

Nutrition in Pregnancy and Growth in Southwest China (NPGSC) cohort: Design, implementation, and characteristics

Xiao Zhang¹ | Yunhui Gong² | Yue Chen¹ | Karen Della Corte³ | Ruonan Duan¹ | Guo Tian⁴ | Yi Liang^{4,5} | Hongmei Xue^{4,6} | Jieyi Zhang^{4,7} | Ming Li⁴ | Fang He⁴ | Dagang Yang⁵ | Rong Zhou² | Guo Cheng⁴ 

¹West China School of Public Health and West China Fourth Hospital, Sichuan University, Chengdu, China

²Key Laboratory of Birth Defects and Related Diseases of Women and Children (Sichuan University), Ministry of Education, West China Second University Hospital, Sichuan University, Chengdu, China

³Nutrition, Consumption and Health, Faculty of Natural Sciences, University Paderborn, Paderborn, Germany

⁴Laboratory of Molecular Translational Medicine, Centre for Translational Medicine, Key Laboratory of Birth Defects and Related Diseases of Women and Children (Sichuan University), Ministry of Education, West China Second University Hospital, Sichuan University, Chengdu, China

⁵Department of Clinical Nutrition, Affiliated Hospital of Guizhou Medical University, Guizhou Medical University, Guiyang, China

⁶College of Public Health, Hebei University, Baoding, China

⁷Sichuan Provincial Centre for Disease Control and Prevention, Chengdu, China

Correspondence

Guo Cheng, Laboratory of Molecular Translational Medicine, Centre for Translational Medicine, Key Laboratory of Birth Defects and Related Diseases of Women and Children (Sichuan University), Ministry of Education, West China Second University Hospital, Sichuan University, Chengdu, Sichuan, China.
Email: ehw_cheng@126.com

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Abstract

Background: Pregnancy and birth cohorts addressing maternal nutrition and its impact on health outcomes have been rare in China, especially in Southwest China.

Objectives: To describe the design, implementation, baseline characteristics, and initial results of the Nutrition in Pregnancy and Growth in Southwest China (NPGSC) cohort.

Population: Pregnant women with their children in Southwest China.

Design: NPGSC participants have been prospectively recruited since 2014. Pregnant women were invited to participate in the study at their first routine ultrasound examination in gestational weeks 9–11. Data were assessed three times during pregnancy (9–11, 20–22, and 33–35 gestation weeks), and eight times in infants and toddlers.

Methods: Pre-pregnancy body weight and height were self-reported; gestational weight gain was measured at regular intervals. Both food frequency questionnaires (FFQ) and 24-hour dietary recalls were used to collect dietary intakes during pregnancy, and FFQ for diet before pregnancy. Information on pregnancy outcomes was extracted from the medical birth registry. Anthropometry of children in the first 3 years of life was measured by trained investigators. Other child outcomes, including feeding practices (self-reported by mothers) and cognitive development (assessed by the Chinese version of Ages and Stages Questionnaire), were recorded.

Preliminary results: Between 2014 and 2018, 12 989 pregnant women were enrolled, and 2296 children completed the 3 years follow-up. Among them, 115 pregnancies ended in stillbirth. Mean maternal pre-pregnancy BMI was 21.1 kg/m² and mean gestational weight gain was 13.5 kg. 18.6% of mothers developed gestational diabetes and 1.5% of mothers were diagnosed with preeclampsia. Mean birthweight and birth length of children were, respectively, 3329 g and 49.4 cm.

Conclusion: We built a prospective cohort in Southwest China, which can provide valuable data to investigate the relevance of nutrition for the health of mothers and children.

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A commentary for this article appears on pages 734-735

KEYWORDS

cohort studies, infant health, NPGSC, nutrition surveys, pregnancy outcome

1 | BACKGROUND

Environmental exposures in fetal and infant life may have long-term programming effects on health.¹ Previous evidence has indicated that poor nutrition before and during pregnancy, including low dietary quality, low fibre intake, and a high glycaemic index, increases the risk of adverse pregnancy outcomes in mothers (eg anaemia, gestational hypertensive, and diabetic disorders)^{2,3} and infants (eg fetal death, pre-term birth, and macrosomia),⁴⁻⁶ as well as increasing a child's risks of chronic diseases in later life.^{7,8} Furthermore, higher maternal pre-pregnant body mass index and inappropriate gestational weight gain also yielded persistent effects on children's growth.⁹ However, most of the existing studies have been conducted in Western countries. Since the announcement of the universal two child policy, women giving birth in China are more likely to be older,¹⁰ which is related to adverse pregnancy outcomes.¹¹ Whether maternal age interacts with the associations between dietary factors and pregnancy outcome, as well as child growth and development remains unclear. Therefore, understanding the relevance of maternal nutrition and lifestyle practices before and during pregnancy for maternal health and child growth and development among the Chinese population is of major public health relevance.

