			
<0.15	276.4 (11.5)	275.6 (14.9)	278.2 (9.7)
0.15-<0.30	277.8 (9.9)	274.5 (9.7)	275.9 (10.5)
0.30-<0.40	277.3 (11.1)	274.0 (12.6)	278.0 (10.6)
>=0.40	277.1 (11.1)	276.2 (11.3)	278.8 (9.5)

* Results are given as mean (SD)

** SD is incalculable because only one sample in the category

*** Both mean and SD are incalculable (no subjects in this category) or calculation meaningless (no subjects in the comparison category)

Table G.4 Relationship between selected maternal and infant determinants and gestational age as dichotomized variables in Caucasian, immigrant Chinese, native Chinese, subjects with concordant ultrasound- and LNMP-determined GA

	Caucasian		Immigrant Chinese		Native Chinese	
	Preterm, % yes	Postterm, % yes	Preterm, % yes	Postterm, % yes	Preterm, % yes	Postterm, % yes
Infant sex						
Male	5.0	3.5	6.7	0.9	2.8	5.3
Female	4.2	3.1	6.9	1.2	5.2	2.3
Age, y						
< 20	3.4	2.8	**	**	**	**
20 - 29	4.3	3.6	8.1	1.2	4.2	4.0
30 - 34	4.4	3.2	5.2	1.2	0.0	0.0
>= 35	6.6	2.4	6.5	0.0	0.0	0.0
Marital status						
Married	4.1	3.2	6.9	1.1	3.9	3.9
Unmarried	7.1	3.8	0.0	0.0	12.5	0.0
Parity						
Nulliparous	4.9	4.4	6.6	2.0	3.6	4.1
Multiparous	4.3	2.2	6.9	0.3	7.1	1.8
Education, y completed						
0 - 10	7.0	2.2	5.3	2.1	4.1	5.2
11 - 12	4.5	3.2	11.5	0.8	5.5	3.5
13 - 16	4.3	3.6	5.2	0.0	2.4	1.6
>= 17	3.2	3.7	7.4	1.2	0.0	0.0
Smoking, cigarettes/d						
0	4.1	3.3	6.8	1.1	**	**
1 - 9	5.7	3.0	0.0	0.0	**	**
10 - 19	6.2	3.1	0.0	0.0	**	**
>= 20	5.9	3.6	0.0	0.0	**	**
Alcohol consumption						
No	4.8	3.0	6.6	1.1	**	**
Occasionally	4.1	3.9	12.2	0.0	**	**
>= 1 drink/d	4.8	2.4	**	**	**	**
Social drug use						
No	4.5	3.4	**	**	**	**
Yes	10.2	5.1	**	**	**	**
Diabetes						
No	4.5	3.4	6.6	1.1	**	**
Yes	7.1	1.0	10.7	0.0	**	**
Height, cm						
< 151	7.5	2.3	2.6	0.0	10.0	10.0
151 - 160	5.1	3.1	7.0	0.7	4.9	2.9
161 - 169	4.1	3.2	5.4	2.2	2.7	5.0
>= 170	4.3	4.0	0.0	0.0	0.0	0.0
Prepregnancy BMI						
<17.8	5.5	4.4	3.2	0.0	4.6	0.0
17.8-<19.8	5.1	2.8	7.9	1.0	2.7	2.7
19.8-<26.0	3.8	3.5	5.3	1.6	4.5	4.9
>=26.0	5.1	3.1	7.1	0.0	14.3	0.0
Net Wt gain, kg/week						
<0.15	5.0	2.7	5.3	2.6	3.5	5.8
0.15-<0.30	3.2	3.6	6.5	0.4	5.0	2.7
0.30-<0.40	3.9	3.3	4.6	3.4	2.6	5.1
>=0.40	5.5	3.4	4.7	0.0	4.9	2.4

** Incalculable (no subjects in this category) or calculation meaningless (no subjects in the comparison category)

Table G.5 Relationship between selected maternal and infant determinants and FGR in Caucasian, immigrant Chinese, and native Chinese, subjects with concordant ultrasound- and LNMP-determined GA*

	Caucasian	Immigrant Chinese	Native Chinese
Infant sex			
Male	1.033 (0.121)	1.011 (0.108)	0.954 (0.108)
Female	0.993 (0.118)	0.972 (0.114)	0.930 (0.112)
Age, y			
< 20	0.990 (0.118)	0.894 (**)	***
20 - 29	1.007 (0.119)	0.971 (0.109)	0.943 (0.111)
30 - 34	1.020 (0.122)	1.005 (0.110)	0.912 (0.100)
>= 35	1.030 (0.126)	1.026 (0.121)	0.936 (0.133)
Marital status			
Married	1.017 (0.120)	0.991 (0.112)	0.942 (0.111)
Unmarried	0.995 (0.129)	1.029 (0.127)	0.977 (0.095)
Parity			
Nulliparous	0.998 (0.121)	0.965 (0.108)	0.942 (0.111)
Multiparous	1.029 (0.120)	1.013 (0.111)	0.982 (0.100)
Education, y completed			
0 - 10	1.002 (0.122)	0.985 (0.114)	0.947 (0.113)
11 - 12	1.009 (0.123)	0.990 (0.113)	0.939 (0.101)
13 - 16	1.020 (0.119)	0.998 (0.114)	0.936 (0.116)
>= 17	1.026 (0.117)	0.996 (0.112)	0.916 (0.110)
Smoking, cigarette/d			
0	1.026 (0.118)	0.992 (0.113)	***
1 - 9	0.994 (0.126)	0.997 (0.118)	***
10 - 19	0.971 (0.128)	0.905 (0.021)	***
>= 20	0.976 (0.123)	1.058 (0.059)	***
Alcohol consumption			
No	1.014 (0.121)	0.993 (0.112)	***
Occasionally	1.014 (0.123)	1.004 (0.127)	***
>= 1 drink/d	0.965 (0.121)	***	***
Social drug use			
No	1.014 (0.121)	***	***
Yes	0.947 (0.122)	***	***
Diabetes			
No	1.012 (0.121)	0.989 (0.110)	***
Yes	1.063 (0.129)	1.050 (0.154)	***
Height, cm			
< 151	0.966 (0.123)	0.964 (0.128)	0.875 (0.093)
151 - 160	0.996 (0.120)	0.989 (0.104)	0.934 (0.107)
161 - 169	1.020 (0.119)	1.022 (0.119)	0.954 (0.113)
>= 170	1.048 (0.119)	1.114 (0.228)	0.998 (0.113)
Prepregnancy BMI			
<17.8	0.967 (0.120)	0.952 (0.099)	0.898 (0.113)
17.8-<19.8	0.990 (0.117)	0.984 (0.116)	0.933 (0.106)
19.8-<26.0	1.019 (0.120)	1.009 (0.116)	0.958 (0.110)
>=26.0	1.042 (0.125)	1.066 (0.133)	0.953 (0.115)
Net Wt gain, kg/week			
<0.15	1.001 (0.129)	0.967 (0.116)	0.898 (0.113)
0.15-<0.30	1.003 (0.118)	0.990 (0.117)	0.932 (0.106)
0.30-<0.40	1.018 (0.118)	1.003 (0.119)	0.958 (0.110)
>=0.40	1.038 (0.127)	1.019 (0.117)	0.953 (0.115)

* Results are given as mean (SD)

** SD is incalculable because only one sample in the category

*** Both mean and SD are incalculable (no subjects in this category) or calculation meaningless (no subjects in the comparison category)

Table G.6 Relationship between selected maternal and infant determinants and FGR as dichotomized variables in Caucasian, immigrant Chinese, native Chinese, subjects with concordant ultrasound- and LNMP-determined GA

	Caucasian		Immigrant Chinese		Native Chinese	
	SGA	LGA	SGA	LGA	SGA	LGA
Infant sex						
Male	5.9	16.7	7.6	10.3	17.3	4.2
Female	10.3	9.3	12.0	7.5	21.7	3.0
Age, y						
< 20	12.4	8.4	-	-	-	-
20 - 29	8.4	11.9	13.0	6.2	18.7	3.7
30 - 34	7.6	14.0	7.6	9.2	34.8	0.0
>= 35	7.5	17.0	4.4	17.4	28.6	14.3
Marital status						
Married	7.4	13.5	9.8	8.7	19.7	3.5
Unmarried	12.3	10.8	8.3	16.7	0.0	12.5
Parity						
Nulliparous	10.0	10.7	12.9	6.6	20.7	3.6
Multiparous	6.1	15.6	7.2	10.8	8.9	3.6
Education, y completed						
0 - 10	10.2	10.4	12.1	8.4	18.9	4.4
11 - 12	9.0	12.6	10.8	8.5	15.2	2.1
13 - 16	6.6	13.7	9.0	9.7	23.6	4.1
>= 17	6.8	13.7	4.9	8.6	41.7	0.0
Smoking, cigarettes/d						
0	5.9	14.7	9.7	8.8	**	**
1 - 9	10.2	10.4	14.3	14.3	**	**
10 - 19	16.9	8.0	0.0	0.0	**	**
>= 20	14.7	8.1	0.0	0.0	**	**
Alcohol consumption						
No	7.9	13.3	9.2	9.2	**	**
Occasionally	8.2	13.0	12.2	9.8	**	**
>= 1 drink/d	19.1	9.5	**	**	**	**
Social drug use						
No	8.0	13.2	**	**	**	**
Yes	23.7	1.7	**	**	**	**
Diabetes						
No	8.2	12.8	9.7	7.7	**	**
Yes	5.0	22.9	10.7	35.7	**	**
Height, cm						
< 151	14.9	6.9	21.1	15.8	40.0	0.0
151 - 160	10.1	10.6	8.9	6.6	20.9	3.9
161 - 169	7.0	13.4	5.4	15.1	17.6	3.6
>= 170	4.9	18.2	20.0	40.0	0.0	0.0
Prepregnancy BMI						
<17.8	17.2	6.6	12.9	3.2	33.9	3.1
17.8-<19.8	10.9	8.4	11.9	9.9	21.8	2.1
19.8-<26.0	7.2	13.4	7.4	11.1	14.9	4.9
>=26.0	5.0	19.0	7.1	42.8	12.5	0.0
Net Wt gain, kg/week						
<0.15	11.3	11.3	15.8	7.9	22.1	0.0
0.15-<0.30	8.6	11.3	10.0	11.8	21.2	3.2
0.30-<0.40	7.0	13.2	8.0	10.0	19.9	6.4
>=0.40	5.9	17.6	4.7	14.0	12.2	2.4

** Incalculable (no subjects in this category) or calculation meaningless (no subjects in the comparison category)

APPENDIX H. RESULTS OF LINEAR REGRESSION DIAGNOSTICS

Linear regression diagnostics of birth weight (final multiple linear regression model for BW in which GA was included as a confounding factor and an interaction term (with maternal race), subject with concordant ultrasound- and LNMP-determined GA)

Table H.1. Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	15	431364433	28757628	165.61	0.0000
Error	6834	1186722211	173649		
C Total	6849	1618086644			

Root MSE	417	R-square	0.27
Dep Mean	3439	Adj R-sq	0.27
C.V.			12.12

Table H.2. Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	840.94	140.35	5.99	0.0001
AGE	1	0.95	1.25	0.76	0.4461
SEX1	1	-124.77	10.09	-12.37	0.0001
MARIT1	1	-20.74	16.83	-1.23	0.2179
SCHOOL	1	2.32	1.74	1.34	0.1818
PARITY	1	45.78	6.79	6.74	0.0001
SM1	1	-74.45	5.56	-13.40	0.0001
HEIGHT	1	12.06	0.82	14.65	0.0001
BMI1	1	23.18	1.43	16.16	0.0001
NWGR	1	468.37	41.12	11.39	0.0001
GA1	1	-689.43	69.31	-9.95	0.0001
GA2	1	227.47	88.60	2.57	0.0103
RACE1	1	44.00	26.44	1.66	0.0961
RESI1	1	-149.00	31.23	-4.77	0.0001
RACGA1	1	-211.33	74.73	-2.83	0.0047
RACGA2	1	26.30	93.40	0.28	0.7783

Table H.3. Tolerance* and variance inflation*

Variable	DF	Tolerance	Variance Inflation
INTERCEP	1	.	0.00000000
AGE	1	0.78811323	1.26885320
SEX1	1	0.99807098	1.00193275
MARIT1	1	0.91366879	1.09448852
SCHOOL	1	0.81866860	1.22149549
PARITY	1	0.82593265	1.21075248
SM1	1	0.88918955	1.12461960
HEIGHT	1	0.93119465	1.07388933
BMI1	1	0.92425116	1.08195699
NWGR	1	0.95536128	1.04672443
GA1	1	0.13839961	7.22545403
GA2	1	0.09951315	10.04892270
RACE1	1	0.34011952	2.94014291
RESI1	1	0.35490471	2.81765774
RACGA1	1	0.13758278	7.26835168
RACGA2	1	0.09915960	10.08475253

* Indices measure the collinearty. If the value is high (for example, a tolerance > 0.9 or a variance inflation > 10, potential collinearty should be alarmed)

Table H.4. Collinearity Diagnostics*

Number	Eigenvalue	Condition Number	Var Prop INTERCEP	Var Prop AGE	Var Prop SEX1	Var Prop MARIT1
1	8.1683	1.0000	0.0000	0.0003	0.0041	0.0017
2	1.9445	2.0496	0.0000	0.0000	0.0000	0.0006
3	1.7706	2.1479	0.0000	0.0000	0.0015	0.0006
4	1.1472	2.6684	0.0000	0.0001	0.0045	0.1595
5	0.9507	2.9313	0.0000	0.0000	0.0002	0.3396
6	0.6390	3.5754	0.0000	0.0000	0.0081	0.3513
7	0.5364	3.9022	0.0000	0.0000	0.2421	0.0991
8	0.4744	4.1494	0.0000	0.0004	0.7263	0.0268
9	0.1395	7.6534	0.0001	0.0033	0.0082	0.0005
10	0.0720	10.6536	0.0000	0.0004	0.0004	0.0003
11	0.0494	12.8583	0.0000	0.0000	0.0002	0.0001
12	0.0453	13.4223	0.0002	0.0073	0.0005	0.0083
13	0.0323	15.9116	0.0009	0.0593	0.0007	0.0008
14	0.0193	20.5572	0.0009	0.4675	0.0002	0.0002
15	0.0105	27.9431	0.0337	0.4523	0.0025	0.0104
16	0.0007	107.9017	0.9641	0.0090	0.0006	0.0001

Table H.4. Con't

Number	Var Prop SCHOOL	Var Prop PARITY	Var Prop SM1	Var Prop HEIGHT	Var Prop BMI1	Var Prop NWGR
1	0.0006	0.0033	0.0026	0.0000	0.0004	0.0019
2	0.0000	0.0005	0.0002	0.0000	0.0000	0.0000
3	0.0001	0.0026	0.0002	0.0000	0.0000	0.0001
4	0.0001	0.0019	0.1301	0.0000	0.0000	0.0003
5	0.0001	0.0858	0.0710	0.0000	0.0000	0.0000
6	0.0004	0.0091	0.7313	0.0000	0.0000	0.0001
7	0.0003	0.5688	0.0074	0.0000	0.0000	0.0022
8	0.0024	0.1735	0.0061	0.0000	0.0007	0.0154
9	0.0154	0.0362	0.0009	0.0001	0.0075	0.8930
10	0.0025	0.0011	0.0015	0.0000	0.0001	0.0001
11	0.0110	0.0006	0.0004	0.0000	0.0028	0.0000
12	0.5896	0.0034	0.0441	0.0001	0.0753	0.0030
13	0.0989	0.0282	0.0000	0.0006	0.1499	0.0003
14	0.2579	0.0514	0.0011	0.0013	0.4765	0.0212
15	0.0189	0.0333	0.0029	0.0453	0.2425	0.0621
16	0.0019	0.0001	0.0000	0.9525	0.0442	0.0001

Table H.4. Con't

Number	Var Prop GA1	Var Prop GA2	Var Prop RACE1	Var Prop RESI1	Var Prop RACGA1	Var Prop RACGA2
1	0.0001	0.0001	0.0006	0.0003	0.0001	0.0001
2	0.0131	0.0152	0.0000	0.0000	0.0131	0.0151
3	0.0220	0.0100	0.0000	0.0006	0.0224	0.0101
4	0.0009	0.0001	0.0009	0.1419	0.0002	0.0000
5	0.0000	0.0000	0.0010	0.1098	0.0003	0.0001
6	0.0000	0.0000	0.0003	0.0187	0.0000	0.0000
7	0.0000	0.0004	0.0008	0.0388	0.0000	0.0001
8	0.0002	0.0002	0.0022	0.0036	0.0000	0.0002
9	0.0001	0.0000	0.0060	0.0028	0.0000	0.0000
10	0.8803	0.0043	0.0149	0.0323	0.8793	0.0044
11	0.0087	0.9452	0.0000	0.0217	0.0088	0.9450
12	0.0194	0.0162	0.1822	0.0479	0.0209	0.0153
13	0.0490	0.0073	0.6664	0.4384	0.0479	0.0084
14	0.0004	0.0000	0.0175	0.0002	0.0009	0.0001
15	0.0053	0.0010	0.1000	0.1427	0.0059	0.0010
16	0.0005	0.0000	0.0072	0.0003	0.0002	0.0000

* Further diagnoses for collinearty. If the eigenvalue and condition number are large, and the correlation between two independent variables is high (>0.9), there might be a high collinearty.

Figure H.1. Distribution of studentized residuals by predicted value of BW (Legend: A = 1 obs, B = 2 obs, etc. Note: 4507 missing. 4284 hidden. 16 out of range. A well-fitted model would expect a similar even distribution of residuals around 0 across different predicted BW)

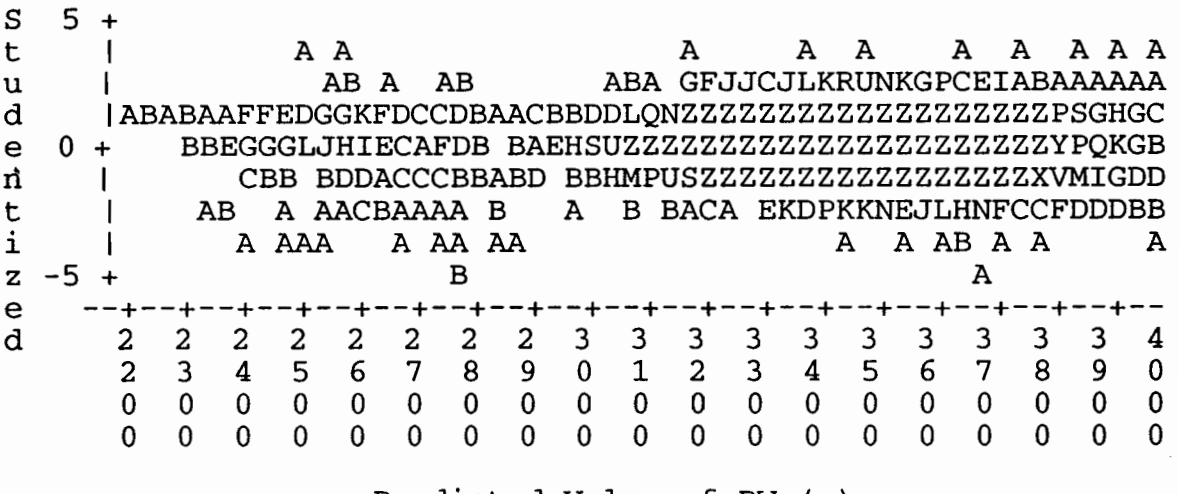


Figure H.2. Distribution of studentized residuals by sex (Legend: A = 1 obs, B = 2 obs, etc. Note: 4507 missing. 6477 hidden. A well-fitted model would expect a similar even distribution of residuals aroud 0 in boys vs girls)