To date, pregnancy and birth cohorts addressing maternal nutrition and its impact on health outcomes have been rare in China, especially in Southwest China. To fill this gap, the Nutrition in Pregnancy and Growth in Southwest China (NPGSC) cohort was initiated. The aim of this study is to describe the design features, implementation procedures, baseline characteristics, and initial results of the NPGSC cohort, in which the impact of maternal nutrition and lifestyle characteristics before and during pregnancy and in the 1st, 2nd, or 3rd trimester of pregnancy, on maternal health, birth outcomes, infant nutritional status, as well as subsequent physical and cognitive development of child were longitudinally investigated.

2 | METHODS

2.1 | Cohort selection

The NPGSC cohort was initiated in January 2014. Using a sampling design stratified by urban and rural locations, a representative sample of pregnant women and their children was drawn from public hospitals and community health care centres in Southwest China (Sichuan Province, Yunnan Province and Guizhou Province, Figure 1). Within

Synopsis

Study question

Is there any association between maternal nutrition and the health of mothers and their children in a Southwest Chinese population?

What's already known

Previous studies have shown that inadequate nutrition before and during pregnancy increased the risk of adverse outcomes in mothers and infants. However, pregnancy and birth cohorts addressing maternal nutrition and its impact on health outcomes have been rare in China, especially in Southwest China.

What this study adds

About 12 989 pregnant women and their children have been recruited in the Nutrition in Pregnancy and Growth in Southwest China cohort since 2014. Information on maternal nutrition, pregnancy outcomes, and growth of children followed up until 3 years was collected to provide evidence on the impact of maternal nutrition on maternal and child's health.

each urban area, 1-2 public hospitals or community health care centres were randomly selected, while 2-3 community health care centres were randomly selected within each rural area. At each site, a two-stage (obstetrician-person) sampling was used. At first, obstetricians within each site were listed by the human resources offices of the hospitals or the community health care centres, in each 5-20 obstetricians were randomly selected and invited. In each site, 1-3 obstetricians per hospital voluntarily approved to take part in. Until December 2018, 27 study sites (12 urban and 15 rural centres) with 51 obstetricians were ever involved, 11 sites and 22 obstetricians averagely remained in cohort per year. Secondly, all pregnant women cared for by the selected obstetricians were invited to participate. Whenever a woman refused or was unable to participate, a replacement pregnant woman was selected from another obstetrician who had already participated in the cohort of similar composition in the same site using simple random sampling method (6.2%). The replacements were used to ensure an adequate sample size within each selected site and to maximise the representativeness of the surveyed samples with regard to the distributions of age, educational and individual/family economic status. If the second



FIGURE 1 Location of the Nutrition in Pregnancy and Growth in Southwest China (NPGSC) study [Colour figure can be viewed at wileyonlinelibrary.com]

woman did not participate, a third woman was selected. At enrolment, all participants provided written informed consent for all examinations and for linkage of their data from the Medical Birth Registry and the data of their children from the health registries.

Pregnant women were invited to participate in the study at their first routine ultrasound examination in gestational weeks 9–11. To facilitate follow-up, only women who had lived in their current residence for at least 2 years and intended to live in the attachment area for the next 4 years were eligible.

Data collection was performed at the first routine ultrasound examination (phase 1; P1), at gestational weeks 20–22 (P2), at gestational weeks 33–35 (P3), and at 8 time points in infancy and childhood (Figure 2). At P1, each woman was asked to complete a self-administered questionnaire. And participants were interviewed by trained investigators with respect to their diet and physical activity at all three phases. Information on current and past pregnancy outcomes, complications, and infant abnormalities recorded in the Medical Birth Registry were linked to the study database. Children were scheduled to visit the health registries for medical examination and assessment of anthropometry when they were 3, 6, 12, 18, 24, 30, and 36 months old at public hospitals or community health care centres. At the first two visits, mothers were interviewed about feeding practices by trained investigators. At 12, 24, and 36 months, blood samples were collected for medical examination.

2.2 | Ethics approval

The study was approved by the Ethics Committee of the Sichuan University.