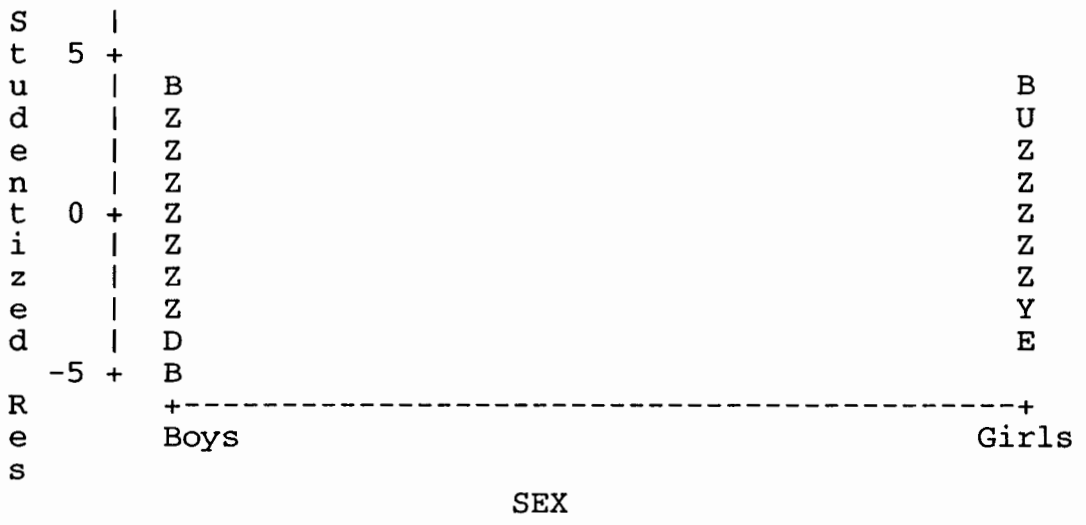


Figure H.3. Distribution of studentized residuals by marital status (Legend: A = 1 obs, B = 2 obs, etc. Note: 4507 missing. 6508 hidden. A well-fitted model would expect a similar even distribution of residuals aroud 0 in infants whose mother married vs unmarried)

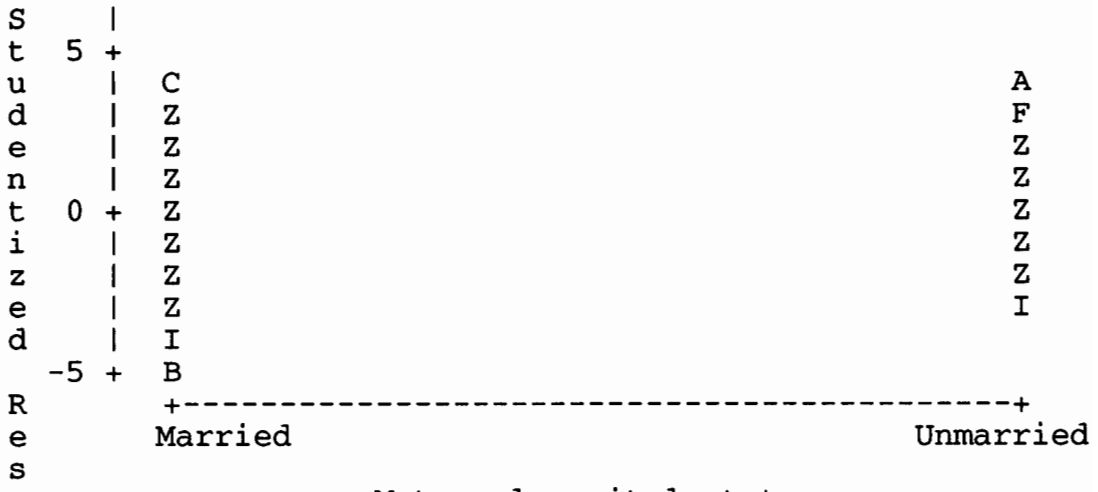


Figure H.4. Distribution of studentized residuals by maternal education (Legend: A = 1 obs, B = 2 obs, etc. Note: 4451 missing. 5000 hidden. 170 out of range. A well-fitted model would expect a similar even distribution of residuals aroud 0 in infants whose mother had different years of schooling)

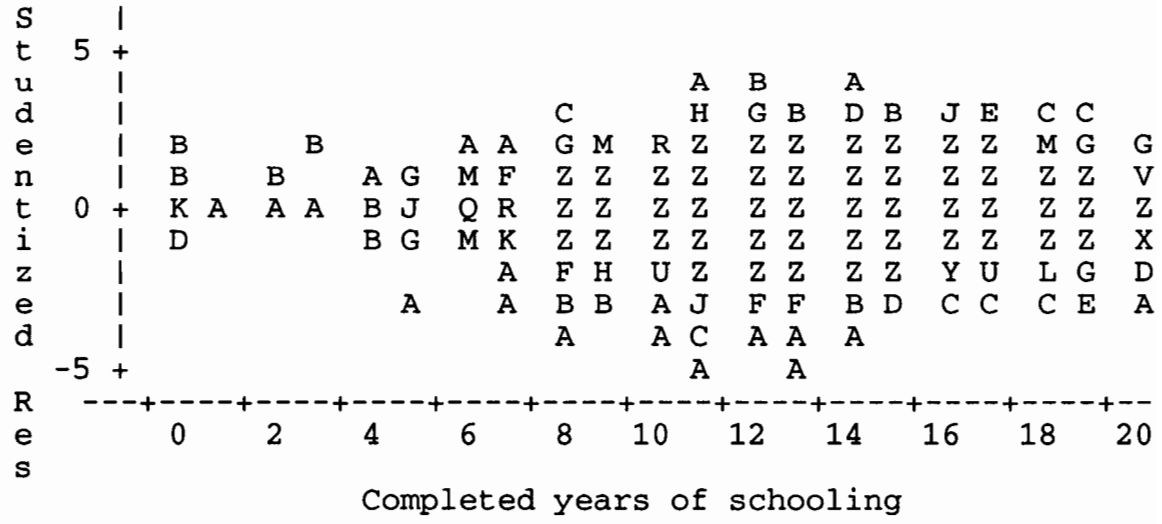


Figure H.5. Distribution of studentized residuals by parity (Legend: A = 1 obs, B = 2 obs, etc. Note: 4507 missing. 6241 hidden. A well-fitted model would expect a similar even distribution of residuals aroud 0 across different numbers of parity)

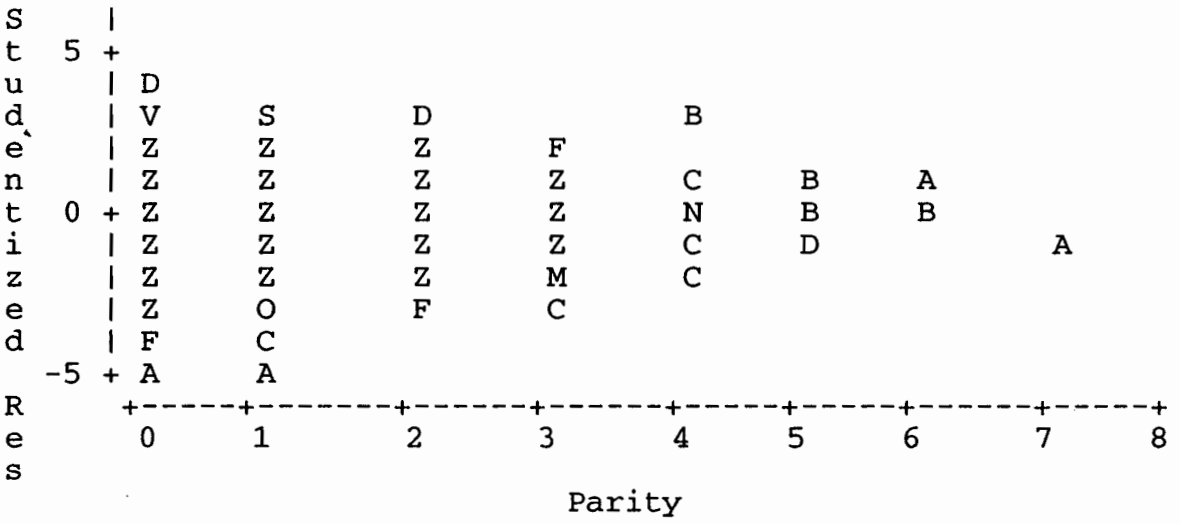


Figure H.6. Distribution of studentized residuals by maternal smoking (Legend: A = 1 obs, B = 2 obs, etc. Note: 4507 missing. 6247 hidden. A well-fitted model would expect a similar even distribution of residuals aroud 0 in infants with different amount of maternal smoking)

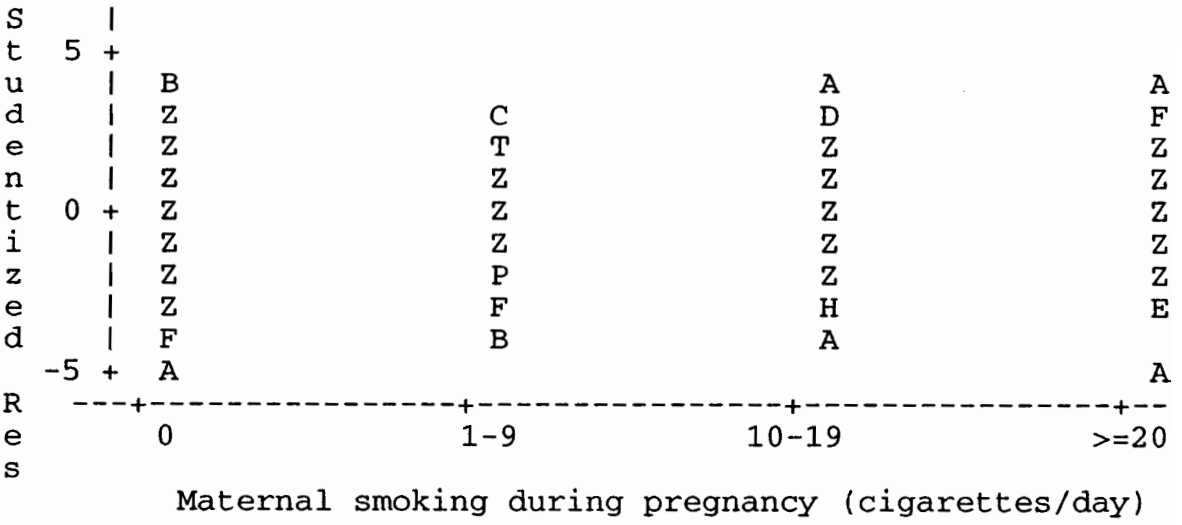


Figure H.7. Distribution of studentized residuals by maternal height (Legend: A = 1 obs, B = 2 obs, etc. Note: 4507 missing. 4481 hidden. A well-fitted model would expect a similar even distribution of residuals aroud 0 in infants with different values of maternal height)

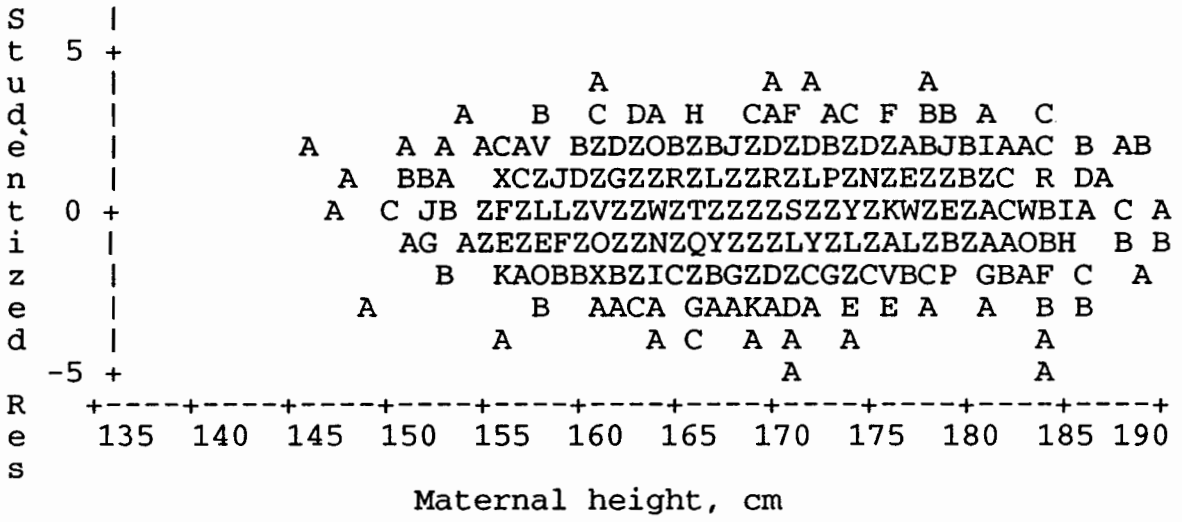


Figure H.8. Distribution of studentized residuals by maternal prepregnancy BMI (Legend: A = 1 obs, B = 2 obs, etc. Note: 4493 missing, 3062 hidden, and 97 out of range. A well-fitted model would expect a similar even distribution of residuals aroud 0 in infants with different values of maternal prepregnancy BMI)

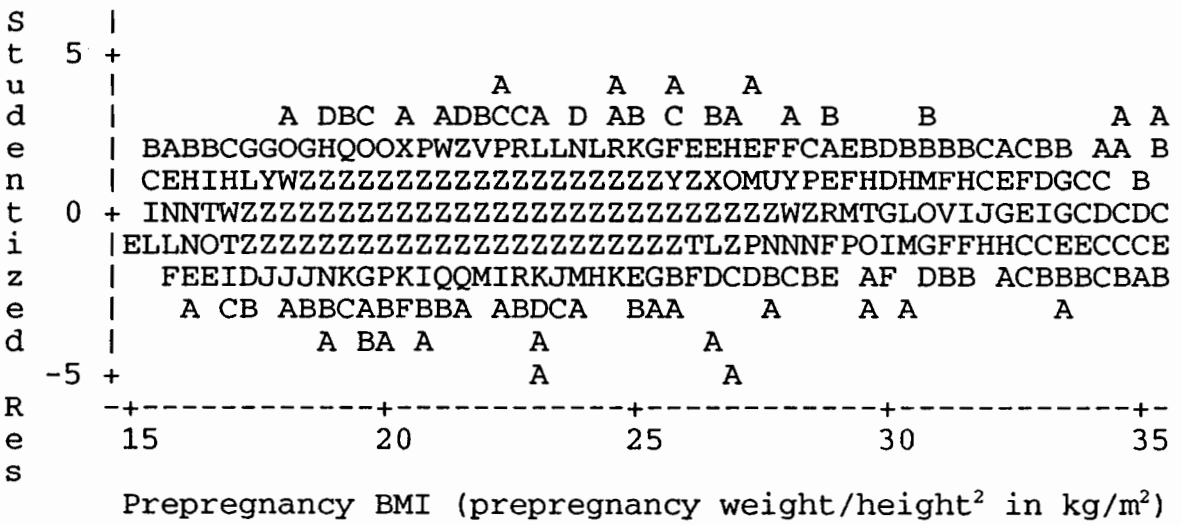
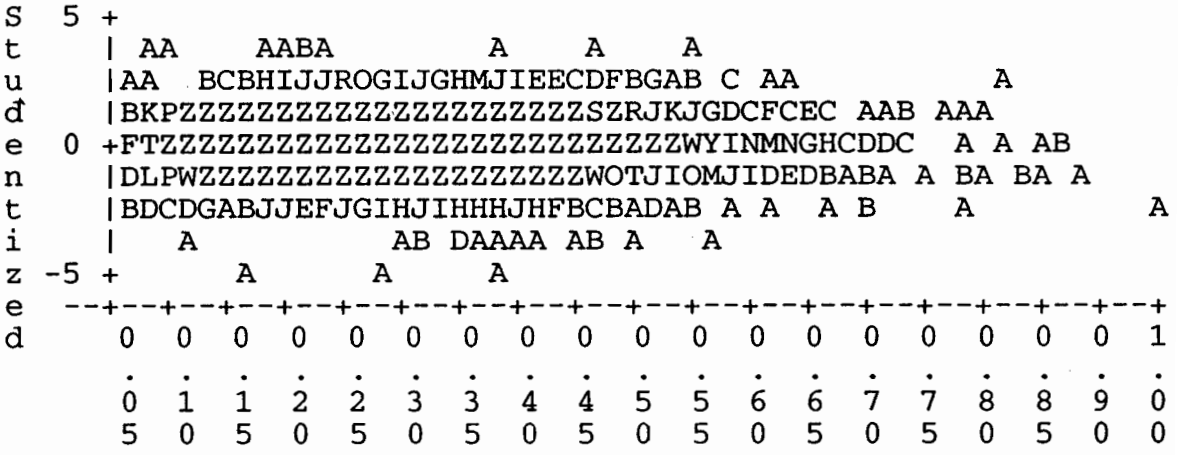


Figure H.9. Distribution of studentized residuals by maternal gestational weight gain rate (Legend: A = 1 obs, B = 2 obs, etc. Note: 4473 missing, 4016 hidden, and 175 out of range. A well-fitted model would expect a similar even distribution of residuals aroud 0 in infants with different values of maternal gestational weight gain rate)



Net gestational weight gain rate ((Last wt before delivery - prepregnancy wt - BW)/GA in kg/week)

Figure H.10. Distribution of studentized residuals by preterm delivery (Legend: A = 1 obs, B = 2 obs, etc. Note: 4507 missing and 6513 hidden. A well-fitted model would expect a similar even distribution of residuals aroud 0 in infants with preterm vs not)

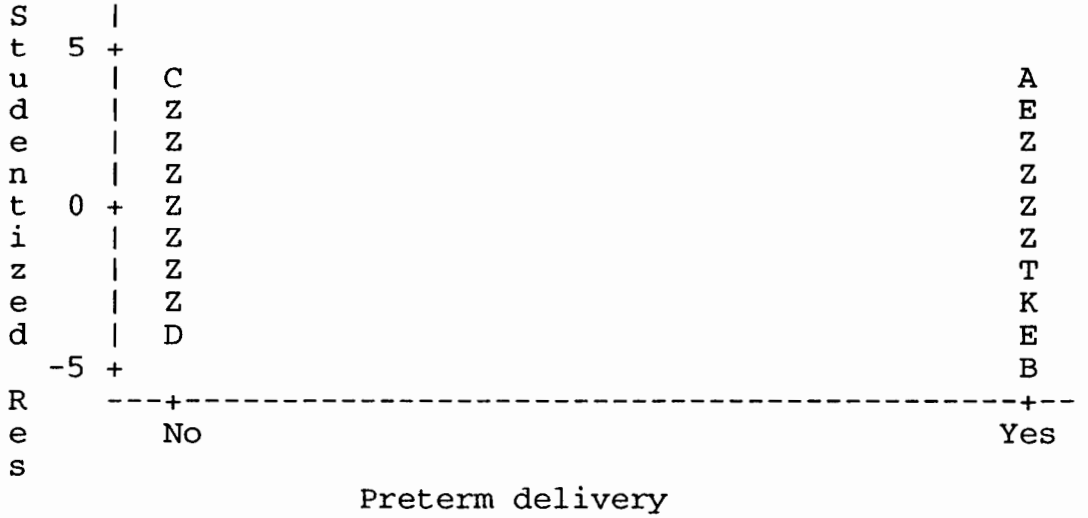


Figure H.11. Distribution of studentized residuals by postterm delivery (Legend: A = 1 obs, B = 2 obs, etc. Note: 4507 missing and 6545 hidden. A well-fitted model would expect a similar even distribution of residuals aroud 0 in infants with postterm vs not)

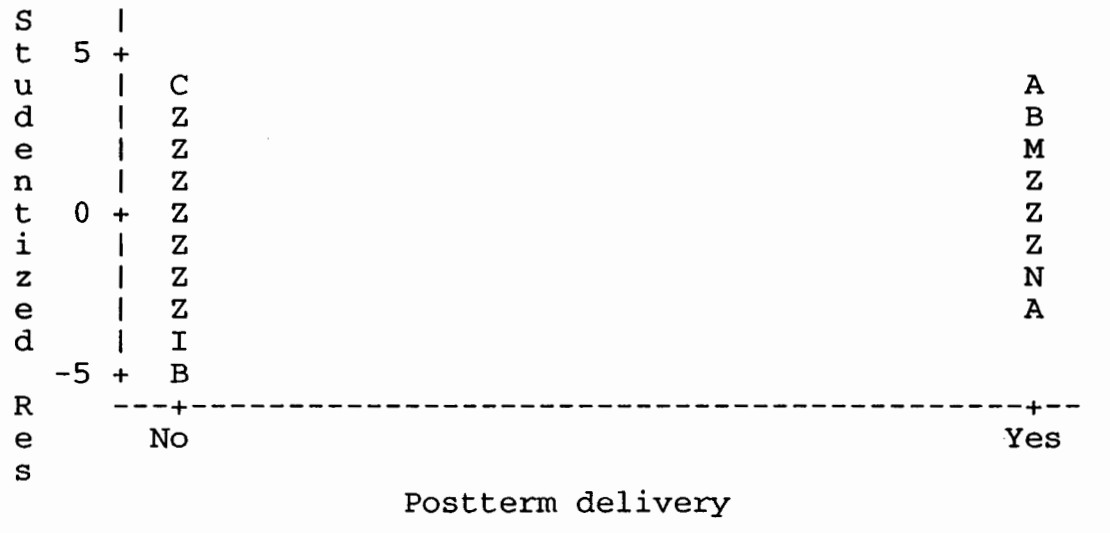


Figure H.12. Distribution of studentized residuals by race (Legend: A = 1 obs, B = 2 obs, etc. Note: 4507 missing and 6519 hidden. A well-fitted model would expect a similar even distribution of residuals aroud 0 in Chinese vs Caucasian infants)