2.3 | Data assessment

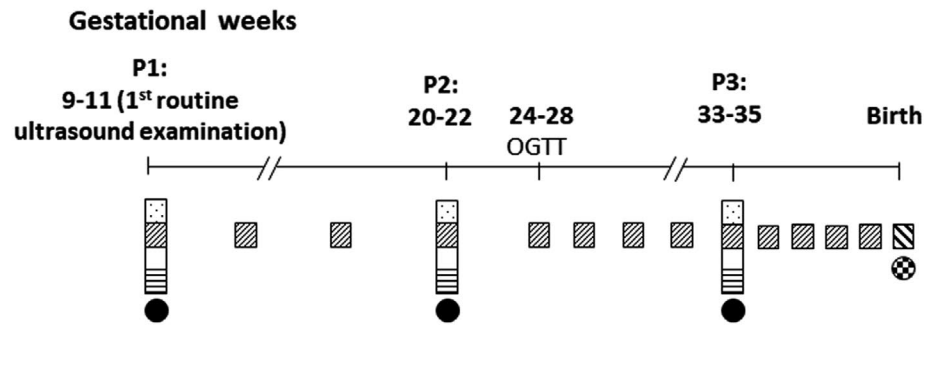
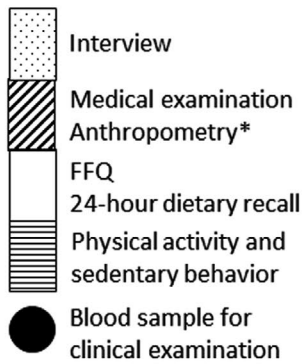
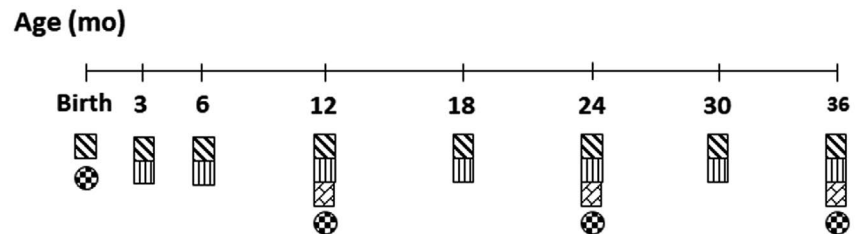
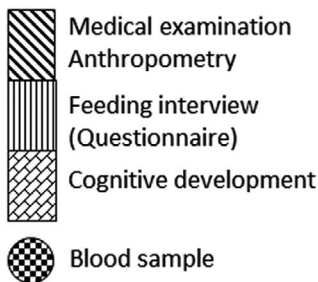
2.3.1 | Maternal demographic characteristics and other information

At P1, the self-administered questionnaire collected data on age, residence, occupation, education level, and personal income at the time of enrolment. In addition, reproductive history, medical history, and family history of chronic diseases were assessed.

Gestational age was assessed during the first ultrasound scan on the day of registration. Gestational age was estimated by combining ultrasonography data with self-reports on the last menstrual period. If both measures were available and consistent (± 14 days), then self-reported data were used; otherwise, the ultrasound estimate was adopted.

2.3.2 | Maternal lifestyle practices

Information about maternal lifestyle of each woman was recorded by interviewer using validated questionnaires at P1, P2, and P3.¹² These questionnaires included lifestyle practices (eg active/passive smoking, alcohol consumption, and tea/coffee consumption), physical activity (eg walking and climbing stairs), sedentary behaviours (eg watching television, using computers, and phone use), water drinking, and supplement intakes (type, dose, frequency of used vitamins, minerals, or other products). In addition, women were asked to report their usual bedtime at night and waking up time, as well as the time they take to fall asleep. Their sleep duration could thus be obtained. Information on the frequency and duration of napping were also obtained.

Mothers**Offspring***

*routine examination, lineage of their data from the Medical Birth Registry and the data of offspring from the health registries

FIGURE 2 Assessment timeline of the Nutrition in Pregnancy and Growth in Southwest China (NPGSC) cohort

2.3.3 | Maternal dietary exposures

At P1, women were interviewed by trained investigators with respect to their diet by means of a modified validated 128-item food frequency questionnaire (FFQ)¹³ covering consumption of the previous 12 months before pregnancy and one 24-hour dietary recall. A 24-hour dietary recall and a FFQ addressing consumption during the previous 12 weeks were subsequently administered at P2 and P3. Visual aids such as standard serving bowls, plates, and glasses were displayed to the participants to improve the accuracy of estimated portion sizes.

Previous evidence has shown the appropriateness of employing the 128-item FFQ to assess dietary intake for women in southeast China.¹⁴ The FFQ was used to ascertain how often, on average (never to ≥ 5 times/d), the participants had consumed the respective food groups. The assessment of each food group (eg white rice, bread, whole grain food, vegetables and fruits, meat) was performed using standard serving sizes. To this end, participants were offered a range of different serving sizes. The frequency and amount of consumption of each food or beverage per unit of time were converted into food intake per day. Total energy and nutrient intakes were calculated using our institution's in-house nutrient database,¹⁵ which reflects the composition of Chinese food¹⁶ and includes information on standard nutrient tables, product labels, and recipe simulations from any food item recorded in previous studies conducted at our institute.