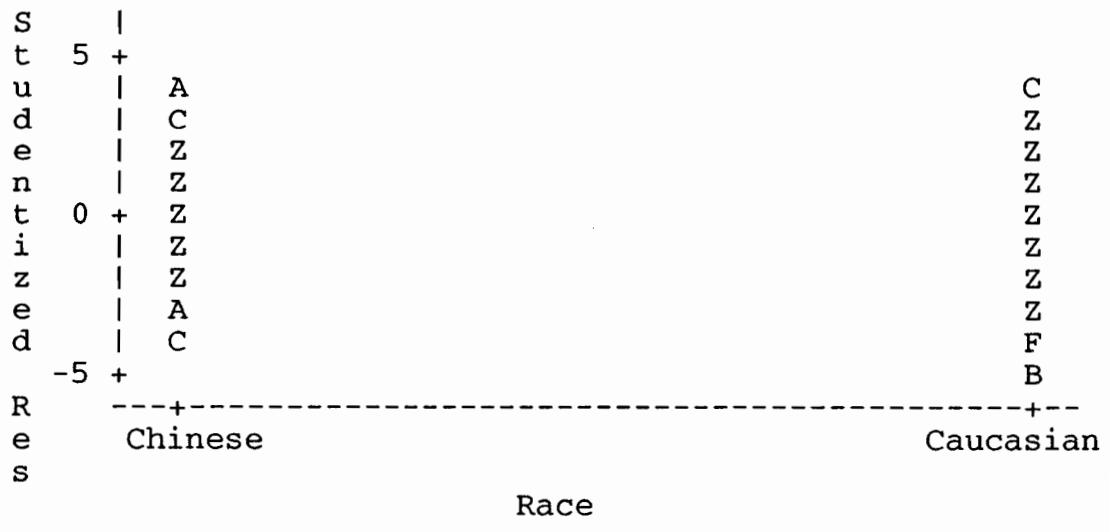


Figure H.13. Distribution of studentized residuals by residence (Legend: A = 1 obs, B = 2 obs, etc. Note: 4507 missing and 6526 hidden. A well-fitted model would expect a similar even distribution of residuals aroud 0 in infants living in China vs living in Canada)

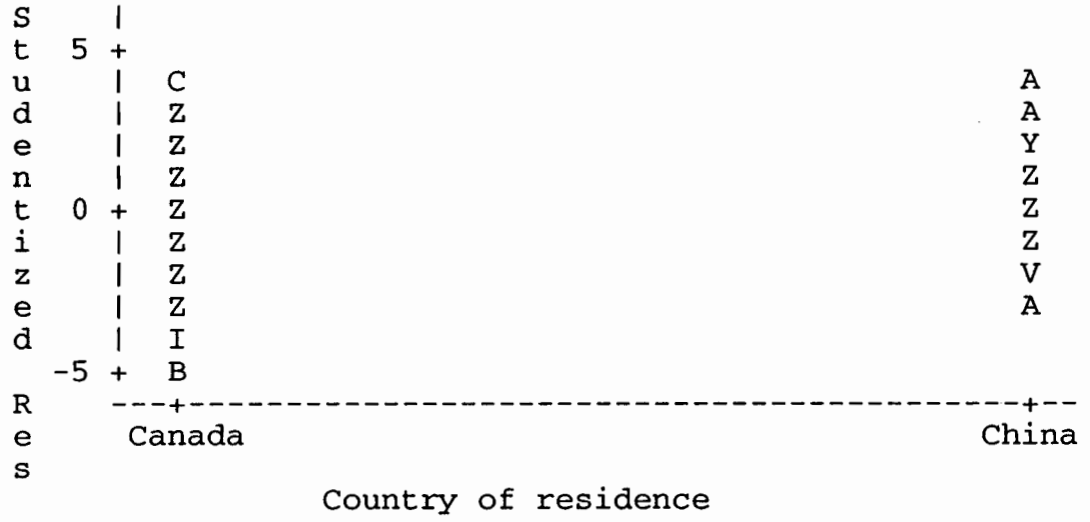


Figure H.14. Distribution of studentized residuals by interaction of race and preterm delivery (Legend: A = 1 obs, B = 2 obs, etc. Note: 4507 missing and 6517 hidden. A well-fitted model would expect a similar even distribution of residuals aroud 0 in preterm Caucasian infants vs others)

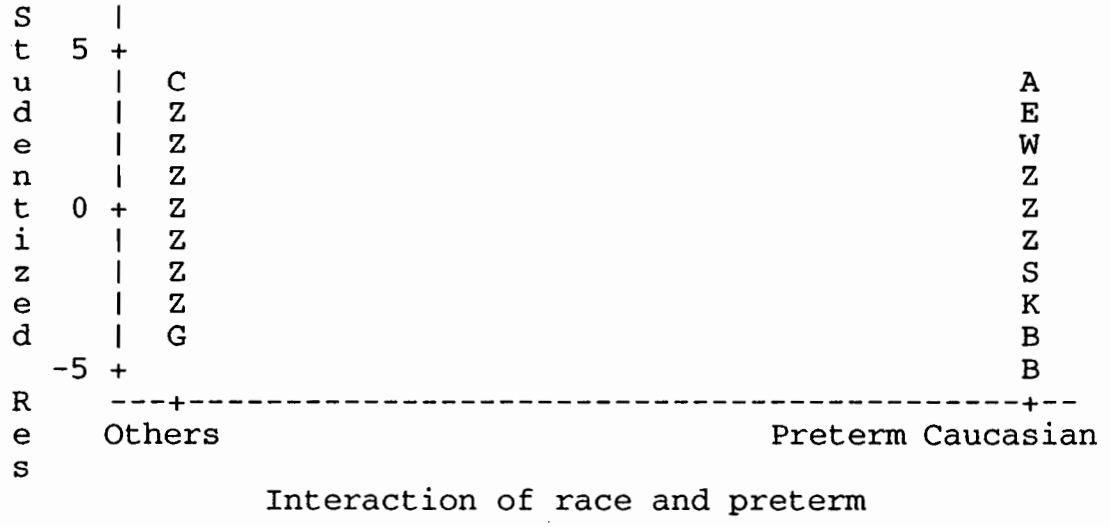
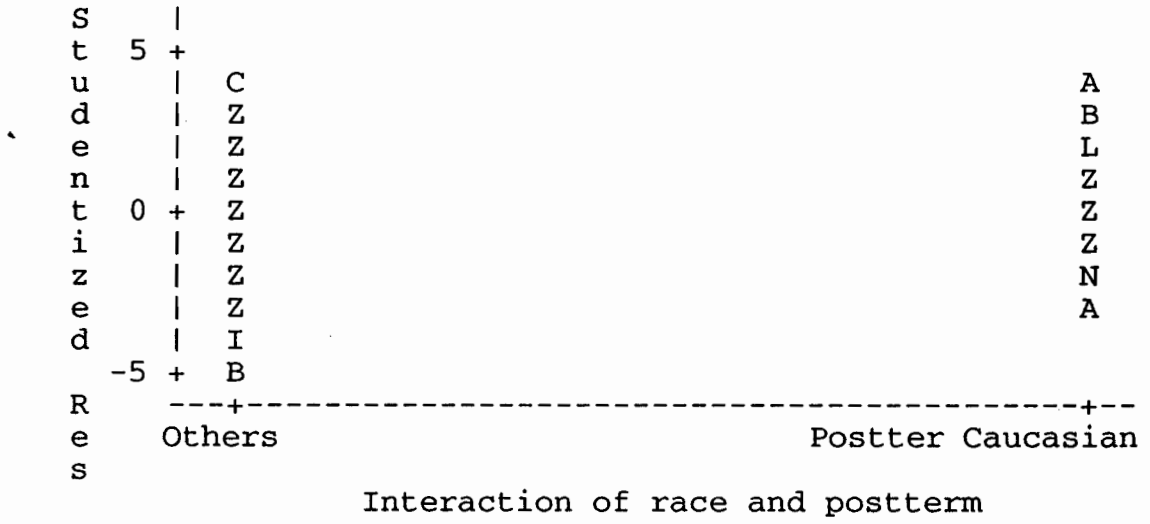


Figure H.15. Distribution of studentized residuals by interaction of race and postterm delivery (Legend: A = 1 obs, B = 2 obs, etc. Note: 4507 missing and 6546 hidden. A well-fitted model would expect a similar even distribution of residuals aroud 0 in postterm Caucasian infants vs others)



APPENDIX I. ASSESSMENT OF COMPARIBILITY OF SUBJECTS WITH MISSING OUTCOME AND/OR DETERMINANT VALUES

Nearly every study subject had a BW record, and more than 90% had an LNMP-determined GA record. Ultrasound-determined GA was missing in a substantial proportion of the study subjects (21.9%, 36.1%, and 52.9% in Caucasian, immigrant Chinese, and native Chinese respectively). While data on all of the determinants among native Chinese were nearly complete, a substantial proportion of data on maternal educational attainment and anthropometric measurement was missing in Caucasians and immigrant Chinese (Table I.1).

Immigrant and native Chinese subjects with an ultrasound-determined GA had slightly heavier BWs, larger FGRs, and shorter GAs than subjects without an ultrasound-determined GA. But in Caucasians, outcomes were comparable between subjects with and without ultrasound-determined GA (Table I.2). The distributions of determinants between subjects with and without ultrasound-determined GA were quite comparable in all three study groups. Although some of the differences were statistically significant, the magnitude of these differences is usually small (Table I.3).

The distributions of outcomes showed substantial differences in all three study groups, with significantly heavier BWs, larger FGRs, and shorter GAs in subjects with concordant GA estimates compared to those with discordant estimates (Tables

I.4). By contrast, for subjects with both ultrasound-and LNMP-determined GA estimates, the distributions of determinants in subjects with concordant GAs were quite similar to those in subjects with discordant GA estimates in all three study groups (Table I.5).

Caucasian subjects with missing anthropometric measurement records had slightly decreased BWs, GAs, and FGRs compared with those whose measurements were unavailable, whereas subjects with missing data on maternal education showed a moderate decrease in these measures (Table I.6). However, no significant differences were observed in BW, FGR, or GA in immigrant Chinese subjects with missing anthropometric measurements or maternal educational data (Table I.7). Since there were very few missing values in native Chinese, such a comparison is unnecessary.

Table I.1 Frequency of missing values for outcomes and determinants in Caucasian, immigrant Chinese, and native Chinese

	Caucasian (n=18665)		Immigrant Chinese (n=1597)		Native Chinese (n=1862)	
	#	%	#	%	#	%
BW	5	0.0	0	0.0	3	0.2
LNMP GA	1659	8.9	157	9.8	16	0.9
Ultrasound GA	4085	21.9	577	36.1	985	52.9
Infant's sex	4	0.0	0	0.0	0	0.0
Parity	0	0.0	0	0.0	0	0.0
Maternal age	0	0.0	0	0.0	0	0.0
Marital status	0	0.0	0	0.0	0	0.0
Education	2177	11.7	327	20.5	0	0.0
Height	4602	24.7	575	36.0	4	0.2
Prepregnancy BMI	5991	32.1	730	45.7	5	0.3
Net gestational Wt gain	4622	24.8	696	43.6	24	1.3
Gestational hypertension	0	0.0	0	0.0	0	0.0
Diabetes	0	0.0	0	0.0	*	*
Smoking	323	1.7	44	2.8	0	0.0
Alcohol consumption	149	0.8	310	19.4	0	0.0
Social drug use	114	0.6	366	22.9	0	0.0
Delivery method	0	0.0	0	0.0	0	0.0
Multiple birth	0	0.0	0	0.0	0	0.0
Malformation	0	0.0	0	0.0	0	0.0
Birth outcome (fetal death)	0	0.0	0	0.0	0	0.0

* Not available

Table I.2 Comparison of outcome distributions for subjects with and without ultrasound-determined GA in Caucasian, immigrant Chinese, and native Chinese*

	Caucasian		Immigrant Chinese		Native Chinese	
	Ultrasound-GA		Ultrasound-GA		Ultrasound-GA	
	Yes (n=14580)	No (n=4085)	Yes (n=1020)	No (n=577)	Yes (n=877)	No (n=985)
Continuous variables**						
BW	3385 (577)	3366 (573)[c]	3253 (502)	3203 (452)[b]	3152 (446)	3099 (497)[b]
GA	277 (15)	277 (14)[c]	275 (15)	277 (12)[c]	278 (12)	279 (15)[c]
FGR	1.00 (.15)	1.00 (.14)[a]	0.98 (.14)	0.95 (.13)[a]	0.92 (.12)	0.90 (.13)[a]
Categorical variables						
% LBW	5.6	5.7[c]	5.1	5.9[c]	5.8	8.2[b]
% HBW	11.4	10.5[c]	5.0	3.1[c]	1.8	1.8[c]
% Preterm delivery	7.2	6.9[c]	8.9	6.7[c]	5.2	7.2[c]
% Postterm delivery	7.0	7.4[c]	6.0	6.6[c]	8.9	11.5[c]
% SGA	11.9	12.0[c]	16.8	18.3[c]	25.8	34.6[a]
% LGA	12.8	12.5[c]	10.0	7.3[c]	3.8	3.0[c]

* GAs, FGRs, preterm deliveries, postterm deliveries, SGAs, and LGAs were based on LNMP-determined GA estimates alone
** Results are given as mean (SD)
[a] $P < 0.01$ for comparison between subjects with and without ultrasound-GA
[b] $P < 0.05$ for comparison between subjects with and without ultrasound-GA
[c] $P > 0.05$ for comparison between subjects with and without ultrasound-GA

Table I.3 Comparison of determinant distributions for subjects with and without ultrasound-determined GA in Caucasian, immigrant Chinese, and native Chinese*

	Caucasian		Immigrant Chinese		Native Chinese	
	Ultrasound-GA		Ultrasound-GA		Ultrasound-GA	
	Yes (n=14580)	No (n=4085)	Yes (n=1020)	No (n=577)	Yes (n=877)	No (n=985)
Continuous variables*						
Age,y	28.8 (4.8)	28.3 (4.8)[a]	29.4 (4.3)	28.6 (4.3)[a]	26.1 (2.7)	25.9 (2.9)[b]
School,y	13.4 (3.1)	13.2 (3.2)[a]	12.1 (3.9)	12.0 (3.8)[c]	10.7 (2.8)	9.7 (3.1)[a]
Height,cm	163 (6.5)	163 (6.4)[c]	158 (5.3)	158 (5.3)[c]	161 (4.5)	160 (4.7)[b]
BMI[1]	22.4 (3.9)	22.2 (3.7)[a]	20.3 (2.9)	19.8 (2.8)[b]	20.4 (2.3)	20.6 (2.2)[b]
Wt gain[2]	.29 (.13)	.29 (.13)[c]	.26 (.11)	.25 (.11)[c]	.28 (.14)	.24 (.12)[a]
Categorical variables						
% Female	48.9	49.2[c]	50.3	49.7[c]	48.4	49.5[c]
% Primiparas	49.6	47.4[b]	45.6	48.7[c]	90.2	86.9[b]
% Married	83.9	80.0[a]	97.4	96.0[c]	99.1	99.3[c]
% Severe PIH	0.5	0.7[c]	0.3	1.2[b]	1.9	3.4[b]
% Diabetes	4.2	3.6[c]	4.1	1.0[a]	**	**
% Drug use	0.8	1.3[a]	0.0	0.0[c]	0.0	0.0[c]
% >=1 drink/d	0.5	0.6[c]	0.0	0.0[c]	0.0	0.0[c]
% Smoked	26.8	29.0[b]	2.1	2.0[a]	0.0	0.0[c]
% C-section	21.3	20.1[c]	20.0	16.5[c]	24.6	22.1[c]
% Multiple births	2.6	1.9[b]	1.5	1.4[c]	3.7	3.4[c]
% Congenital malformation	5.1	6.2[a]	5.3	6.8[c]	0.2	0.7[c]
% Fetal death	0.5	0.6[c]	0.1	0.4[c]	0.8	2.2[b]

* Results are given as mean (SD)
** Not available
[1]. Prepregnancy weight/height^2 in kg/m^2
[2]. (Last weight before delivery - prepregnancy weight - BW)/GA in kg/week
[a] $P < 0.01$ for comparison between subjects with and without ultrasound-GA
[b] $P < 0.05$ for comparison between subjects with and without ultrasound-GA
[c] $P > 0.05$ for comparison between subjects with and without ultrasound-GA

Table I.4 Comparison of outcome distributions for subjects with concordant vs discordant ultrasound- and LNMP-determined GA in Caucasian, immigrant Chinese, and native Chinese*

	Caucasian		Immigrant Chinese		Native Chinese	
	Concordant-GA		Concordant-GA		Concordant-GA	
	Yes (n=11037)	No (n=2294)	Yes (n=723)	No (n=198)	Yes (n=581)	No (n=291)
Continuous variables**						
BW	3410 (565)	3298 (612)[a]	3276 (503)	3194 (520)[b]	3178 (431)	3099 (473)[b]
GA	276 (14)	281 (20)[a]	274 (13)	282 (18)[a]	277 (11)	282 (14)[a]
FGR	1.01 (.13)	0.94 (.15)[a]	0.99 (.12)	0.93 (.20)[a]	0.94 (.11)	0.89 (.13)[a]
Categorical variables						
% LBW	5.1	7.9[a]	4.7	6.1[c]	5.0	7.6[c]
% HBW	11.9	10.4[a]	5.5	3.0[c]	1.9	1.7[c]
% Preterm delivery	6.5	10.5[a]	8.2	11.6[c]	5.3	4.8[c]
% Postterm delivery	3.2	25.2[a]	1.0	24.2[a]	3.6	19.6[a]
% SGA	9.1	26.2[a]	10.8	34.9[a]	19.8	37.9[a]
% LGA	12.9	7.6[a]	9.1	11.6[c]	3.6	4.1[c]

* GAs, FGRs, preterm delivery, postterm delivery, SGAs, and LGAs were based on LNMP-determined GA estimates alone

** Results are given as mean (SD)

[a] $P < 0.01$ for comparison between subjects with concordant vs discordant ultrasound- and LNMP-determined GAs

[b] $P < 0.05$ for comparison between subjects with concordant vs discordant ultrasound- and LNMP-determined GAs

[c] $P > 0.05$ for comparison between subjects with concordant vs discordant ultrasound- and LNMP-determined GAs

Table I.5 Comparison of determinant distributions for subjects with concordant vs discordant ultrasound- and LNMP-determined GA in Caucasian, immigrant Chinese, and native Chinese

	Caucasian		Immigrant Chinese		Native Chinese	
	Concordant-GA		Concordant-GA		Concordant-GA	
	Yes (n=11037)	No (n=2294)	Yes (n=723)	No (n=198)	Yes (n=581)	No (n=291)
Continuous variables*						
Age,y	29.1 (4.7)	28.2 (4.7)[a]	29.7 (4.3)	28.6 (4.1)[a]	26.1 (2.6)	26.2 (2.9)[c]
School,y	13.5 (3.1)	13.2 (3.2)[a]	12.2 (3.9)	11.9 (3.8)[c]	10.7 (2.8)	10.6 (2.7)[c]
Height,cm	163 (6.4)	163 (6.7)[c]	158 (5.1)	158 (5.7)[c]	160 (4.5)	160 (4.6)[c]
BMI[1]	22.4 (3.8)	22.5 (4.1)[c]	20.4 (3.0)	20.3 (2.6)[c]	20.4 (2.3)	20.4 (2.2)[c]
Wt gain[2]	.30 (.13)	.29 (.14)[c]	.26 (.10)	.24 (.12)[b]	.28 (.14)	.27 (.14)[c]
Categorical variables						
% Female	47.5	53.8[a]	48.8	55.6[c]	48.0	48.8[c]
% Primiparas	50.0	49.2[c]	45.9	47.5[c]	89.5	92.1[c]
% Married	86.2	79.6[a]	97.8	97.0[c]	98.6	100.0[b]
% Severe PIH	0.4	0.8[c]	0.4	0.0[b]	1.5	2.7[b]
% Diabetes	4.1	4.8[c]	4.2	4.6[c]	**	**
% Drug use	0.4	1.0[b]	0.0	0.0[c]	0.0	0.0[c]
% >=1 drink/d	0.4	0.5[c]	0.0	0.0[c]	0.0	0.0[c]
% Smoked	25.4	28.3[a]	2.1	1.0[c]	0.0	0.0[c]
% C-section	21.6	20.2[c]	20.5	15.7[c]	24.6	24.1[c]
% Multiple births	2.6	2.6[c]	1.8	1.0[c]	3.4	4.1[c]
% Congenital malformation	5.0	5.5[c]	5.8	4.6[c]	0.3	0.3[c]
% Fetal death	0.4	0.7[c]	0.1	0.0[c]	0.7	1.0[c]

* Results are given as mean (SD)
** Not available
[1] Prepregnancy weight/height^2 in kg/m^2
[2] (Last weight before delivery - prepregnancy weight - BW)/GA in kg/week
[a] $P < 0.01$ for comparison between subjects with concordant vs discordant ultrasound- and LNMP-determined GAs
[b] $P < 0.05$ for comparison between subjects with concordant vs discordant ultrasound- and LNMP-determined GAs
[c] $P > 0.05$ for comparison between subjects with concordant vs discordant ultrasound- and LNMP-determined GAs

Table I.6 Comparison of BW, GA, and FGR between Caucasian subjects with available determinant values and those with missing values*

	BW,g	GA, d	FGR
Maternal education			
Not missing (n=16,485)	3398 (554)	277.4 (14.2)	0.999 (0.131)
Missing (n=2,177)	3254 (707)[a]	274.0 (20.0)[a]	0.985 (0.144)[a]
Maternal height			
Not missing (n=14,060)	3393 (564)	277.2 (14.5)	0.998 (0.132)
Missing (n=4,600)	3344 (608)[a]	276.2 (16.6)[a]	0.995 (0.134)[c]
Maternal prepregnancy BMI			
Not missing (n=12,672)	3396 (560)	277.4 (14.2)	0.997 (0.132)
Missing (n=5,988)	3349 (606)[a]	276.1 (16.6)[a]	0.997 (0.134)[c]
Net pregnancy weight gain rate			
Not missing (n=12,904)	3404 (555)	277.6 (14.0)	0.997 (0.131)
Missing (n=4,102)	3330 (662)[a]	275.1 (17.6)[a]	0.998 (0.136)[c]

* GAs and FGRs were based on LNMP-determined GA estimates alone; results are given as mean (SD)
[a] $P < 0.01$ for comparison of subjects with vs without available determinant values
[c] $P > 0.05$ for comparison of subjects with vs without available determinant values

Table I.7 Comparison of BW, GA, and FGR measured as continuous variables between immigrant Chinese subjects with available determinant values and those with missing values*

	BW,g	GA, d	FGR
Maternal education			
Not missing (n=1,270)	3236 (486)	275.8 (14.0)	0.966 (0.127)
Missing (n=327)	3229 (578)[c]	276.3 (13.2)[c]	0.963 (0.131)[c]
Maternal height			
Not missing (n=1,022)	3250 (486)	276.0 (13.7)	0.968 (0.131)
Missing (n=575)	3206 (482)[c]	275.6 (14.2)[c]	0.961 (0.121)[c]
Maternal prepregnancy BMI			
Not missing (n=867)	3256 (499)	276.2 (13.9)	0.967 (0.133)
Missing (n=730)	3209 (467)[c]	275.5 (13.8)[c]	0.965 (0.120)[c]
Net pregnancy weight gain rate			
Not missing (n=827)	3269 (485)	276.3 (13.8)	0.969 (0.131)
Missing (n=613)	3198 (482)[a]	275.4 (13.9)[c]	0.962 (0.123)[c]

* GAs and FGRs were based on LNMP-determined GA estimates alone; results are given as mean (SD)
[a] $P < 0.01$
[c] $P > 0.05$

APPENDIX J. COMPARIBILITY OF TERMINAL DIGIT PREFERENCE IN BW RECORDS BETWEEN THE TWO HOSPITALS

Table J.1 shows that there was a stronger terminal 0 preference in BW records of native Chinese infants than in records of Caucasian or immigrant Chinese infants.

Table J.1 Comparison of terminal digit distribution in BW recording among Caucasian, immigrant Chinese, and native Chinese infants*

Terminal digit	Caucasian		Immigrant Chinese		Native Chinese	
	#	%	#	%	#	%
0	15,934	85.4	1,302	81.5	1,857	99.9
5	2,720	14.6	295	18.5	2	0.1
Others	11	0.0	0	0.0	0	0.0

* Difference is statistically significant ($P < 0.01$)

When the cutpoints for LBW and HBW were changed from the conventional ones (<2,500 g and >4,000 g, respectively) to the ones including the cutpoint value (i.e., <=2,500 g and >=4,000 g, respectively, the prevalences of LBW and HBW were increased only moderately in Caucasian and immigrant Chinese infants, but the increases were substantial in native Chinese infants (Table J.2). But such increases in LBW and HBW after changing cutpoints in native Chinese infants altered neither the direction nor the clinical meaning of comparisons among the three groups, although the difference in LBW rates became more statistically 'significant' (Table J.2).

Table J.2 Assessment of the consequences of terminal digit preference in BW recording on the rates of LBW and HBW in Caucasian, immigrant Chinese, and native Chinese infants

	Caucasian (n=18,665)	Immigrant Chinese (n=1,597)	Native Chinese (n=1,862)	X^{2*}
LBW(< 2,500)[1]	5.6	5.4	7.0	6.5[b]
LBW(<=2,500)[2]	5.9	5.7	8.7	23.7[a]
HBW(> 4,000)[1]	11.2	4.3	1.8	228.5[a]
HBW(>=4,000)[2]	11.9	4.4	2.7	220.7[a]

* Chi-square test for differences in LBW and HBW rates among Caucasian, immigrant Chinese, and native Chinese

[1] Conventional definition

[2] Changed definition containing the cutpoint

[a] $P < 0.01$

[b] $P < 0.05$

APPENDIX K. COMPARISON OF DETERMINANTS AND OUTCOMES BETWEEN MOTHERS WITH 'CERTAIN' VS 'UNCERTAIN' CHINESE NAMES

Table K.1 Comparison of determinants of BW, GA, and FGR, and selected pregnancy outcomes (other than BW, GA, and FGR) in immigrant Chinese infants of mothers with certain Chinese family name vs those of mothers with uncertain names, i.e., those possibly mixed with Vietnamese names

	Certain Chinese name (n=980)	Uncertain Chinese name (n=617)
Continuous variables*		
Age, y	29.2 (4.2)	29.2 (4.5)[c]
Height, cm	158.2 (4.9)	157.2 (5.8)[c]
Prepregnancy BMI, Kg/m^2	20.3 (3.0)	19.9 (2.6)[c]
Net Wt gain (kg/week)	0.25 (0.11)	0.26 (0.11)[c]
Education, y completed	11.8 (4.0)	12.4 (3.7)[c]
Categorical variables		
% Female	50.5	49.0[c]
% Primiparas	45.8	48.1[c]
% Married	97.8	95.5[b]
% Severe PIH	0.3	1.1[c]
% Diabetes	3.0	3.6[c]
% Smoked	2.2	1.8[c]
% C-section	17.5	20.8[c]
% Multiple births	1.6	1.1[c]
% Congenital malformation	5.1	7.0[c]
% Fetal death	0.0	0.5[b]

* Results are given as mean (SD)
[b] $P < 0.05$ for comparison between mothers with certain Chinese family names vs uncertain Chinese family names
[c] $P > 0.05$ for comparison between mothers with certain Chinese family names vs uncertain Chinese family names

Table K.2 Comparison of BW, GA, and FGR in immigrant Chinese infants of mothers with certain Chinese family name vs those of mothers with uncertain names, i.e., those possibly mixed with Vietnamese names*

	Certain Chinese name (n=980)	Uncertain Chinese name (n=617)
Continuous variables**		
Birth wt, g	3232 (462)	3239 (520)[c]
Gestational age, d	276.2 (12.7)	275.5 (15.5)[c]
Fetal growth ratio	0.964 (0.134)	0.977 (0.141)[c]
Categorical variables		
% LBW	5.3	5.5[c]
% HBW	3.6	5.5[c]
% Preterm delivery	7.2	9.4[c]
% Postterm delivery	5.0	8.1[b]
% SGA	16.6	17.2[c]
% LGA	7.2	11.4[b]

* GAs, FGRs, preterm deliveries, postterm deliveries, SGAs, and LGAs were based on LNMP-determined GA estimates alone
** Results are given as mean (SD)
[b] $P < 0.05$ for comparison between mothers with certain Chinese family names vs uncertain Chinese family names
[c] $P > 0.05$ for comparison between mothers with certain Chinese family names vs uncertain Chinese family names

APPENDIX L. COMPARISON OF DETERMINANTS AND OUTCOMES IN EARLIER VS LATER YEARS AMONG CAUCASIANS AND IMMIGRANT CHINESE

Table L.1 Descriptive statistics for immigrant Chinese mothers by year of delivery (continuous variables)*

	Age, y	Education, y completed	Height, cm	Prepregnancy BMI	Net Wt gain (kg/week)
1978(n=128)	27.6 (4.1)	9.8 (3.8)	157.4 (5.3)	19.9 (2.5)	0.24 (0.09)
1979(n= 83)	27.2 (3.9)	12.5 (3.7)	158.2 (4.3)	19.9 (3.2)	0.23 (0.09)
1980(n= 63)	28.1 (4.1)	11.8 (4.0)	156.9 (4.2)	19.4 (1.6)	0.22 (0.11)
1981(n= 63)	28.7 (4.4)	12.2 (3.9)	156.7 (5.4)	20.9 (5.6)	0.22 (0.11)
1982(n=115)	28.5 (3.9)	11.9 (4.2)	156.6 (5.6)	19.8 (2.3)	0.26 (0.11)
1983(n=156)	29.0 (4.5)	11.6 (4.0)	157.5 (5.3)	19.5 (2.3)	0.23 (0.09)
1984(n=150)	29.3 (4.6)	11.4 (3.7)	157.6 (5.6)	20.3 (2.7)	0.26 (0.11)
1985(n=182)	29.4 (4.3)	11.9 (3.9)	158.0 (5.2)	20.4 (3.0)	0.25 (0.11)
1986(n=145)	29.3 (4.1)	11.7 (4.2)	158.2 (5.5)	19.6 (2.7)	0.27 (0.10)
1987(n=147)	29.9 (4.1)	11.8 (3.6)	157.8 (5.2)	20.8 (3.3)	0.25 (0.11)
1988(n=168)	30.0 (4.4)	12.9 (3.8)	158.0 (5.4)	20.5 (2.5)	0.28 (0.11)
1989(n=197)	30.0 (4.2)	12.8 (3.7)	159.2 (5.1)	20.5 (3.1)	0.29 (0.12)
*b***	0.2338[a]	0.0847[b]	0.1422[a]	0.0585[b]	0.0047[a]

* Results are given as mean (SD); deliveries from January 1 to March 31 1990 have been combined with those of 1989

** Slope for linear regression between year of delivery and maternal characteristics

[a] $P < 0.01$

[b] $P < 0.05$

Table L.2 Descriptive statistics for immigrant Chinese mothers by year of delivery (categorical variables)*

	% married	% primiparas	% C-section	% severe PIH	% smoked
1978(n=128)	99.2	52.3	17.2	0.8	3.1
1979(n= 83)	100.0	42.2	13.3	0.0	2.4
1980(n= 63)	96.8	49.2	23.8	3.2	0.0
1981(n= 63)	98.4	49.2	14.3	1.6	3.2
1982(n=115)	97.4	46.1	15.7	0.9	1.7
1983(n=156)	97.4	48.7	15.4	0.0	0.0
1984(n=150)	98.0	42.7	16.7	0.0	1.3
1985(n=182)	95.6	47.2	23.6	1.1	2.2
1986(n=145)	95.2	43.4	18.6	0.0	1.4
1987(n=147)	97.3	42.2	17.0	0.7	2.7
1988(n=168)	95.2	46.4	20.2	0.6	2.4
1989(n=197)	95.4	50.8	23.4	0.5	3.1
*b***	-0.0068[b]	-0.0008[c]	0.0028[b]	-0.0002[c]	-0.0007[c]

* Deliveries from January 1 to March 30 1990 have been combined with those of 1989

** Slope for gradient in proportions by year of delivery (Fleiss JL: Statistical methods for rates and proportions. 2nd ed New York:John Wiley & Sons, 1981. PP 143-146)

[b] $P < 0.05$

[c] $P > 0.05$

Table L.3 Outcomes in immigrant Chinese infants by year of delivery (continuous variables)*

	BW, g	GA, d	FGR
1978(n=128)	3206 (438)	277.6 (11.9)	0.951 (0.135)
1979(n= 83)	3242 (495)	277.1 (15.5)	0.948 (0.101)
1980(n= 63)	3236 (458)	277.4 (11.8)	0.971 (0.130)
1981(n= 63)	3176 (274)	275.0 (11.3)	0.949 (0.120)
1982(n=115)	3225 (443)	276.6 (12.8)	0.956 (0.117)
1983(n=156)	3238 (548)	276.0 (14.7)	0.966 (0.149)
1984(n=150)	3228 (440)	275.7 (14.5)	0.969 (0.136)
1985(n=182)	3274 (482)	277.5 (12.3)	0.964 (0.135)
1986(n=145)	3215 (508)	275.8 (13.0)	0.966 (0.140)
1987(n=147)	3206 (555)	273.7 (19.1)	0.983 (0.147)
1988(n=168)	3219 (434)	273.7 (12.9)	0.987 (0.123)
1989(n=197)	3289 (502)	275.9 (12.3)	0.988 (0.158)
*b***	3.5135[c]	-0.2427[b]	0.0035[a]

* Results are given as mean (SD); deliveries from January 1 to March 30 1990 have been combined with those of 1989; because of limited sample size, all subjects were included, and GAs and FGRs were based on LNMP alone

** Slope for linear regression between year of delivery and pregnancy outcomes

[a] $P < 0.01$

[b] $P < 0.05$

[c] $P > 0.05$

Table L.4 Descriptive statistics for Caucasian mothers by year of delivery (continuous variables)*

	Age, y	Education, y completed	Height, cm	Prepregnancy BMI	Net wt gain (kg/week)
1983(n=2695)	28.0 (4.7)	12.9 (3.1)	163.1 (4.7)	21.9 (3.5)	11.3 (4.9)
1984(n=2511)	28.4 (4.7)	13.1 (3.2)	162.5 (6.3)	22.1 (3.7)	11.5 (5.1)
1985(n=2536)	28.6 (4.7)	13.2 (3.3)	162.8 (6.5)	22.2 (3.7)	11.3 (5.2)
1986(n=2465)	28.7 (4.9)	13.3 (3.1)	162.8 (6.4)	22.5 (3.9)	11.4 (5.2)
1987(n=2623)	29.0 (4.8)	13.5 (3.0)	163.3 (6.6)	22.4 (3.9)	11.4 (5.2)
1988(n=2508)	29.0 (5.0)	13.7 (3.0)	163.6 (6.5)	22.6 (4.1)	11.9 (5.4)
1989(n=3326)	29.1 (4.8)	13.8 (3.1)	163.2 (6.5)	22.8 (4.2)	11.7 (5.3)
*b***	0.1659[a]	0.1413[a]	0.0995[a]	0.1400[a]	0.0023[a]

* Results are given as mean (SD); deliveries from January 1 to March 30 1990 have been combined with those of 1989

** Slope for linear regression between year of delivery and maternal characteristics

[a] $P < 0.01$

[b] $P < 0.05$

APPENDIX M. OUTCOMES IN SUBJECTS WITHOUT EXCLUSION FOR DISCORDANT ULTRASOUND- AND LNMP-DETERMINED GA

Table M.1 Sample size in all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V) among Caucasian, immigrant Chinese, and native Chinese infants, subjects without exclusion for discordant ultrasound- and LNMP-determined GA*

	Caucasian	Immigrant Chinese	Native Chinese
I	18665 (100.0)	1597 (100.0)	1862 (100.0)
II	18574 (99.5)	1574 (99.8)	1833 (98.4)
III	17108 (91.7)	1473 (92.2)	1726 (92.7)
IV	6564 (43.1)	925 (65.9)	1004 (56.4)
V	3414 (24.8)	280 (23.1)	972 (55.3)

* Results are given as number (percent)

p. a. 48
missing

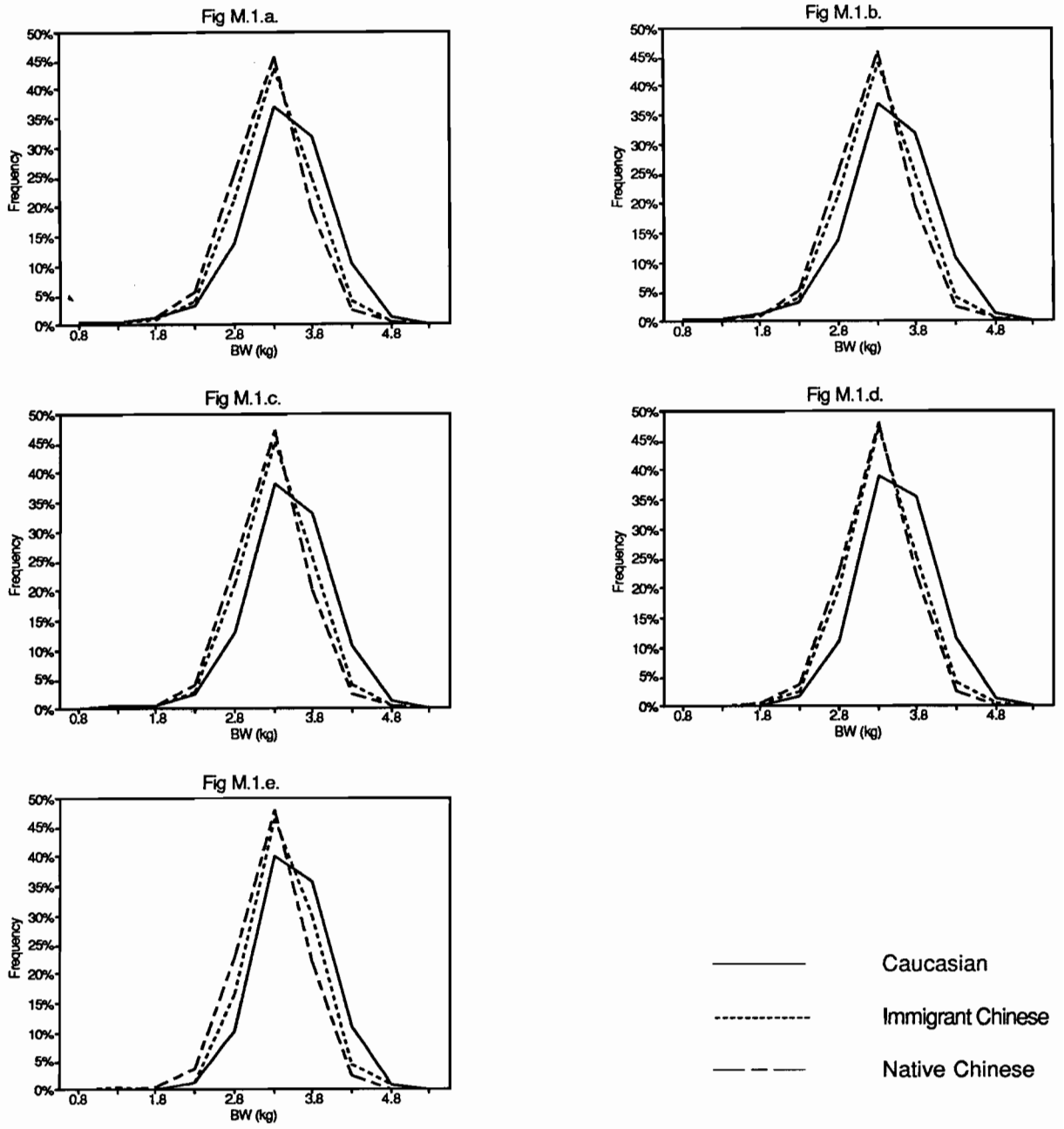


Figure M.1. BW distribution in Caucasian, immigrant Chinese, and native Chinese infants, subjects without exclusion for discordant ultrasound- and LNMP-determined GA: a. all births; b. live births; c. singleton, live, non-malformed births to mothers without severe PIH; d. 'risk-free I' births; e. 'risk-free II' births