To improve the accuracy of estimates of individual intakes, we combined the FFQ with a 24-hour dietary recall to collect detailed

dietary intakes.¹⁷ Information on timing, place, as well as food and beverages eaten in the past 24 hours was requested. Details on recipes and the types and brands of all food items reported were noted. Dietary intake data from the 24-hour recall were converted into nutrient intake data using the in-house nutrient database.

2.3.4 | Maternal anthropometric exposures

Height and weight before pregnancy were self-reported by mothers, while weight during pregnancy was extracted from medical records, which was measured with an ultrasonic meter to the nearest 100 g and scheduled every 4 weeks from enrolment to 24 weeks, every 2 weeks until week 33, and weekly thereafter until birth. Pre-pregnancy body mass index (BMI) was calculated as $\text{weight}/\text{height}^2$ (kg/m^2) and categorised according to WHO criteria (<18.5 kg/m^2 as underweight, 25.0 – 29.9 kg/m^2 as overweight, and no less than 30 kg/m^2 as obese). Excess weight gain was defined by the recommendation of optimal gestational weight gain (GWG) from the Institute of Medicine updated in 2009. GWG of over 18 kg in pregravid underweight women, over 16 kg in normal weight women, over 11.5 kg in overweight weight, and more than 9 kg in obese women were considered excessive. Blood pressure was measured on the right upper arm after a 5–10 minutes rest in a quiet environment using the mercurial blood pressure device. In routine antenatal care, gestational weight and blood pressure were evaluated three or four times during each trimester.



2.4 | Clinical maternal outcomes

At P1, P2, and P3, fasting serum lipids (triglyceride, total cholesterol, high-density lipoprotein, and low-density lipoprotein cholesterol), glucose, insulin, glycosylated haemoglobin, urea nitrogen and creatinine, thyroid hormones (free thyroxine, thyroid-stimulating hormone, and thyroxine), and blood haemoglobin were measured.

After a fasting plasma glucose test performed at P1 to exclude pre-existing diabetes (≥ 7.00 mmol/L), participants underwent a two-hour 75-g oral-glucose-tolerance test at 24–28 weeks of gestation by clinical care. A diagnosis of gestational diabetes mellitus (GDM) was made if any one of the following values was met or exceeded: 0 hour (fasting), ≥ 5.1 mmol/L; 1 hour, ≥ 10.0 mmol/L; and 2 hours, ≥ 8.5 mmol/L.¹⁸ Mothers diagnosed with GDM received dietary treatment followed by insulin treatment for management if the diet alone was insufficient to restore glucose homeostasis. Women with pre-eclampsia were identified as follow: systolic blood pressure ≥ 140 mm Hg and/or diastolic blood pressure ≥ 90 mm Hg after 20 weeks of gestation in previously normotensive women, along with the presence of proteinuria (two or more dipstick readings of 2+ or greater, one catheter sample reading of 1+ or greater, or a 24-hour urine collection containing at least 300 mg of protein).¹⁹

2.5 | Child feeding exposures

Information on feeding practices was collected at the age of 3, 6, 12, 18, 24, 30, and 36 months. In the first 6 months, feeding was categorised as exclusive breast feeding, bottle feeding, and mixed feeding. The duration of breast feeding was reported by mothers, and parents were asked to report the timing of introduction of complementary feeding and the types of solid, semi-solid, and soft food.

When children reached the age of 12 months, parents were asked to record the amount and frequency of each food and beverage consumed by their child over three consecutive days with a single food record. Estimates of portion sizes in terms of household measures (eg one spoon) and report units (eg half a banana was considered one report unit) were given special attention. Parents were given a HELP list to improve the diet record, which contains approximately 150 food items, following a preliminary analysis of food and beverages commonly consumed by toddlers with our in-house database. These 150 food items were hierarchically organised into 13 food groups: infant and toddler food, beverages, grains, fruits, dairy food, vegetables, eggs and egg dishes, meats, fish and fish products, flavourings, sweets, ice-cream, and other food.

2.6 | Child anthropometrical measurement and perinatal outcomes

Anthropometric measurements of children were taken by trained investigators in each study centre according to standard procedures. Recumbent length in child under 2 years of age was measured to the nearest 0.1 cm with a stadiometer. From the age of 2 years onward,

with an ultrasonic meter, height was measured to the nearest 0.1 cm and weight was assessed to the nearest 100 g. Body weight and length were used to assess stunting, underweight, overweight, and obesity according to WHO criteria on child growth standards.