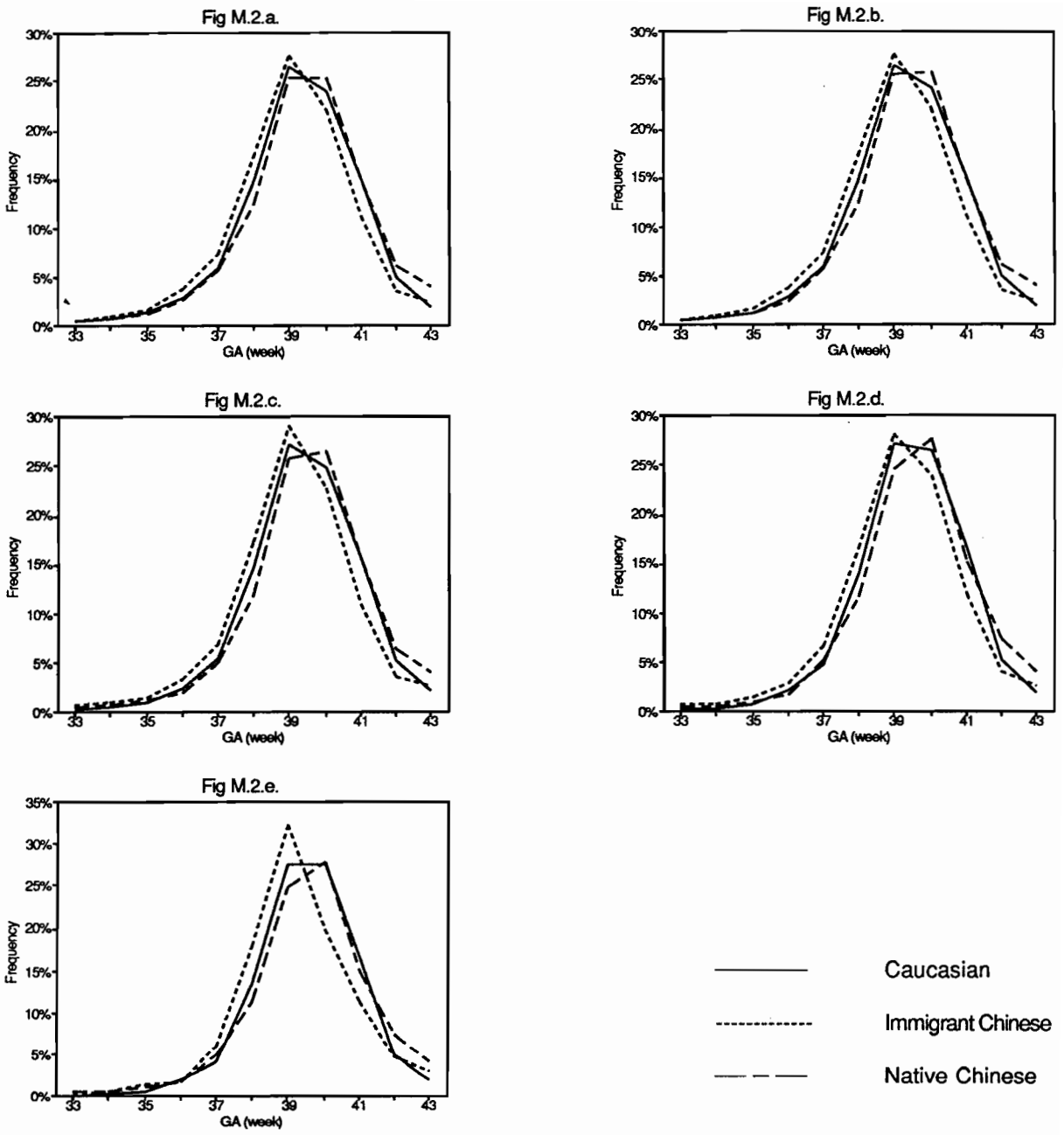


Figure M.2. GA distribution in Caucasian, immigrant Chinese, and native Chinese infants, subjects without exclusion for discordant ultrasound- and LNMP-determined GA: a. all births; b. live births; c. singleton, live, non-malformed births to mothers without severe PIH; d. 'risk-free I' births; e. 'risk-free II' births

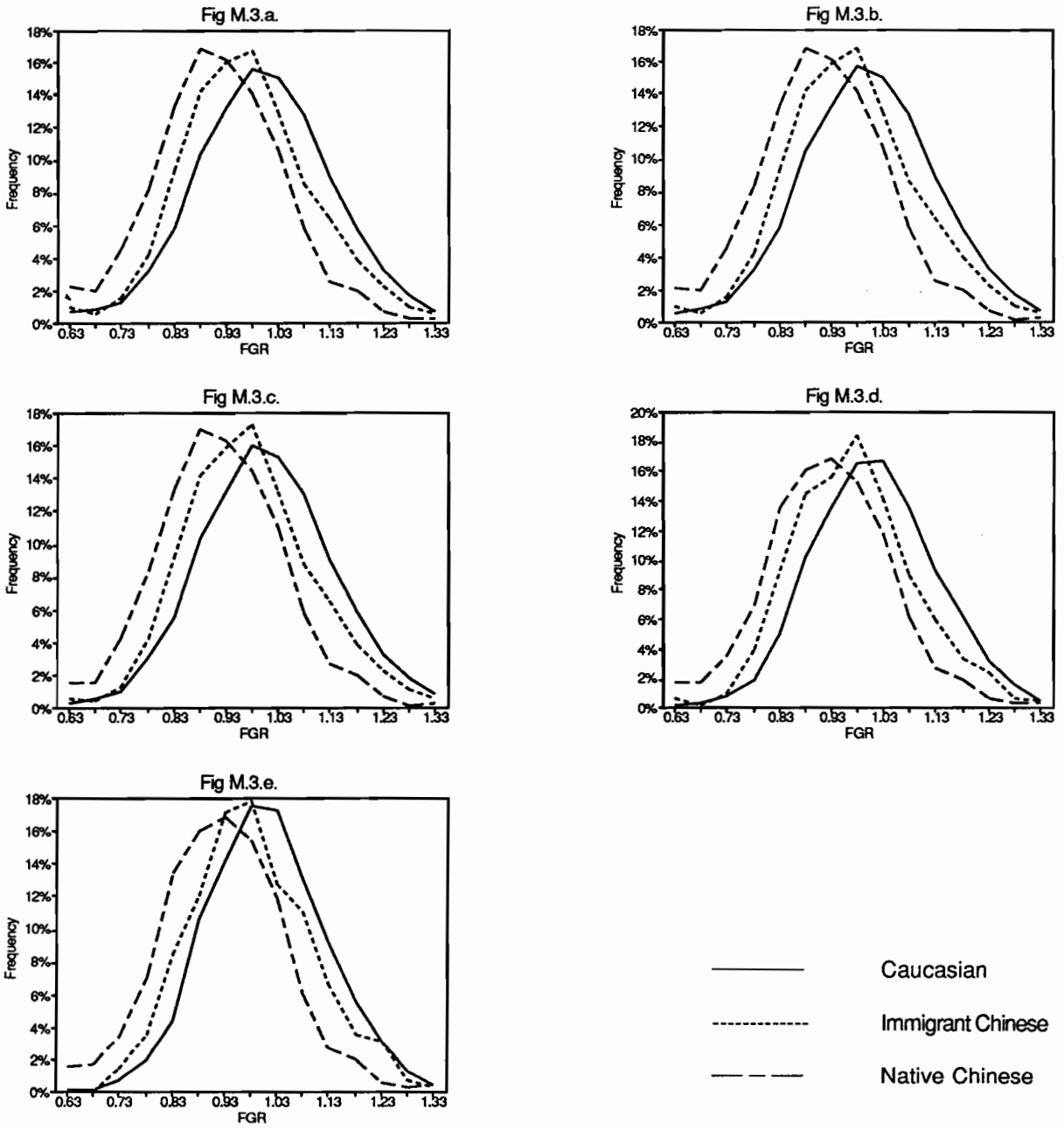


Figure M.3. FGR distribution in Caucasian, immigrant Chinese, and native Chinese infants, subjects without exclusion for discordant ultrasound- and LNMP-determined GA: a. all births; b. live births; c. singleton, live, non-malformed births to mothers without severe PIH; d. 'risk-free I' births; e. 'risk-free II' births

Table M.2 Comparison of skewness and kurtosis coefficients for BW, GA, and FGR distributions among Caucasian, immigrant Chinese, and native Chinese infants of all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V), subjects without exclusion for discordant ultrasound- and LNMP-determined GA

	Caucasian		Immigrant Chinese		Native Chinese	
	Skewness	Kurtosis	Skewness	Kurtosis	Skewness	Kurtosis
BW, g						
I	-0.93	3.00	-0.69	2.72	-0.55	2.49
II	-0.79	2.56	-0.69	2.74	-0.30	1.72
III	-0.49	1.97	-0.40	2.50	-0.08	1.51
IV	-0.40	2.08	-0.29	2.06	0.01	1.49
V	-0.31	1.86	-0.13	2.26	0.02	1.48
GA, d						
I	-2.33	12.24	-1.38	7.34	-0.92	3.74
II	-2.11	11.07	-1.38	7.40	-0.62	2.50
III	-1.84	11.25	-0.97	5.40	-0.59	2.76
IV	-1.67	12.03	-1.08	6.52	-0.37	2.20
V	-1.15	8.56	-1.00	7.64	-0.39	2.24
FGR						
I	-0.05	0.43	0.17	0.69	0.04	0.72
II	-0.01	0.32	0.17	0.68	0.07	0.64
III	0.07	0.19	0.33	0.50	0.21	0.50
IV	0.11	0.09	0.32	0.77	0.12	0.80
V	0.11	0.08	0.53	0.45	0.12	0.82

Table M.3 Comparison of mean BW, GA, and FGR in Caucasian, immigrant Chinese, and native Chinese infants of all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V), subjects without exclusion for discordant ultrasound- and LNMP-determined GA

	Caucasian	Immigrant Chinese	Native Chinese	F*
BW, g				
I	3318	3235	3124	213.0[a]
II	3389	3235	3136	221.9[a]
III	3425	3266	3164	263.7[a]
IV	3469	3276	3192	203.2[a]
V	3472	3339	3193	156.3[a]
GA, d				
I	277.0	275.9	278.9	19.9[a]
II	277.2	275.9	279.2	24.9[a]
III	278.1	276.5	279.8	25.7[a]
IV	279.0	277.0	280.0	16.2[a]
V	279.4	277.4	280.2	7.7[b]
FGR				
I	0.997	0.966	0.911	377.6[a]
II	0.998	0.966	0.911	383.2[a]
III	1.002	0.970	0.916	374.8[a]
IV	1.006	0.969	0.921	230.7[a]
V	1.003	0.982	0.921	180.5[a]

* One-way ANOVA for mean difference among Caucasian, immigrant Chinese, and native Chinese infants

[a] $P < 0.01$

[b] $P < 0.05$

Table M.4 Comparison of variation of BW, GA, and FGR in Caucasian, immigrant Chinese, and native Chinese infants of all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V), subjects without exclusion for discordant ultrasound- and LNMP-determined GA*

	Caucasian	Immigrant Chinese	Native Chinese	X^{2**}
BW, g				
I	576, 0.170	485, 0.150	474, 0.152	94.6[a]
II	560, 0.165	485, 0.150	455, 0.145	92.3[a]
III	512, 0.150	447, 0.137	431, 0.136	63.5[a]
IV	469, 0.137	430, 0.137	418, 0.132	14.4[a]
V	440, 0.130	427, 0.138	419, 0.132	1.2[c]
GA, d				
I	15.0, 0.054	13.8, 0.050	13.7, 0.049	22.8[a]
II	14.4, 0.052	13.8, 0.050	13.1, 0.047	16.4[a]
III	13.0, 0.047	12.8, 0.046	12.7, 0.045	1.0[c]
IV	11.8, 0.043	12.9, 0.046	12.5, 0.044	9.3[b]
V	11.0, 0.039	12.6, 0.045	12.5, 0.044	16.0[a]
FGR				
I	0.132, 0.133	0.128, 0.132	0.125, 0.137	-3.1[c]
II	0.131, 0.131	0.128, 0.132	0.124, 0.136	5.6[c]
III	0.128, 0.128	0.124, 0.127	0.121, 0.139	1.3[c]
IV	0.119, 0.119	0.118, 0.125	0.121, 0.133	1.2[c]
V	0.114, 0.117	0.122, 0.129	0.121, 0.133	4.3[c]

* Results are presented as SD, CV

** Bartlett's test for homogeneity among Caucasian, immigrant Chinese, and native Chinese

[a] $P < 0.01$

[b] $P < 0.05$

[c] $P > 0.05$

Table M.5 Comparison of dichotomized outcomes in Caucasian, immigrant Chinese, and native Chinese of all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V), subjects without exclusion for discordant ultrasound- and LNMP-determined GA

	Caucasian	Immigrant Chinese	Native Chinese	X^{2*}
% LBW				
I	5.6	5.4	7.0	6.5[b]
II	5.3	5.3	6.4	4.0[c]
III	3.5	3.3	4.9	9.3[b]
IV	2.1	2.9	4.2	17.4[a]
V	1.5	1.8	4.2	27.0[a]
% HBW				
I	11.2	4.3	1.8	228.5[a]
II	11.2	4.3	1.9	222.7[a]
II	11.5	4.3	2.0	214.2[a]
IV	11.8	4.2	1.7	137.0[a]
V	11.2	5.4	1.7	88.7[a]
% Preterm delivery				
I	7.1	8.1	6.2	4.7[c]
II	6.9	8.0	5.6	7.8[b]
III	5.3	6.8	4.8	7.2[b]
IV	4.0	6.2	4.0	9.9[a]
V	3.2	4.6	4.1	2.9[c]
% Postterm delivery				
I	7.1	6.2	10.3	28.7[a]
II	7.1	6.2	10.3	27.7[a]
III	7.3	6.2	10.5	27.0[a]
IV	7.2	6.7	11.6	25.1[a]
V	7.1	7.9	11.6	20.6[a]
% SGA				
I	12.0	16.9	30.4	491.9[a]
II	11.8	16.9	30.3	497.7[a]
III	10.8	15.7	29.3	496.6[a]
IV	8.4	14.9	27.6	330.6[a]
V	7.6	13.3	27.5	282.1[a]
% LGA				
I	12.1	8.3	3.4	141.7[a]
II	12.1	8.3	3.4	140.5[a]
III	12.3	8.4	3.5	134.2[a]
IV	11.8	7.2	3.5	75.9[a]
V	10.5	9.0	3.5	45.3[a]

* Chi-square test for differences of prevalences among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$; [b] $P < 0.05$; [c] $P > 0.05$

Table M.6 Sample sizes in all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V) among Caucasian, immigrant Chinese, and native Chinese infants, primiparas*

	Caucasian	Immigrant Chinese	Native Chinese
I	9166 (100.0)	746 (100.0)	1647 (100.0)
II	9123 (99.5)	744 (99.7)	1643 (99.8)
III	8383 (91.5)	680 (91.2)	1533 (93.1)
IV	3196 (40.5)	430 (62.5)	896 (56.5)
V	1672 (23.3)	141 (23.3)	874 (47.1)

* Results are given as number (percent)

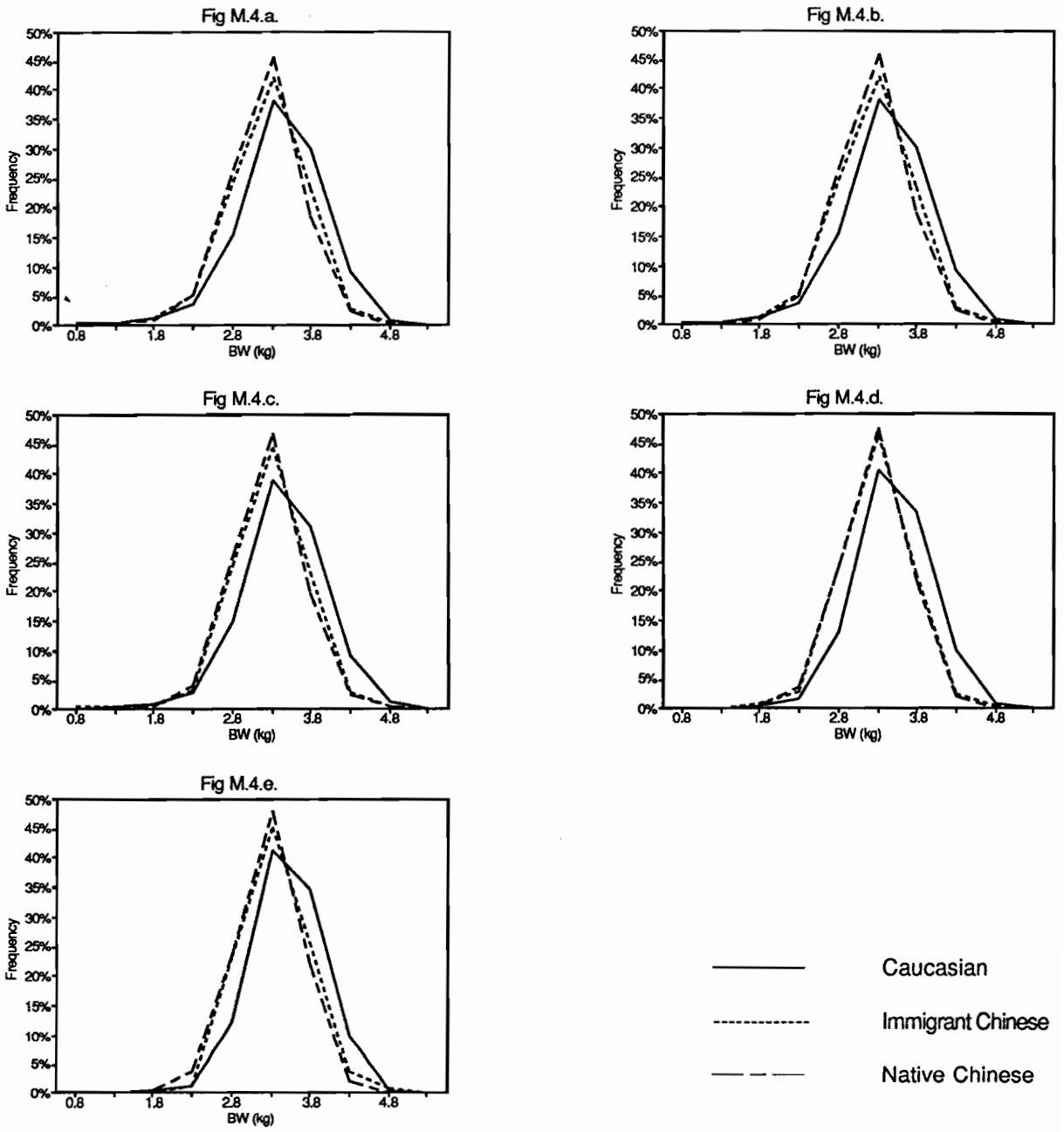


Figure M.4. BW distribution in Caucasian, immigrant Chinese, and native Chinese infants, primiparas without exclusion for discordant ultrasound- and LNMP-determined GA: a. all births; b. live births; c. singleton, live, non-malformed births to mothers without severe PIH; d. 'risk-free I' births; e. 'risk-free II' births

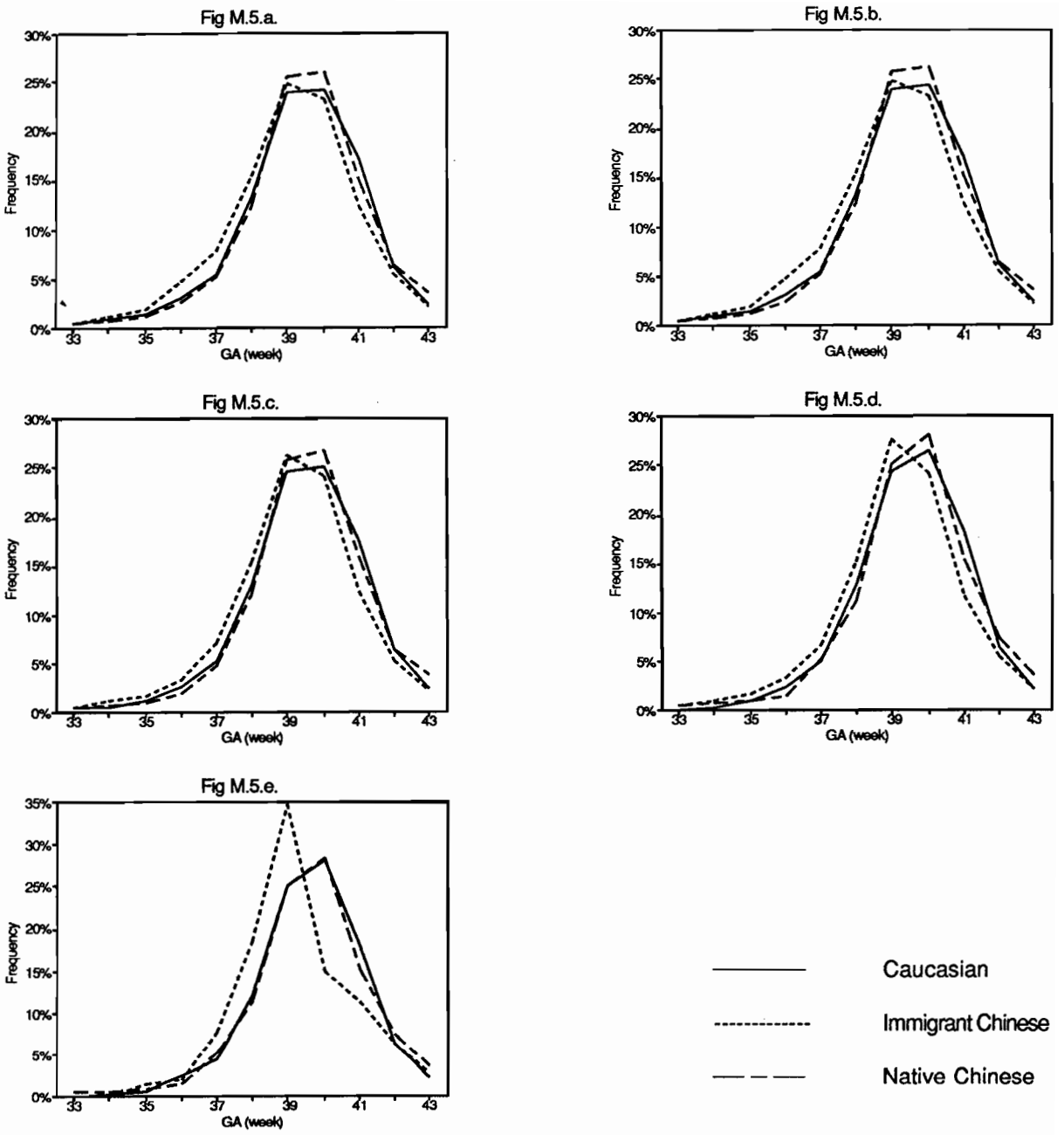


Figure M.5. GA distribution in Caucasian, immigrant Chinese, and native Chinese infants, primiparas without exclusion for discordant ultrasound- and LNMP-determined GA: a. all births; b. live births; c. singleton, live, non-malformed births to mothers without severe PIH; d. 'risk-free I' births; e. 'risk-free II' births