Stillbirth was defined as a fetal death occurring after 20 weeks of gestation and before or during delivery in the NPGSC cohort. Spontaneous or induced pregnancy loss before 20 weeks was considered as abortion. Preterm birth was defined as a gestational age at birth under 37 weeks.²⁰ Neonates with birthweight over 4000g were considered to have macrosomia.²¹ Small for gestational age and large for gestational age were defined as newborns with gestational age- and sex-adjusted birthweight less than the 10th percentile and over the 90th percentile, respectively.²²

2.7 | Child cognitive outcomes

Cognitive development of children at age of 12, 24, and 36 months was assessed using the Chinese version of the Ages and Stages Questionnaires-Third Edition (ASQ-3), the ASQ-Chinese (ASQ-C), which has been widely adopted by over 50 child health organisations.²³ The ASQ-C is a parent-completed questionnaire, including five developmental domains (ie communication, gross motor, fine motor, problem solving, and personal-social).

2.8 | Quality control for data collection process

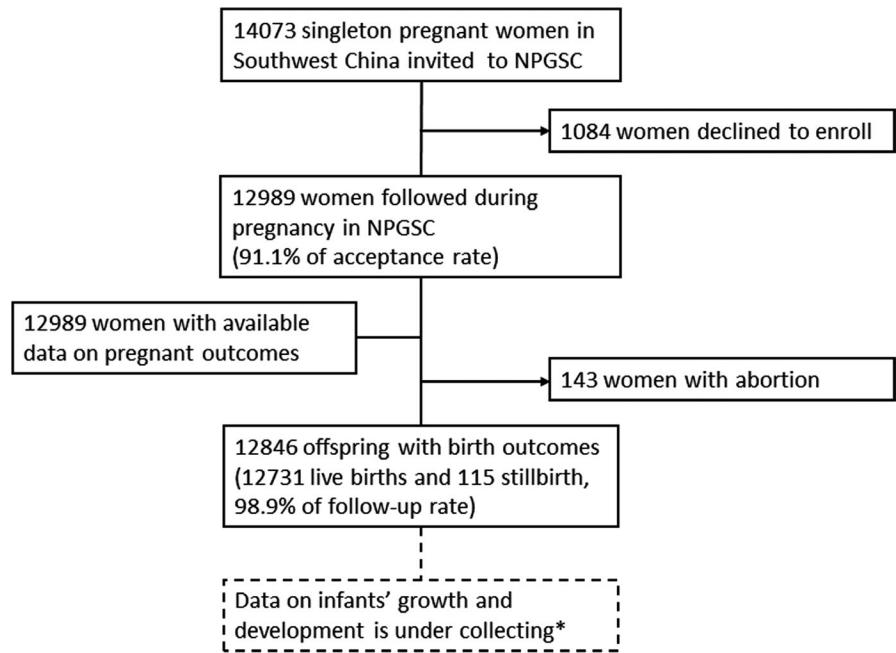
To ensure the accurate and standard measurement throughout the study, several quality assurance methods were undertaken. Prior to study implementation, a five-day training was conducted in study offices at each site. A training manual describing all standardised procedures in detail was developed, and all instruments for data collection were calibrated. During the study, data checks were conducted for completeness and accuracy immediately after questionnaires were completed. In each site, the trained investigators who performed the measurements underwent quarterly quality control by senior investigators. The coefficient of variation within and between study sites was less than 5% for each measurement. In addition, double entries were carried out and corrections were made for data entry and management.

All study laboratories successfully completed a standardisation and certification program. All laboratory equipment was calibrated, and blinded duplicate samples were used. Participants were informed about all clinical data within 36 hours after collection.

2.9 | Statistical analysis

All statistical analyses were performed with SAS software (SAS, version 9.3, 2011, SAS Institute Inc). Characteristics of study participants were presented as mean (standard deviation) or frequencies. Anthropometric and nutritional data of pregnant women were displayed in different pregnancy trimesters and pre-pregnancy.

FIGURE 3 Sample collection and exclusion of the Nutrition in Pregnancy and Growth in Southwest China (NPGSC) cohort from 2014 to 2018



NPGSC=Nutrition in Pregnancy and Growth in Southwest China cohort

*Data collected between 2014-2018 were displayed in this analysis. Since offspring were asked to be followed-up until 3 years of age, part of infants haven't reached final assessment to date, data on children growth thus remained unreported.

3 | RESULTS

3.1 | Follow-up and representativity of participants

The flow of sample is displayed in Figure 3. Between January 2014 and December 2018, with a response rate of 46.9% and drop-out rate of 47.1%, 51 obstetricians from 27 hospitals and health care centres were ever involved in NPGSC cohort. 14 073 pregnant women were invited by those obstetricians. Of these, 1084 women declined to enrol, yielding an acceptance rate of 91.1% in pregnant women, 12 989 women were recruited into NPGSC cohort. Until giving birth to children, with a follow-up rate of 98.9%, 143 participants were lost to follow-up for spontaneous or induced abortion. The basic characteristics (age, education level, and personal income) did not differ between women with abortion and those with children. While follow-up is still continuing, of 3496 children born between January 2014 and December 2015, 2296 (65.7%) were included in the 3 years old follow-up. The comparability between NPGSC participants and women in Southwest China is displayed in Table S1. Except for the prevalence of women with a higher educational level, mothers in NPGSC had similar characteristics as those in the general population.

3.2 | Participants' characteristics

The maternal and birth characteristics of children are presented in Table 1. Approximately 48.2% of women came from urban

areas; they were 26.3 years old on average at the time of the pregnancy, and more than half of them accepted education of university level. 18.6% of them developed GDM during the pregnancy, and 1.5% of them were diagnosed with preeclampsia. 48.1% of the 12 846 infants (not including the 143 abortions) were female. Birthweight and birth length of children were, respectively, 3329 kg and 49.4 cm on average. 5.2% of them were preterm, and 3.9% were classified as having macrosomia.

Anthropometric and nutritional characteristics before and during pregnancy are shown in Table 2. Compared to their recall before pregnancy, during pregnancy, women reported a lower physical activity level and consumed more energy from cookies and cakes as well as fruits, especially tropical and subtropical fruit. Sugar-sweetened beverage intake was notably higher in the 1st trimester. In the 2nd and the 3rd trimesters, women gained more body weight and consumed more energy, of which more energy stemmed from protein and fat and less from carbohydrate in the 3rd trimester. In addition, women consumed more meat, dairy and dairy products, fish and shrimp, and soybeans and their products in the 2nd and 3rd trimesters compared to pre-pregnancy and 1st trimester recall.

3.3 | Key findings to date

Up to now, several publications based on NPGSC maternal and birth data have been published. Key findings are presented below (Table 3).



TABLE 1 Characteristics of pregnant women and their children at birth in the Nutrition in Pregnancy and Growth in Southwest China cohort^a

Characteristics	Number (%) (n = 12 989)
Mothers	n = 12 989
Age at pregnancy (y), mean (SD)	26.3 (3.7)
Urban residence	6260 (48.2)
High education level ^b	7169 (55.2)
Continue to work until maternity leave	7286 (56.1)
Moderate personal monthly income ^c	6312 (48.6)
Family history of diabetes	3221 (24.8)
Active smoking before pregnancy	2429 (18.7)
Alcohol drinking before pregnancy	1455 (11.2)
Tea drinking before pregnancy	4923 (37.9)
Coffee drinking before pregnancy	4091 (31.5)
Nulliparity ^d	8910 (68.6)
Caesarean delivery	6767 (52.1)
Gestational diabetes mellitus	2415 (18.6)
Preeclampsia	194 (1.5)
Children	n = 12 846
Female	6178 (48.1)
Gestational age (wk)	39.2 (3.5)
Birthweight (g)	3329.3 (516.2)
Birth length (cm)	49.4 (2.6)
Preterm birth	667 (5.2)
Stillbirth	115 (0.9)
Macrosomia	501 (3.9)
Small for gestational age	423 (3.3)
Large for gestational age	1862 (14.5)

^aValues are means (SD) or frequencies.

^bAt least 12 y of school education.

^cPersonal income per month at least ≥ 3000 CNY (Chinese Yuan), which is considered an average level among the general population in Southwest China.

^dParity refers to the number of prior live births or stillbirths delivered 20 wk or later. A woman with no previous live births or stillbirths is considered to be nulliparous.

3.3.1 | The impact of dietary factors on maternal health

Higher dietary intakes of total protein and animal protein in mid-pregnancy were associated with an increased risk of GDM.²⁴ In addition, higher energy intake in the 3rd trimester¹² was associated with increased risk of excessive GWG. Adequate energy density based on food and milk in the 3rd trimester decreased the risk of excessive GWG. However, dietary energy intake and energy density in the 1st or 2nd trimester of pregnancy were not associated with GWG.¹²

3.3.2 | The relevance of maternal anthropometry on maternal health and fetal growth

The relevance of pre-pregnancy BMI and GWG on the risk of GDM was investigated. The results showed that elevated pre-pregnancy BMI increased the risk of GDM. Excessive weight gain in the 1st and 2nd trimesters was associated with the increased risk of GDM, particularly in women of advanced maternal age.²⁵

We also found that lower maternal pre-pregnancy BMI and inadequate GWG were associated with higher risk of SGA neonates, but yielded lower risk of children with LGA and macrosomia.²⁶ Moreover, higher GWG in mothers in the 2nd and 3rd trimesters increased the risk of fetal macrosomia.