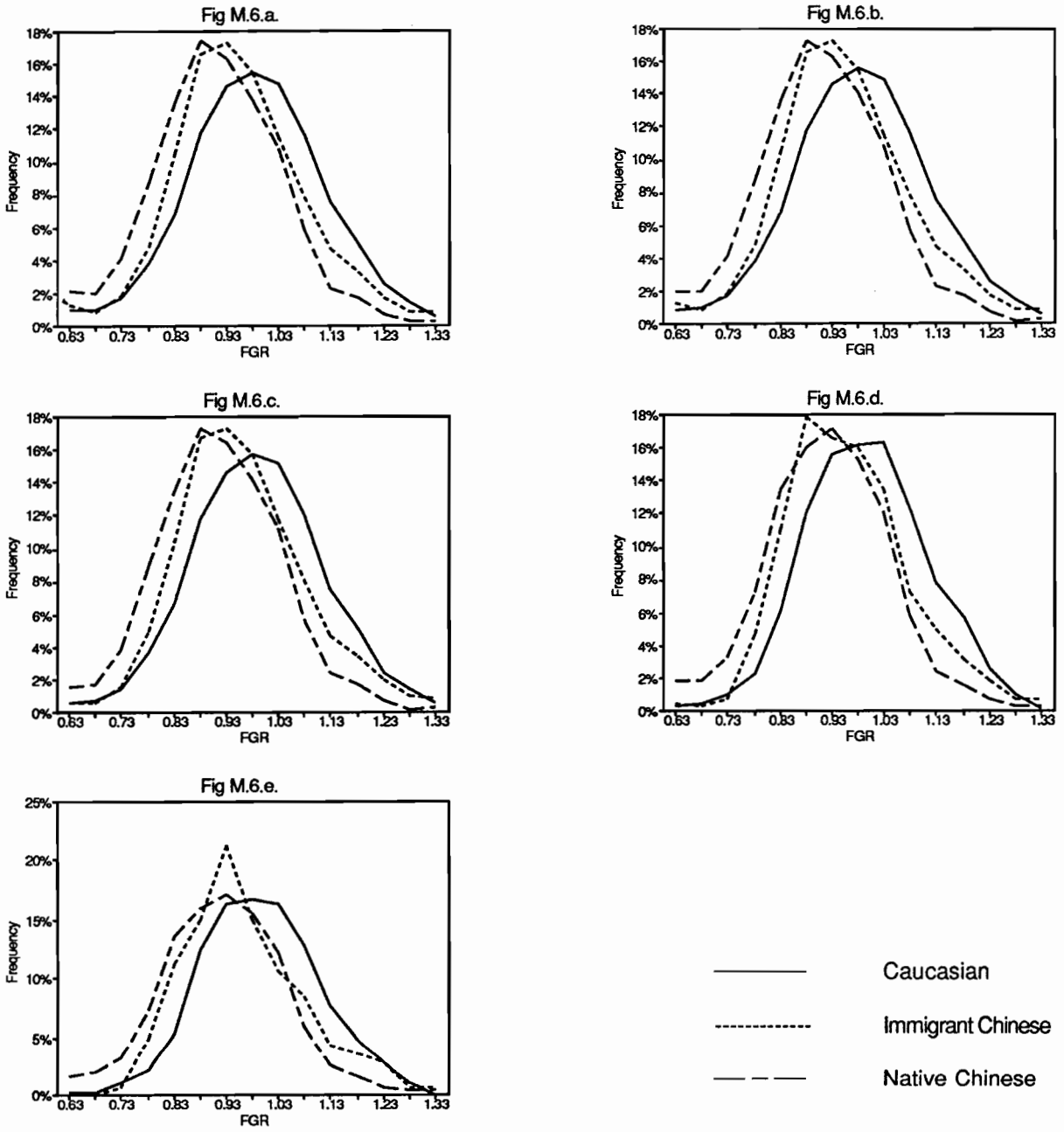


Figure M.6. FGR distribution in Caucasian, immigrant Chinese, and native Chinese infants, primiparas without exclusion for discordant ultrasound- and LNMP-determined GA: a. all births; b. live births; c. singleton, live, non-malformed births to mothers without severe PIH; d. 'risk-free I' births; e. 'risk-free II' births

Table M.7 Comparison of skewness and kurtosis coefficients for BW, GA, and FGR distributions among Caucasian, immigrant Chinese, and native Chinese infants of all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V), primiparas without exclusion for discordant GAs

	Caucasian		Immigrant Chinese		Native Chinese	
	Skewness	Kurtosis	Skewness	Kurtosis	Skewness	Kurtosis
BW, g						
I	-0.94	2.91	-0.86	3.12	-0.54	2.65
II	-0.83	2.59	-0.86	3.12	-0.25	1.70
III	-0.56	2.07	-0.67	3.43	-0.00	1.30
IV	-0.42	1.80	-0.45	2.72	0.02	1.63
V	-0.24	1.38	0.38	0.35	0.03	1.65
GA, d						
I	-2.18	10.56	-1.48	7.56	-0.98	4.18
II	-2.06	10.12	-1.48	7.56	-0.60	2.52
III	-1.76	9.69	-1.16	5.09	-0.55	2.62
IV	-1.55	10.09	-1.38	7.06	-0.28	1.93
V	-0.79	4.52	0.23	0.38	-0.31	1.96
FGR						
I	-0.06	0.50	0.17	0.90	0.04	0.80
II	-0.01	0.39	0.17	0.90	0.08	0.69
III	0.07	0.30	0.35	0.73	0.21	0.52
IV	0.09	0.06	0.42	1.10	0.12	0.83
V	0.08	0.05	0.79	0.73	0.12	0.83

Table M.8 Comparison of mean BW, GA, and FGR in Caucasian, immigrant Chinese, and native Chinese infants of all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V), primiparas without exclusion for discordant GAs

	Caucasian	Immigrant Chinese	Native Chinese	F*
BW, g				
I	3336	3172	3119	124.7[a]
II	3344	3172	3133	126.2[a]
III	3380	3209	3159	152.7[a]
IV	3424	3218	3185	117.6[a]
V	3436	3281	3187	96.3[a]
GA, d				
I	277.6	276.3	279.0	9.9[a]
II	277.8	276.3	279.4	13.4[a]
III	278.8	276.9	279.9	11.8[a]
IV	279.5	276.9	280.3	10.4[a]
V	280.1	277.8	280.2	3.4[a]
FGR				
I	0.981	0.949	0.909	218.0[a]
II	0.982	0.949	0.909	223.9[a]
III	0.986	0.954	0.913	218.8[a]
IV	0.991	0.955	0.919	130.9[a]
V	0.990	0.962	0.919	102.1[a]

* One-way ANOVA for mean difference among Caucasian, immigrant Chinese, and native Chinese infants

[a] $P < 0.01$

Table M.9 Comparison of variation of BW, GA, and FGR in Caucasian, immigrant Chinese, and native Chinese infants of all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V), primiparas without exclusion for discordant GAs*

	Caucasian	Immigrant Chinese	Native Chinese	X^{2**}
BW, g				
I	578, 0.173	493, 0.155	469, 0.150	70.6[a]
II	563, 0.168	493, 0.155	448, 0.143	78.0[a]
III	515, 0.152	452, 0.141	425, 0.135	50.2[a]
IV	474, 0.138	431, 0.146	418, 0.131	12.6[a]
V	438, 0.131	401, 0.139	418, 0.130	2.9[c]
GA, d				
I	15.4, 0.056	14.0, 0.051	13.4, 0.048	30.5[a]
II	15.0, 0.054	14.0, 0.051	12.6, 0.045	42.4[a]
III	13.5, 0.048	13.2, 0.048	12.3, 0.044	11.0[a]
IV	12.3, 0.044	13.2, 0.049	12.1, 0.043	2.6[c]
V	11.1, 0.040	10.9, 0.041	12.1, 0.043	5.0[b]
FGR				
I	0.132, 0.134	0.127, 0.134	0.123, 0.135	8.1[a]
II	0.130, 0.133	0.127, 0.134	0.122, 0.134	5.7[b]
III	0.127, 0.128	0.122, 0.128	0.119, 0.130	6.4[b]
IV	0.117, 0.119	0.118, 0.126	0.120, 0.131	1.5[c]
V	0.113, 0.118	0.121, 0.125	0.119, 0.130	2.6[c]

* Results are presented as SD, CV

** Bartlett's test for homogeneity among Caucasian, immigrant Chinese, and native Chinese

[a] $P < 0.01$; [b] $P < 0.05$; [c] $P > 0.05$

Table M.10 Comparison of dichotomized outcomes among Caucasian, immigrant Chinese, and native Chinese infants of all births (I), live births (II), singleton, live, non-malformed births to mothers without severe PIH (III), 'risk-free I' births (IV), and 'risk-free II' births (V), primiparas without exclusion for discordant GAs

	Caucasian	Immigrant Chinese	Native Chinese	X^{2*}
% LBW				
I	6.3	7.1	6.7	0.6[c]
II	6.0	7.1	6.1	1.9[c]
III	4.1	4.4	4.7	1.2[c]
IV	2.4	3.7	4.1	8.4[b]
V	1.6	1.4	4.1	16.0[a]
% HBW				
I	9.5	2.8	1.7	144.2[a]
II	9.6	2.8	1.7	144.5[a]
III	9.8	2.9	1.8	137.3[a]
IV	9.7	2.8	1.6	81.9[a]
V	9.6	4.3	1.6	60.2[a]
% Preterm delivery				
I	7.7	9.0	5.9	9.0[b]
II	7.4	9.0	5.3	13.0[a]
III	5.7	7.4	4.5	7.8[b]
IV	4.3	7.2	3.7	8.9[b]
V	3.5	3.5	3.8	0.3[c]
% Postterm delivery				
I	8.6	7.5	9.8	4.0[c]
II	8.6	7.5	9.9	4.2[c]
III	8.9	7.4	10.2	4.9[c]
IV	8.7	7.5	11.2	6.7[b]
V	8.7	9.2	11.1	3.9[c]
% SGA				
I	14.4	19.6	30.7	265.3[a]
II	14.2	19.6	30.6	263.8[a]
III	13.2	18.3	29.7	267.0[a]
IV	10.1	17.3	27.7	180.4[a]
V	9.2	17.0	27.6	147.8[a]
% LGA				
I	9.8	7.0	3.0	84.0[a]
II	9.9	7.0	3.0	84.1[a]
III	10.0	7.3	3.1	79.0[a]
IV	9.6	6.7	3.2	39.7[a]
V	8.6	8.5	3.1	28.1[a]

* Chi-square test for differences of prevalences among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$
[b] $P < 0.05$
[c] $P > 0.05$

Table M.11 Percent SGA in preterm, term, and postterm Caucasian, immigrant Chinese, and native Chinese infants, subjects without exclusion for discordant ultrasound- and LNMP-determined GA

	Caucasian (n=18,665)	Immigrant Chinese (n=1,579)	Native Chinese (n=1,862)	X^{2*}
Preterm	16.4	10.1	23.6	8.1[b]
Term	10.3	15.2	27.4	394.5[a]
Postterm	28.6	48.3	59.0	80.2[a]

* Chi-square test for difference of prevalence of SGA among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$
[b] $P < 0.05$

Table M.12 Percent SGA in preterm, term, and postterm Caucasian, immigrant Chinese, and native Chinese infants, primiparas without exclusion for discordant ultrasound- and LNMP-determined GA

	Caucasian (n=9,166)	Immigrant Chinese (n=746)	Native Chinese (n=1,647)	X^{2*}
Preterm	18.7	15.5	21.6	1.0[c]
Term	12.5	17.3	28.2	228.2[a]
Postterm	29.7	49.0	57.9	51.2[a]

* Chi-square test for difference of prevalence of SGA among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$
[b] $P < 0.05$

Table M.13 Mean BW and FGR as a function of GA in Caucasian, immigrant Chinese, native Chinese infants, subjects without exclusion for discordant ultrasound- and LNMP-determined GA*

GA, wk	Caucasian (n=18,665)		Immigrant Chinese (n=1,579)		Native Chinese (n=1,862)	
	BW	FGR	BW	FGR	BW	FGR
33	2090 (574)	0.973 (0.188)	2460 (655)	1.046 (0.104)	2045 (505)	1.010 (0.251)
34	2330 (554)	0.990 (0.192)	2848 (436)	1.172 (0.134)	2444 (483)	1.067 (0.176)
35	2617 (521)	1.031 (0.175)	2639 (409)	1.067 (0.160)	2440 (449)	0.959 (0.151)
36	2876 (506)	1.036 (0.161)	2793 (475)	1.020 (0.175)	2541 (603)	0.938 (0.184)
37	3050 (506)	1.012 (0.155)	3002 (476)	1.003 (0.143)	2861 (392)	0.956 (0.133)
38	3281 (439)	1.009 (0.131)	3204 (416)	0.985 (0.126)	3059 (408)	0.939 (0.113)
39	3451 (442)	1.010 (0.127)	3304 (387)	0.969 (0.112)	3173 (375)	0.929 (0.110)
40	3551 (423)	1.002 (0.118)	3397 (403)	0.959 (0.114)	3207 (404)	0.905 (0.114)
41	3620 (448)	0.979 (0.121)	3409 (357)	0.924 (0.098)	3294 (433)	0.891 (0.119)
42	3653 (474)	0.950 (0.123)	3398 (459)	0.883 (0.120)	3303 (446)	0.862 (0.105)

* Results are given as mean (SD)

Table M.14 Mean BW and FGR as a function of GA in Caucasian, immigrant Chinese, and native Chinese infants, primiparas without exclusion for discordant ultrasound- and LNMP-determined GA*

GA, wk	Caucasian (n=9,166)		Immigrant Chinese (n=746)		Native Chinese (n=1,647)	
	BW	FGR	BW	FGR	BW	FGR
33	2153(659)	0.962(0.189)	2463(342)	1.149(0.085)	2045(505)	1.010(0.251)
34	2256(552)	0.960(0.198)	2736(405)	1.152(0.126)	2627(442)	1.138(0.159)
35	2549(523)	1.009(0.174)	2588(377)	1.040(0.150)	2383(451)	0.929(0.138)
36	2823(452)	1.032(0.157)	2735(523)	0.996(0.193)	2563(617)	0.948(0.180)
37	2980(487)	0.992(0.153)	2957(511)	1.001(0.150)	2847(384)	0.949(0.131)
38	3227(447)	0.992(0.133)	3096(391)	0.955(0.121)	3032(400)	0.931(0.109)
39	3385(441)	0.991(0.127)	3264(409)	0.956(0.117)	3159(375)	0.925(0.110)
40	3505(415)	0.989(0.117)	3293(369)	0.929(0.103)	3210(405)	0.906(0.114)
41	3585(441)	0.970(0.119)	3449(305)	0.934(0.083)	3271(430)	0.884(0.118)
42	3624(473)	0.942(0.124)	3367(500)	0.875(0.131)	3305(448)	0.863(0.103)

* Results are given as mean (SD)

Table M.15 Relationship between selected maternal and infant determinants and BW (g) in Caucasian, immigrant Chinese, native Chinese, subjects without exclusion for discordant ultrasound- and LNMP-determined GA*

	Caucasian	Immigrant Chinese	Native Chinese
Infant sex			
Male	3489 (519)	3324 (438)	3231 (428)
Female	3364 (497)	3210 (450)	3094 (423)
Age, y			
< 20	3308 (511)	3283 (401)	2910 (541)
20 - 29	3409 (508)	3229 (438)	3167 (426)
30 - 34	3459 (497)	3326 (435)	3101 (418)
>= 35	3443 (558)	3279 (511)	3218 (663)
Marital status			
Married	3454 (497)	3265 (448)	3164 (431)
Unmarried	3288 (559)	3297 (446)	3231 (372)
Parity			
Nulliparous	3381 (515)	3209 (452)	3159 (425)
Multiparous	3469 (505)	3315 (438)	3206 (475)
Education, y completed			
0 - 10	3323 (549)	3274 (423)	3148 (434)
11 - 12	3414 (514)	3249 (455)	3162 (424)
13 - 16	3464 (490)	3256 (484)	3222 (432)
>= 17	3490 (478)	3304 (413)	3106 (384)
Smoking, cigarette/d			
0	3485 (496)	3268 (444)	**
1 - 9	3350 (532)	3215 (364)	**
10 - 19	3259 (513)	3216 (337)	**
>= 20	3233 (521)	3487 (539)	**
Alcohol consumption			
No	3425 (510)	3271 (446)	**
Occasionally	3433 (510)	3234 (460)	**
>= 1 drink/d	3272 (623)	**	**
Social drug use			
No	3429 (510)	**	**
Yes	3093 (548)	**	**
Diabetes			
No	3422 (509)	3261 (440)	**
Yes	3507 (568)	3414 (603)	**
Height, cm			
< 151	3200 (539)	3166 (414)	3016 (425)
151 - 160	3365 (490)	3258 (438)	3113 (433)
161 - 169	3456 (493)	3402 (449)	3240 (416)
>= 170	3566 (513)	3411 (472)	3322 (399)
Prepregnancy BMI			
< 17.8	3232 (518)	3153 (371)	2989 (447)
17.8 - < 19.8	3334 (484)	3245 (465)	3140 (395)
19.8 - < 26.0	3464 (486)	3359 (450)	3204 (436)
>= 26.0	3533 (524)	3461 (563)	3313 (438)
Net Wt gain, Kg/week			
< 0.15	3367 (520)	3217 (468)	3094 (416)
0.15 - < 0.30	3424 (470)	3276 (432)	3156 (433)
0.30 - < 0.40	3457 (500)	3320 (429)	3296 (421)
>= 0.40	3521 (511)	3428 (524)	3254 (453)

* Results are given as mean (SD)
** Incalculable (no subjects in this category) or calculation meaningless (no subjects in the comparison category)

Table M.16 Relationship between selected maternal and infant determinants and BW as dichotomized variables in Caucasian, immigrant Chinese, native Chinese, subjects without exclusion for discordant ultrasound- and LNMP-determined GA*