4 | COMMENT

4.1 | Principal findings

We developed the Nutrition in Pregnancy and Growth in Southwest China cohort to assess the short- and long-term influence of nutrition before and during pregnancy on maternal and child health. The NPGSC enrolled 12 989 pregnant women with 12 846 children. Follow-up of children is on-going, but follow-up rates are available for 3496 children recruited in the first 2 years of whom 2296 (65.7%) completed the 3 years follow-up. The first wave of analyses of NPGSC cohort suggested that the higher intakes of total protein and animal protein were associated with higher GDM risk. In addition, NPGSC mothers who were underweight or overweight/obese before pregnancy and gained excessive weight during pregnancy had higher risks of adverse maternal and neonatal outcomes, particularly for women of advanced maternal age.

4.2 | Strengths of the study

The main strengths of the NPGSC study lie in its relatively large sample size as well as repeated and detailed information on socio-demographics, dietary intake, lifestyle practices, anthropometry, and biochemical assessment of mothers and children. Unlike other studies that have focused primarily on maternal exposures during pregnancy, we ascertained data on maternal characteristics before pregnancy. The longitudinal nature with frequent follow-up times enables us to determine the critical developmental stage and factors related to maternal health, delivery outcomes, and children's growth and development. In addition, using a staged random sampling design, women included were from multiple geographic and health care settings.

4.3 | Limitations of the data

Some limitations should be mentioned. Firstly, we were not able to provide full information on follow-up of the children as they have

TABLE 2 Anthropometric and nutritional data of pregnant women during pre-pregnancy and the pregnancy trimesters in the Nutrition in Pregnancy and Growth in Southwest China cohort^a

	Pre-pregnancy (n = 12 989)	1st trimester (n = 12 989)	2nd trimester (n = 12 893)	3rd trimester (n = 12 846)
Anthropometric data				
Body weight, kg	54.2 (5.0)	55.4 (5.3)	60.7 (5.8)	68.1 (6.5)
Body mass index, ^b kg/m ²	21.2 (2.0)	21.6 (3.3)	23.6 (2.8)	26.5 (2.9)
Gestational age, ^c wk	-	10.9 (0.7)	21.1 (0.3)	33.6 (0.5)
Gestational weight gain during each trimester, kg	-	1.1 (3.1)	5.3 (2.9)	7.1 (3.2)
Physical activity ² , MET-h/wk	18.2 (9.8)	11.6 (8.9)	16.2 (9.9)	12.6 (10.7)
Sedentary behaviours, h/d	3.7 (2.8)	4.6 (3.9)	3.8 (3.2)	4.2 (3.8)
Multivitamin use, %	7299 (56.2)	11 858 (91.3)	10 599 (81.6)	10 326 (79.5)
Daily nutritional data				
Total energy, kcal	1701 (526)	1641 (502)	2023 (569)	2065 (593)
Carbohydrate, % of energy	53.1 (9.2)	53.5 (10.8)	50.1 (10.3)	49.8 (8.6)
Protein, % of energy	15.6 (3.8)	17.3 (3.2)	18.1 (4.2)	17.8 (3.6)
Fat, % of energy	30.3 (6.8)	29.2 (6.1)	31.8 (5.8)	32.4 (5.5)
Total fibre, g	11.8 (5.2)	8.6 (3.9)	12.6 (3.1)	13.9 (4.5)
Grain, g	367 (51)	318 (46)	382 (41)	378 (49)
Meat, g	93 (21)	85 (24)	132 (22)	141 (23)
Eggs, g	47 (6)	41 (5)	62 (4)	58 (6)
Dairy and dairy products, g	219 (28)	261 (21)	379 (24)	370 (22)
Fish and shrimp, g	27 (4)	20 (7)	76 (5)	62 (4)
Vegetables, g	227 (21)	215 (46)	234 (24)	249 (26)
Fruit, g	217 (42)	357 (61)	412 (39)	398 (35)
Tropical and subtropical fruit, g	129 (24)	172 (33)	225 (28)	168 (19)
Nuts, g	9 (21)	19 (17)	23 (17)	24 (19)
Cookie and cake, g	53 (9)	142 (35)	127 (26)	102 (19)
Sugar-sweetened beverage, mL	358 (28)	389 (41)	273 (32)	228 (33)
Soybeans and its products, g	23 (16)	19 (27)	41 (18)	38 (16)

^aValues are means (SD).^bMetabolic equivalent hours of activity per week.^cMean gestational age in children when women conducted data assessments in different trimesters.

not all been assessed. However, the information of children born between 2014 and 2015 and followed to 3 years of age was provided. The follow-up rate was 65.7% among children, implying that one in three children were lost, perhaps due to the frequent and extended period of follow-up in the NPGSC cohort. A higher follow-up rate in children was expected in the following visits, as more attention was paid to propaganda and publicity, increased compliance

by obstetricians, as well as more steps were taken to attract children and guardians into follow-up. Secondly, a response rate of 46.9% and drop-out rate of 47.1% appeared among NPGSC obstetricians, which may result selection bias. However, a 91% acceptance rate was addressed in NPGSC women, and analyses indicated their representativeness of general population. On the whole, pregnant women in NPGSC cohort to some extent represented the overall

**TABLE 3** Major findings from the Nutrition in Pregnancy and Growth in Southwest China cohort

Publication	Major concern	Main findings
Liang et al ²⁴	Dietary protein, meat, dairy and gestational diabetes mellitus (GDM)	Higher dietary intakes of total protein and animal protein in mid-pregnancy increased the risk of GDM in pregnant Chinese women.
Yin et al ¹²	Dietary energy intake (EI) and energy density (ED) and gestational weight gain (GWG)	Dietary energy intake in the 3rd trimester of pregnancy might be the risk factor of excessive gestational weight gain, while moderate ED may be a protective factor.
Liang et al ²⁵	Pre-pregnancy body mass index (BMI) and gestational weight gain (GWG) and GDM	Elevated pre-pregnancy BMI increased the risk of GDM. Excessive weight gain in the first and second trimesters was associated with the increased risk of GDM, particularly in women of advanced maternal age.
Li et al ²⁶	Pre-pregnancy BMI, GWG, and birthweight	Lower pre-pregnancy BMI increased the risk of small for gestational age infants, while pre-pregnancy overweight and excessive GWG increased the risk of large for gestational age infants.

pregnant women in Southwest China, while households of children completed followed up exhibited preferable education status of guardians and higher household incomes, thus may have resulted in the selection of children from more “health conscious” households. Furthermore, the current NPGSC cohort focuses on the period from pre-pregnancy to toddler stage. Collecting data on exposures and outcomes in later childhood and adolescence is not currently in the study protocol. However, with further funding, we may be able to extend the follow-up to young adulthood.

4.4 | Interpretation

In recent years, epidemiological studies have shown that childhood health is influenced by environmental exposures in fetal and infant life, such as maternal pre-pregnancy obesity,^{27,28} excessive gestational weight gain,²⁹ and low or high birthweight.^{30,31} However, the combined effects of these factors (eg of maternal pre-pregnancy BMI and dietary quality during pregnancy) on maternal and child health have not been extensively examined. Moreover, most of the existing evidence comes from studies in Western countries. To date, five birth cohorts in China comprised more than 5000 study participants³²⁻³⁴ with two major topics: (1) the impact of environmental exposures such as second-hand smoke (Hongkong “Children of 1997”³⁵) on birth defects and developmental disorders (The China-Anhui Birth Cohort Study, C-ABCS³⁶) and child growth (C-ABCS³⁶ and Hongkong “Children of 1997”³⁵), and (2) the association of maternal nutrition and lifestyle with maternal and child health (The Jiaying Birth Cohort in China, JBC,³² the Tongji Maternal and Child Health Cohort, TMCHC,³³ and the Born in Guangzhou Cohort Study, BIGCS³⁴), which was conducted only in one city either in Eastern China (TMCHC,³³ JBC³²) or South-eastern China (BIGCS³⁴).

Improved knowledge of the dietary and lifestyle determinants affecting the later health of mothers and children living in Southwest China requires prospective cohort studies. In terms of public health, a key question is whether there is a critical time window for the influence of dietary factors on maternal and child health. Such an analysis requires repeated diet measurements pre-pregnancy, during pregnancy and in infancy and early childhood. Compared with those existing birth cohorts in China, the NPGSC has the advantage of covering all of these

time periods. Accordingly, topics such as the aetiology and development of GDM and macrosomia can be addressed in the NPGSC cohort.

The first results suggest that the NPGSC women consumed more energy in the 2nd and the 3rd trimesters, which is in line with other populations.³⁷ However, these energy intakes stemmed more from protein and fat and less from carbohydrates, which may be because animal foods are thought to have better nutritional quality for pregnant women in Chinese culture. Both protein intake and animal protein intake increased the risk of GDM among NPGSC population,²⁴ and this was most pronounced for the time window closest to GDM diagnosis. Moreover, since China is experiencing a rapid diet and lifestyle transition (eg high energy intake and sedentary lifestyles),³⁸ more young women tend to enter pregnancy with excessive body weight. Our data suggest that for NPGSC mothers, both being underweight or overweight/obese before pregnancy and gaining weight excessively during pregnancy could result in higher risks of adverse maternal and neonatal outcomes, particularly in older women.^{25,26} This result indicates that a normal weight and a relative young maternal age are recommended for women planning to have babies.

5 | CONCLUSIONS

The NPGSC cohort provides a comprehensive database which will allow for prospective analyses to determine the impacts of nutrition and lifestyle characteristics on health consequences of mothers and children.

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CONFLICT OF INTEREST

None declared.

ORCID

Guo Cheng  <https://orcid.org/0000-0001-7996-6825>

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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