	Caucasian		Immigrant Chinese		Native Chinese	
	LBW	HBW	LBW	HBW	LBW	HBW
Infant sex						
Male	3.2	14.4	2.6	5.6	4.1	3.0
Female	3.9	8.5	4.0	3.1	5.7	1.0
Age, y						
< 20	4.8	6.2	0.0	0.0	20.0	0.0
20 - 29	3.5	10.9	3.5	3.0	4.7	1.8
30 - 34	2.9	12.4	2.1	6.7	4.9	1.2
>= 35	5.1	13.3	2.9	4.1	10.7	14.3
Marital status						
Married	2.8	12.1	3.4	4.3	4.9	1.2
Unmarried	7.0	8.4	0.0	7.0	0.0	0.0
Parity						
Nulliparous	4.1	9.8	4.4	2.9	4.7	1.8
Multiparous	3.0	13.1	2.4	5.6	6.2	3.1
Education, y completed						
0 - 10	6.2	8.7	2.5	4.7	5.4	1.7
11 - 12	3.5	11.3	4.6	4.0	4.8	1.4
13 - 16	2.7	12.3	4.4	3.8	3.6	3.9
>= 17	2.1	12.9	0.7	5.8	3.7	0.0
Smoking, cigarettes/d						
0	2.5	13.3	3.3	4.2	**	**
1 - 9	4.5	9.6	0.0	0.0	**	**
10 - 19	5.9	6.9	0.0	0.0	**	**
>= 20	7.5	5.1	0.0	16.7	**	**
Alcohol consumption						
No	3.4	11.3	3.1	4.1	**	**
Occasionally	3.5	11.9	3.8	6.3	**	**
>= 1 drink/d	8.2	10.6	**	**	**	**
Social drug use						
No	3.4	11.6	**	**	**	**
Yes	13.1	4.6	**	**	**	**
Diabetes						
No	3.4	11.3	3.1	4.2	**	**
Yes	4.6	18.7	4.1	16.3	**	**
Height, cm						
< 151	7.6	5.9	3.6	2.4	8.9	1.8
151 - 168	3.9	8.8	3.7	3.6	6.2	1.2
161 - 169	2.9	11.8	2.0	7.6	2.9	3.1
>= 170	2.2	18.2	0.0	15.4	0.0	2.6
Prepregnancy BMI						
< 17.8	7.5	6.7	2.8	1.4	8.4	0.0
17.8 - < 19.8	4.1	8.1	4.7	3.2	5.2	0.8
19.8 - < 26.0	2.5	11.9	2.4	6.7	4.2	2.8
>= 26.0	3.1	17.8	11.5	15.4	0.0	8.7
Net Wt gain, kg/week						
< 0.15	5.1	9.5	8.5	2.1	6.5	1.3
0.15 - < 0.30	2.6	10.4	2.7	5.0	5.1	1.7
0.30 - < 0.40	2.6	13.0	1.2	3.7	4.2	1.8
>= 0.40	2.6	15.7	1.3	11.7	2.6	4.7

* Conventional definition (<2500 and >4000 for LBW and HBW respectively)
** Incalculable (no subjects in this category) or calculation meaningless (no subjects in the comparison category)

Table M.17 Relationship between selected maternal and infant determinants and GA (d) in Caucasian, immigrant Chinese, native Chinese, subjects without exclusion for discordant ultrasound- and LNMP-determined GA*

	Caucasian	Immigrant Chinese	Native Chinese
Infant sex			
Male	277.6 (13.1)	276.1 (12.5)	279.8 (11.9)
Female	278.6 (12.9)	276.8 (13.2)	279.8 (13.5)
Age, y			
< 20	277.7 (13.9)	273.3 (18.9)	268.8 (31.0)
20 - 29	278.6 (13.3)	277.2 (13.8)	279.8 (12.7)
30 - 34	278.0 (11.8)	277.2 (13.8)	279.0 (9.9)
>= 35	276.0 (14.3)	272.8 (11.5)	283.3 (13.7)
Marital status			
Married	278.4 (12.3)	276.4 (12.9)	279.8 (12.7)
Unmarried	276.4 (16.3)	277.7 (12.6)	280.7 (12.4)
Parity			
Nulliparous	278.8 (13.5)	276.9 (13.2)	279.9 (12.3)
Multiparous	277.5 (12.5)	276.1 (12.5)	279.1 (15.4)
Education, y completed			
0 - 10	276.3 (15.6)	277.1 (12.7)	280.4 (13.9)
11 - 12	278.0 (12.9)	276.0 (13.9)	279.5 (11.1)
13 - 16	278.7 (12.4)	275.7 (12.9)	278.8 (11.0)
>= 17	278.9 (11.5)	277.2 (10.7)	277.2 (11.4)
Smoking, cigarette/d			
0	278.5 (12.5)	276.5 (12.8)	**
1 - 9	277.3 (13.6)	277.7 (7.8)	**
10 - 19	276.9 (12.9)	271.8 (6.7)	**
>= 20	277.0 (15.5)	276.6 (13.6)	**
Alcohol consumption			
No	277.9 (13.1)	276.5 (12.8)	**
Occasionally	278.5 (12.7)	273.9 (12.5)	**
>= 1 drink/d	277.4 (16.5)	**	**
Social drug use			
No	278.1 (12.9)	**	**
Yes	276.3 (18.1)	**	**
Diabetes			
No	278.3 (13.0)	276.5 (12.8)	**
Yes	273.7 (11.9)	274.5 (14.5)	**
Height, cm			
< 151	275.6 (14.7)	276.9 (11.4)	282.1 (16.7)
151 - 160	278.0 (12.7)	276.3 (12.8)	279.5 (13.3)
161 - 169	278.6 (12.2)	277.0 (12.3)	280.1 (11.6)
>= 170	278.5 (12.9)	277.1 (11.3)	279.1 (11.0)
Prepregnancy BMI			
<17.8	277.6 (12.2)	275.1 (11.2)	276.3 (13.7)
17.8-<19.8	277.7 (12.6)	277.1 (12.5)	279.5 (12.9)
19.8-<26.0	278.8 (12.3)	277.1 (13.3)	280.5 (12.4)
>= 26.0	278.1 (12.2)	276.8 (9.2)	282.2 (10.4)
Net Wt gain, kg/week			
< 0.15	278.1 (13.1)	278.0 (15.0)	280.7 (13.2)
0.15 - <0.30	279.1 (11.3)	277.1 (12.2)	280.3 (13.1)
0.30 - <0.40	278.3 (12.7)	275.0 (12.8)	279.1 (11.6)
>= 0.40	278.0 (12.7)	277.6 (13.7)	277.4 (11.8)

* Results are given as mean (SD)
** Both mean and SD are incalculable (no subjects in this category) or calculation meaningless (no subjects in the comparison category)

Table M.18 Relationship between selected maternal and infant determinants and gestational age as dichotomized variables in Caucasian, immigrant Chinese, native Chinese, subjects without exclusion for discordant ultrasound- and LNMP-determined GA

	Caucasian		Immigrant Chinese		Native Chinese	
	Preterm, % yes	Postterm, % yes	Preterm, % yes	Postterm, % yes	Preterm, % yes	Postterm, % yes
Infant sex						
Male	5.6	7.0	6.3	6.2	4.0	9.9
Female	4.9	7.7	7.2	6.2	5.6	11.0
Age, y						
< 20	7.0	7.8	25.0	0.0	20.0	0.0
20 - 29	5.1	8.5	6.1	6.7	5.0	10.8
30 - 34	4.9	6.1	5.0	4.8	1.2	3.7
>= 35	6.9	4.9	8.9	2.4	3.6	10.7
Marital status						
Married	4.5	7.0	6.8	6.1	4.7	10.5
Unmarried	9.3	8.9	6.3	9.4	7.1	7.1
Parity						
Nulliparous	5.7	8.9	7.4	7.4	4.4	10.2
Multiparous	4.8	5.8	6.2	5.1	7.4	12.8
Education, y completed						
0 - 10	9.0	8.9	5.9	6.4	5.6	13.3
11 - 12	5.1	7.6	10.0	7.0	3.7	8.2
13 - 16	4.5	7.2	7.0	6.0	3.9	5.8
>= 17	3.8	6.8	4.3	5.0	7.4	7.4
Smoking, cigarettes/d						
0	4.6	7.3	6.8	6.3	**	**
1 - 9	6.5	6.4	0.0	0.0	**	**
10 - 19	6.4	6.6	0.0	0.0	**	**
>= 20	7.6	8.7	20.0	0.0	**	**
Alcohol consumption						
No	5.5	7.1	6.9	6.3	**	**
Occasionally	4.7	7.9	12.7	5.6	**	**
>= 1 drink/d	4.1	6.8	**	**	**	**
Social drug use						
No	5.1	7.3	**	**	**	**
Yes	11.8	11.8	**	**	**	**
Diabetes						
No	5.2	7.5	6.7	6.2	**	**
Yes	7.4	4.2	9.3	7.0	**	**
Height, cm						
< 151	8.7	8.3	5.4	5.4	7.1	16.1
151 - 160	5.6	6.6	7.1	5.8	5.3	10.4
161 - 169	4.4	7.5	5.0	6.1	4.0	10.3
>= 170	5.1	7.5	0.0	8.3	2.6	7.9
Prepregnancy BMI						
<17.8	5.4	7.6	5.3	3.8	7.8	3.0
17.8-<19.8	5.5	7.1	6.6	8.8	4.5	9.9
19.8-<26.0	4.6	7.3	5.9	6.2	4.3	12.0
>=26.0	5.1	7.6	8.7	0.0	9.1	9.1
Net Wt gain, kg/week						
<0.15	5.5	7.6	8.5	9.6	5.2	13.9
0.15-<0.30	3.6	7.6	5.9	6.6	4.2	12.0
0.30-<0.40	4.7	7.2	5.6	5.6	4.7	7.4
>=0.40	6.7	7.2	7.8	7.8	7.3	5.2

** Incalculable (no subjects in this category) or calculation meaningless (no subjects in the comparison category)

Table M.19 Relationship between selected maternal and infant determinants and FGR in Caucasian, immigrant Chinese, native Chinese, subjects without exclusion for discordant ultrasound- and LNMP-determined GA*

	Caucasian	Immigrant Chinese	Native Chinese
Infant sex			
Male	1.023 (0.127)	0.988 (0.122)	0.933 (0.122)
Female	0.980 (0.125)	0.953 (0.123)	0.897 (0.117)
Age, y			
< 20	0.974 (0.133)	1.094 (0.295)	0.842 (0.178)
20 - 29	0.994 (0.127)	0.960 (0.134)	0.917 (0.120)
30 - 34	1.010 (0.126)	0.984 (0.122)	0.900 (0.120)
>= 35	1.021 (0.134)	1.009 (0.140)	0.909 (0.171)
Marital status			
Married	1.006 (0.126)	0.969 (0.124)	0.916 (0.121)
Unmarried	0.979 (0.137)	1.002 (0.120)	0.926 (0.121)
Parity			
Nulliparous	0.986 (0.127)	0.954 (0.122)	0.913 (0.119)
Multiparous	1.017 (0.127)	0.984 (0.133)	0.934 (0.137)
Education, y completed			
0 - 10	0.986 (0.135)	0.966 (0.122)	0.908 (0.123)
11 - 12	0.998 (0.129)	0.966 (0.129)	0.916 (0.114)
13 - 16	1.007 (0.129)	0.976 (0.123)	0.938 (0.122)
>= 17	1.012 (0.121)	0.971 (0.118)	0.916 (0.104)
Smoking, cigarettes/d			
0	1.015 (0.124)	0.971 (0.123)	**
1 - 9	0.988 (0.133)	0.959 (0.128)	**
10 - 19	0.960 (0.129)	0.926 (0.048)	**
>= 20	0.958 (0.131)	1.090 (0.060)	**
Alcohol consumption			
No	1.002 (0.127)	0.971 (0.124)	**
Occasionally	1.001 (0.129)	0.992 (0.121)	**
>= 1 drink/d	0.977 (0.152)	**	**
Social drug use			
No	1.002 (0.128)	**	**
Yes	0.932 (0.129)	**	**
Diabetes			
No	1.000 (0.127)	0.968 (0.121)	**
Yes	1.049 (0.136)	1.036 (0.171)	**
Height, cm			
< 151	0.960 (0.131)	0.930 (0.137)	0.856 (0.123)
151 - 160	0.985 (0.125)	0.971 (0.121)	0.904 (0.117)
161 - 169	1.007 (0.126)	0.999 (0.123)	0.934 (0.122)
>= 170	1.038 (0.124)	1.013 (0.175)	0.968 (0.126)
Prepregnancy BMI			
< 17.8	0.952 (0.130)	0.936 (0.109)	0.888 (0.112)
17.8 - < 19.8	0.978 (0.123)	0.958 (0.124)	0.909 (0.117)
19.8 - < 26.0	1.007 (0.123)	0.991 (0.115)	0.923 (0.123)
>= 26.0	1.029 (0.136)	1.033 (0.132)	0.957 (0.113)
Net Wt gain, kg/week			
< 0.15	0.983 (0.133)	0.947 (0.124)	0.891 (0.113)
6.5 - < 12.5	0.991 (0.122)	0.966 (0.125)	0.909 (0.122)
12.5 - < 17.5	1.007 (0.125)	0.990 (0.124)	0.931 (0.118)
>= 17.5	1.028 (0.132)	0.996 (0.141)	0.953 (0.118)

* Results are given as mean(SD)
** Both mean and SD are incalculable (no subjects in this category) or calculation meaningless (no subjects in the comparison category)

Table M.20 Relationship between selected maternal and infant determinants and FGR as dichotomized variables in Caucasian, immigrant Chinese, and native Chinese, subjects without exclusion for discordant ultrasound- and LNMP-determined GA

	Caucasian		Immigrant Chinese		Native Chinese	
	SGA	LGA	SGA	LGA	SGA	LGA
Infant sex						
Male	8.0	15.7	12.3	9.2	25.0	4.0
Female	13.8	8.8	19.0	7.6	33.0	2.9
Age, y						
< 20	14.9	8.2	0.0	0.0	50.0	0.0
20 - 29	11.7	10.9	16.9	5.6	28.1	3.3
30 - 34	9.5	13.5	11.1	8.2	39.0	2.4
>= 35	9.4	16.4	8.9	14.8	42.9	14.3
Marital status						
Married	9.7	12.6	15.6	8.3	29.4	3.4
Unmarried	16.8	10.2	18.8	9.4	23.1	7.7
Parity						
Nulliparous	13.2	10.0	18.3	7.3	29.7	3.1
Multiparous	8.5	14.5	13.4	9.3	26.7	6.4
Education, y completed						
0 - 10	15.3	10.3	16.7	6.4	32.0	3.1
11 - 12	11.6	11.9	18.7	7.0	26.6	2.5
13 - 16	9.2	12.8	13.9	6.0	24.8	6.1
>= 17	8.6	12.7	13.6	5.0	33.3	0.0
Smoking, cigarette/d						
0	8.3	13.7	15.7	8.4	**	**
1 - 9	12.1	10.7	20.0	10.0	**	**
10 - 19	19.5	7.5	0.0	0.0	**	**
>= 20	20.3	7.5	0.0	0.0	**	**
Alcohol consumption						
No	10.7	12.3	15.7	8.6	**	**
Occasionally	11.0	12.2	19.7	8.5	**	**
>= 1 drink/d	20.5	13.7	**	**	**	**
Social drug use						
No	10.8	12.3	**	**	**	**
Yes	27.5	3.7	**	**	**	**
Diabetes						
No	11.0	11.9	15.8	7.5	**	**
Yes	6.6	20.9	14.0	32.6	**	**
Height, cm						
< 151	18.5	7.3	28.8	12.3	48.2	3.6
151 - 160	13.2	10.0	15.1	7.0	32.3	2.5
161 - 169	9.5	12.1	10.2	11.3	23.4	4.6
>= 170	6.4	17.1	16.7	16.7	15.8	5.3
Prepregnancy BMI						
<17.8	21.9	6.7	20.9	3.9	39.5	3.0
17.8-<19.8	14.1	8.1	17.6	8.8	31.4	2.3
19.8-<26.0	9.2	12.1	13.1	9.9	26.1	4.0
>= 26.0	8.0	18.1	4.4	30.4	18.2	4.6
Net Wt gain, kg/week						
< 0.15	15.4	9.9	22.3	5.3	34.8	0.7
0.15 - < 0.30	11.2	10.0	17.9	9.2	31.7	3.0
0.30 - < 0.40	9.6	12.9	10.7	8.8	25.5	4.7
>= 0.40	7.6	16.6	12.0	14.7	17.5	7.4

** Incalculable (no subjects in this category) or calculation meaningless (no subjects in the comparison category)

Table M.21 Results of separate multiple linear regression for Caucasian, immigrant Chinese, and native Chinese infants, subjects without exclusion for discordant ultrasound- and LNMP-determined GA

	Caucasian		Immigrant Chinese		Native Chinese	
	b^*(95% C.I.)	r^2	b^*(95% C.I.)	r^2	b^*(95% C.I.)	r^2
BW, g						
A	-2(-4, +1)	.000	9(-1, +18)	.005	0(-8, +8)	.000
B	-130(-113,-148)	.017	-60(-133, +13)	.004	-125(-86,-164)	.021
C	5(1, 8)	.001	0(-10, +10)	.000	7(-1, +13)	.002
D	-57(-33, -82)	.002	137(-80,+354)	.003	125(-99,+349)	.001
E	46(35, 56)	.006	36(-12, +84)	.004	30(-20, +80)	.001
F	-83(-75, -92)	.030	28(-167,+223)	.000	-	-
G	13(12, 14)	.029	16(9, 23)	.032	13(9, 17)	.019
H	32(20, 24)	.027	30(16, 44)	.030	42(33, 51)	.041
I	413(338, 488)	.023	496(139, 853)	.013	499(333, 665)	.019
GA, d						
A	-0.16(-0.10,-0.22)	.003	-0.13(-0.43,+0.16)	.002	0.12(-0.12,+0.36)	.001
B	0.93(0.46, 1.41)	.002	2.00(-2.43,+0.44)	.006	-0.11(-1.32,+1.01)	.000
C	0.12(0.03, 0.21)	.001	-0.04(-0.34,+0.26)	.000	-0.40(-0.18,-0.62)	.007
D	-1.34(-0.65,-2.03)	.001	4.34(-2.15,+9.98)	.003	0.78(-6.13,+7.68)	.000
E	-0.80(-0.52,-1.09)	.003	-1.00(-2.43,+0.44)	.003	-1.01(-2.57,+0.54)	.001
F	-0.48(-0.25,-0.72)	.002	-1.45(-7.38,+4.19)	.000	-	-
G	0.05(0.01, 0.09)	.001	-0.01(-0.22,+0.21)	.000	0.01(-0.12,+0.14)	.000
H	0.08(0.01, 0.14)	.001	0.20(-0.32,+0.62)	.002	0.28(-0.01,+0.58)	.002
I	-3.24(-1.25,-5.23)	.005	-6.07(-9.99,+4.51)	.002	-6.20(-1.00,-11.4)	.003
FGR						
A	.001(.000, .001)	.000	.002(-.001,+.005)	.004	-.001(-.004,+.001)	.001
B	-.020(-.018,-.022)	.031	-.027(-.050,+.005)	.009	-.033(-.022,-.045)	.017
C	.000(-.001,+.001)	.000	.000(-.003,+.003)	.000	.004(.002, .006)	.007
D	-.007(-.000,-.014)	.000	.003(-.065,+.070)	.000	.029(-.039,+.097)	.000
E	.018(.016, .021)	.015	.025(.010, .040)	.018	.020(.004, .035)	.004
F	-.020(-.018,-.022)	.025	.014(-.046,+.075)	.000	-	-
G	.003(.003, .004)	.027	.005(.003, .007)	.030	.003(.002, .005)	.015
H	.005(.005, .006)	.024	.007(.003, .011)	.017	.010(.007, .013)	.026
I	.157(.135, .178)	.015	.202(.092, .313)	.022	.184(.134, .234)	.028

A. Maternal age: exact year.
B. Infant's sex: female=1, male=0.
C. Maternal education: completed years of schooling.
D. Mother's marital status: unmarried=1, currently married=0.
E. Parity: exact number of parity.
F. Maternal smoking during pregnancy: none=0, 1-9=1, 10-19=2, equal or more than 20=3.
G. Maternal height: in cm.
H. Prepregnancy BMI: prepregnancy weight/height^2 in kg/m^2.
I. Net gestational wt gain rate: (last weight before delivery - prepregnancy weight - BW)/GA in kg/week.

Table M.22 Slope (*b*) and 95% CI for BW, GA, and FGR for various determinants obtained from multiple linear regression models in which GA was not included as a determinant or an interaction term, subjects without exclusion for discordant ultrasound- and LNMP-determined GA

Determinants	BW	GA	FGR
A	-1(-3, +1)	-0.14(-0.08,-0.19)	.001(.000, .002)
B	-123(-106,-140)	0.84(0.39, 1.28)	-.041(-.037,-.045)
C	-54(-27, -81)	-1.43(-0.69,-2.17)	-.004(-.011,+.003)
D	5(2, 8)	0.04(-0.04,+0.11)	.001(.000, .002)
E	42(31, 54)	-0.77(-0.47,-1.08)	.017(.014, .020)
F	-79(-70, -88)	-0.53(-0.28,-0.78)	-.019(-.016,-.021)
G	13(12, 14)	0.06(0.02, 0.10)	.003(.003, .004)
H	22(20, 24)	0.08(0.02, 0.10)	.006(.005, .006)
I	416(350, 483)	-4.18(-2.37,-5.99)	.146(.129, .163)
J	66(25, 107)	1.98(0.86, 3.10)	.006(-.005,+.017)
K	-142(-97,-187)	2.11(0.89, 3.34)	-.052(-.041,-.064)

A. Maternal age: exact year
B. Infant's sex: female=1, male=0
C. Mother's marital status: unmarried=1, currently married=0
D. Maternal education: completed years of schooling
E. Parity: exact number of parity
F. Maternal smoking during pregnancy: none=0, 1-9=1, 10-19=2, equal or more than 20=3
G. Maternal height: in cm
H. Prepregnancy BMI: prepregnancy weight (in kg)/height^2 in kg/m^2
I. Net gestational wt gain: (last wt before delivery - prepregnancy wt - BW)/GA in kg/week
J. Mother's race: Caucasian=1, Chinese=0
K. Mother's current country of resident: China=1, Canada=0

Table M.23 Slope (*b*) and 95% CI for BW and FGR for various determinants obtained from stepwise multiple linear regression models in which GA was included both as a determinant and an interaction term (with mother's race), overall study sample

Determinants	BW	FGR
A	-0(-2, +2)	.000(-.000,+.001)
B	-126(-110,-142)	-.040(-.036,-.044)
C	-27(-2, -53)	-.005(-.012,+.002)
D	4(1, 6)	.001(.000, .002)
E	46(35, 56)	.016(.013, .019)
F	-74(-65, -83)	-.019(-.017,-.022)
G	12(11, 14)	.003(.003, .004)
H	22(20, 24)	.006(.005, .006)
I	459(396, 521)	.140(.123, .157)
J	54(15, 93)	.008(-.003,+.019)
K	-148(-106,-190)	-.050(-.039,-.061)
L	-611(-531,-691)	.100(.076, .121)
M	85(25, 145)	-.095(-.079,-.111)
N	-163(-73,-253)	-.042(-.017,-.067)
O	93(24, 161)	.023(.005, .041)

A. Maternal age: exact year
B. Infant's sex: female=1, male=0
C. Mother's marital status: unmarried=1, currently married=0
D. Maternal education: completed years of schooling
E. Parity: exact number of parity
F. Maternal smoking during pregnancy: none=0, 1-9=1, 10-19=2, equal or more than 20=3
G. Maternal height: in cm
H. Prepregnancy BMI: prepregnancy weight (in kg)/height^2 in kg/m^2
I. Net gestational wt gain: (last wt before delivery - prepregnancy wt - BW)/GA in kg/week
J. Mother's race: Caucasian=1, Chinese=0
K. Mother's current country of resident: China=1, Canada=0
L. GA I: preterm (<37 completed weeks)=1, term=0
M. GA II: Postterm (>= 42 completed weeks)=1, term=0
N. Interaction (preterm*mother's race)
O. Interaction (postterm*mother's race)

Table M.24 Odd ratios and 95% CI for LBW, preterm delivery, and SGA for various determinants obtained from stepwise multiple logistic regression models in which GA was not included as a determinant or an interaction term, subjects without exclusion for discordant ultrasound- and LNMP-determined GA

Determinants	LBW	Preterm delivery	SGA
A:			
1.	0.32(0.12,0.90)	0.92(0.52,1.62)	0.68(0.44,1.04)
2.	1.33(1.01,1.77)	0.96(0.77,1.21)	1.14(0.98,1.33)
3.	2.54(1.81,3.56)	1.35(1.01,1.82)	1.28(1.03,1.60)
B	1.30(1.04,1.61)	0.94(0.79,1.12)	1.74(1.55,1.96)
C	1.45(1.07,1.97)	1.79(1.39,2.29)	1.29(1.08,1.55)
D:			
1.	1.61(1.14,2.27)	1.69(1.27,2.24)	1.41(1.17,1.69)
2.	1.31(0.99,1.74)	1.12(0.89,1.41)	1.25(1.08,1.45)
3.	1.07(0.72,1.60)	1.10(0.81,1.49)	1.02(0.83,1.26)
E	1.45(1.14,1.86)	1.00(0.82,1.21)	1.79(1.56,2.05)
F:			
1.	2.66(1.74,4.07)	1.50(1.04,2.16)	1.41(1.06,1.88)
2.	2.53(1.73,3.67)	1.22(0.88,1.70)	2.65(2.15,3.27)
3.	2.72(1.93,3.81)	1.47(1.10,1.97)	2.54(2.09,3.10)
G:			
1.	1.94(1.13,3.33)	1.74(1.08,2.80)	2.30(1.71,3.10)
2.	1.55(1.23,1.97)	1.31(1.07,1.60)	1.47(1.29,1.66)
3.	0.62(0.40,0.95)	1.20(0.91,1.57)	0.67(0.54,0.84)
H:			
1.	2.35(1.63,3.40)	1.10(0.76,1.59)	2.32(1.88,2.85)
2.	1.54(1.19,1.99)	1.13(0.91,1.40)	1.54(1.34,1.76)
3.	0.76(0.51,1.14)	0.93(0.68,1.26)	0.65(0.51,0.82)
I:			
1.	2.12(1.52,2.95)	1.12(0.83,1.51)	1.88(1.56,2.28)
2.	1.08(0.82,1.42)	0.77(0.62,0.96)	1.23(1.07,1.42)
3.	0.92(0.64,1.32)	1.39(1.08,1.79)	0.67(0.54,0.82)
J	1.00(0.59,1.70)	0.70(0.47,1.04)	0.82(0.63,1.08)
K	1.69(0.97,2.92)	0.75(0.48,1.17)	2.32(1.75,3.07)

A. Maternal age (years): 1. <20; 2. 30-34; 3. >=35, 20-29 as the reference
B. Infant's sex: female vs male
C. Mother's marital status: unmarried vs currently married
D. Maternal education (years): 1. <11; 2.11-12; 3. 13-16, > 16 as the reference
E. Parity: first birth vs second or higher births
F. Maternal smoking during pregnancy (cigarettes/day): 1. 1-9; 2. 10-19; 3. >=20, none as the reference
G. Maternal height (cm): 1. <151; 2. 151-160; 3. >=170, 161-169 as the reference
H. Prepregnancy BMI (prepregnancy weight/height^2 in kg/m^2: 1. <17.8; 2. 17.8-<19.8; 3. 26.0-29.0; 4. >=29.0, 19.8-<26.0 as the reference
I. Net gestational wt gain rate (last wt before delivery - prepregnancy wt - BW)/GA in kg/week: 1. <6.5; 2. 6.5-<12.5; 3. >=17.5, 12.5-<17.5 as the reference
J. Mother's race: Caucasian vs Chinese
K. Mother's current country of resident: China vs Canada

Table M.25 Odds ratio and 95% CI for HBW, postterm delivery, and LGA for various determinants obtained from stepwise multiple logistic regression models in which GA was not included as a determinant or an interaction term, subjects without exclusion for discordant ultrasound- and LNMP-determined GA

Determinants	HBW	Postterm delivery	LGA
A:			
1.	0.55(0.28,1.07)	0.74(0.44,1.23)	1.23(0.73,2.08)
2.	0.98(0.84,1.14)	0.72(0.60,0.87)	1.12(0.97,1.30)
3.	1.10(0.90,1.35)	0.63(0.47,0.84)	1.51(1.24,1.83)
B	0.53(0.47,0.61)	1.09(0.95,1.25)	0.52(0.46,0.59)
C	0.98(0.79,1.22)	1.17(1.23,1.94)	1.03(0.83,1.28)
D			
1.	0.91(0.70,1.17)	1.54(1.23,1.94)	0.81(0.64,1.03)
2.	0.96(0.83,1.12)	1.11(0.93,1.33)	0.94(0.81,1.09)
3.	1.02(0.85,1.23)	1.11(0.88,1.40)	0.80(0.66,0.96)
E	0.72(0.63,0.82)	1.58(1.34,1.85)	0.62(0.54,0.71)
F:			
1.	0.69(0.52,0.93)	0.88(0.63,1.24)	0.73(0.55,0.98)
2.	0.51(0.39,0.67)	0.81(0.61,1.09)	0.42(0.32,0.57)
3.	0.45(0.34,0.60)	1.17(0.92,1.50)	0.53(0.41,0.69)
G:			
1.	0.37(0.20,0.66)	1.14(0.76,1.69)	0.53(0.32,0.87)
2.	0.66(0.57,0.77)	0.87(0.74,1.01)	0.74(0.64,0.86)
3.	1.65(1.41,1.94)	0.98(0.80,1.22)	1.47(1.25,1.74)
H:			
1.	0.44(0.29,0.66)	0.75(0.54,1.05)	0.53(0.37,0.76)
2.	0.64(0.54,0.77)	0.94(0.79,1.12)	0.63(0.53,0.76)
3.	1.95(1.64,2.33)	0.99(0.78,1.26)	1.90(1.59,2.27)
I:			
1.	0.50(0.38,0.65)	1.29(1.01,1.65)	0.47(0.36,0.61)
2.	0.78(0.67,0.91)	1.26(1.06,1.49)	0.72(0.62,0.84)
3.	1.30(1.09,1.56)	0.99(0.79,1.24)	1.41(1.19,1.68)
J	1.63(1.08,2.45)	1.15(0.80,1.24)	0.92(0.66,1.27)
K	0.38(0.23,0.65)	1.09(0.74,1.61)	0.43(0.29,0.65)

A. Maternal age (years): 1. <20; 2. 30-34; 3. >=35, 20-29 as the reference
B. Infant's sex: female vs male
C. Mother's marital status: unmarried vs currently married
D. Maternal education (years): 1. <11; 2.11-12; 3. 13-16, > 16 as the reference
E. Parity: first birth vs second or higher births
F. Maternal smoking during pregnancy (cigarettes/day): 1. 1-9; 2. 10-19; 3. >=20, none as the reference
G. Maternal height (cm): 1. <151; 2. 151-160; 3. >=170, 161-169 as the reference
H. Prepregnancy BMI (prepregnancy weight/height^2 in kg/m^2: 1. <17.8; 2. 17.8-<19.8; 3. 26.0-29.0; 4. >=29.0, 19.8-<26.0 as the reference
I. Net gestational wt gain rate (last wt before delivery - prepregnancy wt - BW)/GA in kg/week: 1. <6.5; 2. 6.5-<12.5; 3. >=17.5, 12.5-<17.5 as the reference
J. Mother's race: Caucasian vs Chinese
K. Mother's current country of resident: China vs Canada

Table M.26 Odds ratio and 95% CI for LBW, HBW, SGA, and LGA for various determinants obtained from stepwise multiple logistic regression models in which GA was included both as a determinant and an interaction term (with mother's race), subjects without exclusion for discordant ultrasound- and LNMP-determined GA

Determinants	LBW	HBW	SGA	LGA
A:				
1.	0.23(0.07,0.00)	0.53(0.27,1.03)	0.71(0.46,1.09)	1.26(0.74,2.14)
2.	1.49(1.08,2.04)	1.00(0.86,1.16)	1.20(1.03,1.40)	1.11(0.95,1.29)
3.	2.64(1.76,3.89)	1.16(0.95,1.42)	1.37(1.09,1.72)	1.45(1.19,1.76)
B	1.41(1.11,1.80)	0.52(0.46,0.59)	1.76(1.57,1.99)	0.52(0.46,0.59)
C	1.02(0.71,1.47)	1.01(0.82,1.26)	1.28(1.06,1.54)	1.00(0.80,1.24)
D				
1.	1.33(0.91,1.95)	0.92(0.71,1.20)	1.34(1.11,1.61)	0.78(0.61,1.00)
2.	1.29(0.94,1.77)	0.96(0.82,1.11)	1.25(1.07,1.46)	0.94(0.81,1.09)
3.	1.06(0.68,1.64)	1.02(0.85,1.23)	1.01(0.82,1.25)	0.79(0.66,0.96)
E	1.75(1.32,2.31)	0.69(0.60,0.80)	1.72(1.50,1.98)	0.63(0.54,0.72)
F:				
1.	2.57(1.57,4.19)	0.70(0.52,0.94)	1.45(1.09,1.94)	0.70(0.52,0.94)
2.	2.58(1.68,3.98)	0.52(0.39,0.68)	2.81(2.27,3.47)	0.41(0.30,0.55)
3.	2.81(1.90,4.16)	0.45(0.34,0.59)	2.57(2.10,3.15)	0.51(0.39,0.67)
G:				
1.	1.69(0.91,3.15)	0.36(0.20,0.66)	2.36(1.74,3.21)	0.51(0.31,0.84)
2.	1.48(1.13,1.93)	0.67(0.58,0.78)	1.53(1.34,1.74)	0.71(0.62,0.83)
3.	0.50(0.31,0.80)	1.68(1.43,1.97)	0.67(0.54,0.84)	1.48(1.25,1.75)
H:				
1.	2.82(1.85,4.29)	0.43(0.29,0.65)	2.52(2.04,3.11)	0.51(0.36,0.74)
2.	1.53(1.15,2.04)	0.64(0.53,0.77)	1.58(1.38,1.82)	0.62(0.52,0.75)
3.	0.74(0.47,1.16)	1.97(1.65,2.35)	0.64(0.50,0.81)	1.93(1.61,2.31)
I:				
1.	2.43(1.66,3.55)	0.49(0.38,0.64)	1.87(1.54,2.26)	0.46(0.36,0.60)
2.	1.25(0.92,1.70)	0.75(0.65,0.88)	1.20(1.03,1.38)	0.74(0.63,0.86)
3.	0.72(0.48,1.09)	1.34(1.12,1.60)	0.67(0.54,0.83)	1.38(1.16,1.65)
J	1.08(0.58,2.01)	1.49(0.98,2.25)	0.82(0.62,1.08)	1.08(0.76,1.54)
K	2.04(1.11,3.73)	0.37(0.22,0.64)	2.39(1.80,3.19)	0.45(0.29,0.69)
L	27.9(17.0,45.7)	0.00(0.00,0.00)	0.50(0.28,0.88)	8.38(4.94,14.2)
M	0.83(0.32,2.11)	1.38(0.62,3.12)	4.50(3.31,6.11)	0.13(0.02,0.96)
N	1.42(0.80,2.52)	99.6(0.00,>100)	1.45(0.72,2.92)	0.39(0.22,0.70)
O	0.47(0.12,1.85)	1.71(0.74,3.94)	0.85(0.59,1.22)	2.25(0.30,17.0)

A. Maternal age (years): 1. <20; 2. 30-34; 3. >=35, 20-29 as the reference
B. Infant's sex: female vs male
C. Mother's marital status: unmarried vs currently married
D. Maternal education (years): 1. <11; 2.11-12; 3. 13-16, > 16 as the reference
E. Parity: first birth vs second or higher births
F. Maternal smoking during pregnancy (cigarettes/day): 1. 1-9; 2. 10-19; 3. >=20, none as the reference
G. Maternal height (cm): 1. <151; 2. 151-160; 3. >=170, 161-169 as the reference
H. Prepregnancy BMI (prepregnancy weight/height^2 in kg/m^2: 1. <17.8; 2. 17.8-<19.8; 3. 26.0-29.0; 4. >=29.0, 19.8-<26.0 as the reference
I. Net gestational wt gain rate (last wt before delivery - prepregnancy wt - BW)/GA in kg/week: 1. <6.5; 2. 6.5-<12.5; 3. >=17.5, 12.5-<17.5 as the reference
J. Mother's race: Caucasian vs Chinese
K. Mother's current country of resident: China vs Canada
L. GA I: preterm(<37 completed weeks) vs term
M. GA II: Postterm(>= 42 completed weeks) vs term
N. Interaction (preterm*mother's race)
O. Interaction (postterm*mother's race)

APPENDIX N. COMPARISON OF CONCORDANCE OF ULTRASOUND- AND LNMP-DETERMINED GA AMONG CAUCASIAN, IMMIGRANT CHINESE, AND NATIVE CHINESE INFANTS

Table N.1 Comparison of mean difference between ultrasound- and LNMP-determined GA (LNMP_GA - ultrasound_GA) among Caucasian, immigrant Chinese, and native Chinese infants*

	Caucasian	Immigrant Chinese	Native Chinese	F**
Without exclusion by ± 10 day's criteria:				
Overall	3.94 (8.46)	4.25 (9.76)	5.43 (11.5)	12.1[a]
Preterm	-1.22 (13.9)	-1.90 (12.9)	2.33 (14.3)	1.6[c]
Term	3.45 (6.64)	3.59 (7.47)	4.08 (9.74)	2.9[c]
Postterm	15.19 (11.3)	22.78 (12.3)	20.22 (14.2)	16.8[a]
With exclusion by ± 10 day's criteria:				
Overall	2.36 (4.16)	1.67 (4.41)	2.24 (5.51)	9.1[a]
Preterm	1.72 (4.32)	1.24 (4.71)	0.29 (5.78)	1.8[c]
Term	2.34 (4.14)	1.71 (4.40)	2.25 (5.45)	6.8[a]
Postterm	4.31 (3.81)	1.29 (3.45)	4.86 (5.76)	2.3[c]

* Results are presented as mean (SD)
** One-way ANOVA for mean dofferences among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$
[c] $P > 0.05$

Table N.2 Comparison of proportion (%) that the LNMP-determined GA is larger than ultrasound-determined GA for 7-day or more among Caucasian, immigrant Chinese, and native Chinese infants*

	Caucasian	Immigrant Chinese	Native Chinese	X^{2**}
Without exclusion by ± 10 day's criteria:				
Overall	29.51	30.62	45.99	104.8[a]
Preterm	20.83	18.29	28.89	2.1[c]
Term	26.60	27.93	42.72	91.4[c]
Postterm	73.93	87.27	87.18	11.1[c]
With exclusion by ± 10 day's criteria				
Overall	18.10	15.35	29.78	55.0[a]
Preterm	15.14	11.86	16.13	0.5[c]
Term	17.78	15.83	29.49	48.9[a]
Postterm	32.68	0.00	57.14	8.9[b]

* Results are presented as percent
** Chi-square test for differences in proportions among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$
[b] $P < 0.05$
[c] $P > 0.05$

APPENDIX O. CESAREAN SECTION RATES IN CAUCASIAN, IMMIGRANT CHINESE, AND NATIVE CHINESE WOMEN

Table O.1. Comparison of cesarean section rates among Caucasian, immigrant Chinese, and native Chinese women

	Caucasian	Immigrant Chinese	Native Chinese	X^{2*}
Overall sample	21.0	18.7	23.2	10.5[a]
Subjects with concordant GAs	21.5	20.5	24.6	3.7[c]
Primiparas	22.1	21.4	22.4	0.3[c]

* Chi-square test for difference in prevalences among Caucasian, immigrant Chinese, and native Chinese

[a] $P < 0.01$

APPENDIX P. SELECTED PREGNANCY OUTCOMES (OTHER THAN BW, GA, AND FGR) IN CAUCASIAN, IMMIGRANT CHINESE, AND NATIVE CHINESE INFANTS

Table P.1. Comparison of selected pregnancy outcomes (other than BW, GA, and FGR) among Caucasian, immigrant Chinese, and native Chinese, overall study sample

	Caucasian (n=18,665)	Immigrant Chinese (n=1,597)	Native Chinese (n=1,862)	X^{2*}
% Multiple births	2.4	1.4	3.7	20.6[a]
% Congenital malformation	5.4	5.8	0.5	88.7[a]
% Fetal death	0.5	0.2	1.6	40.2[a]

* Chi-square test for difference in prevalences among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$

Table P.2. Comparison of selected pregnancy outcomes (other than BW, GA, and FGR) among Caucasian, immigrant Chinese, and native Chinese, subjects with concordant ultrasound- and LNMP-determined GA

	Caucasian (n=11,036)	Immigrant Chinese (n=723)	Native Chinese (n=581)	X^{2*}
% Multiple births	2.6	1.8	3.4	3.3[c]
% Congenital malformation	5.0	5.8	0.4	27.8[a]
% Fetal death	0.4	0.1	0.7	3.0[c]

* Chi-square test for difference in prevalences among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$
[c] $P > 0.05$

Table P.3. Comparison of selected pregnancy outcomes (other than BW, GA, and FGR) among Caucasian, immigrant Chinese, and native Chinese, primiparas

	Caucasian (n=9,166)	Immigrant Chinese (n=746)	Native Chinese (n=1,647)	X^{2*}
% Multiple births	2.4	1.7	3.2	5.7[c]
% Congenital malformation	5.4	6.2	0.5	77.1[a]
% Fetal death	0.5	0.1	1.5	27.0[a]

* Chi-square test for difference in prevalences among Caucasian, immigrant Chinese, and native Chinese
[a] $P < 0.01$
[c] $P > 0.05$