Original Article

Dietary patterns of Chinese pregnant women in Hong Kong

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Background and Objectives: Maternal nutrition is important for healthy pregnancy, but it has not been well studied among pregnant women in Hong Kong. This study aims to examine the dietary pattern and nutritional intake of women in early pregnancy, and the associations between dietary patterns, dietary quality, and other health parameters. **Methods and Study Design:** This is a prospective cohort study of healthy Chinese pregnant women, recruited at their first antenatal appointment. Dietary intakes were assessed by a locally validated food frequency questionnaire (FFQ) and dietary patterns were derived by principal component analysis. **Results:** Of 160 women recruited, the mean age was 32.7±3.9 years and body mass index (BMI) before pregnancy was 22.6±3.8 kg/m^2. The dietary analyses were restricted to 156 women who had completed the FFQ. 99% of women had excessive sodium intake and only 2.6% of women met the recommended fibre intake. Three dietary patterns identified were '*sweet and fast-food pattern*', '*prudent pattern*' and '*meat pattern*', which altogether accounted for 23.5% of the total variation. The '*prudent pattern*' was positively associated with dietary quality indices [Dietary Approaches to Stop Hypertension score, ρ=0.323, p<0.01; Dietary Quality Index-International, ρ=0.400, p<0.01; Mediterranean Diet Score, ρ=0.243, p=0.02]; and was inversely associated systolic (B=-2.71, 95% CI -7.06, -0.36) and diastolic blood pressure (B=-2.69, 95% CI -5.12, -0.26), suggesting this pattern represented a relatively healthier dietary option. **Conclusions:** Suboptimal dietary intake is a common issue among pregnant women in Hong Kong. Early dietary assessment and attention are warranted in this population.

Key Words: dietary pattern, pregnancy nutrition, prenatal nutrition, nutritional status, nutritional requirements

INTRODUCTION

The diet and nutritional status in early pregnancy is important to support healthy fetal growth and development.[1,2] There have been only few dietary and nutritional surveys conducted in Hong Kong in the past, which highlighted inadequate intake of various nutrients including iodine,[3,4] vitamin D,[5] fibre, calcium and iron[6] among local women of child-bearing age. Since then, there was no recent update on the dietary and nutritional intake among women in Hong Kong. While maternal diet is an important modifiable factor linked to adverse pregnancy and birth outcomes, the dietary intake and nutritional status of pregnant women in Hong Kong has not been evaluated adequately. Therefore, the aim of this study is to examine the dietary pattern and nutritional intake of women in early pregnancy; and to examine the association between dietary patterns and dietary quality indices, nutrient and food intakes. In addition, the associations between dietary patterns and other health parameters were also explored.

METHODS

Participants and study design

This was a prospective cohort study, conducted between September 2017 to April 2018, at the antenatal clinic of the Prince of Wales Hospital, Shatin, Hong Kong. Women were recruited randomly at their first antenatal visit. The inclusion criteria included (i) healthy Chinese women with a singleton pregnancy of less than 14 weeks at the time of recruitment; (ii) usually residing in Hong Kong; and (iii) fluent in Cantonese Chinese. Women with pre-existing diabetes, known psychiatric conditions, any chronic medical condition requiring long-term medica-

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tions, previous surgical or medical interventions to treat obesity, participation in other intervention trials, or those who followed a restricted diet (e.g., vegetarian) were excluded. The study was conducted according to the Declaration of Helsinki and the research protocol was approved by The Joint Chinese University of Hong Kong–New Territories East Cluster Clinical Research Ethics Committee (CREC Ref: 2017.449). The study design was explained to each participant and written informed consent was obtained from women who expressed interest.

A standardised questionnaire was used to collect demographic information. Anthropometric measurements were recorded from the medical records using the standardised methods. The pregnancy and medical history, pregnancy complications and birth outcomes were collected based on the hospital records, or followed up by phone call.

Assessment of dietary intake

A locally validated food frequency questionnaire (FFQ) was used to assess women's dietary intake retrospectively in the past three months.[6,7] The FFQ contains over 200 food items, including eleven food categories: cereals, vegetables, fruits, meat and poultry, fish and seafood, eggs, milk and dairy products, beverages, dim sum and snacks, soups, oil and condiments. A trained nutritionist was present throughout the interview, using a catalogue of pictures of individual food portions to facilitate portion size estimation. The amount of cooking oil was estimated based on cooking methods, cooking oil type, and portions of food consumed by the participants.[8] Daily nutrients intakes were estimated using Food Processor Nutrition analysis and Fitness software version 8.0 (ESHA Research, Salem, Oregon, USA) with the additional local and Chinese food items.[9-11] Individual food items from the FFQ were then aggregated into thirty-two food groups based on the similarity of food types and nutrients composition, as described and used by another study.[12,13]

Identification of dietary patterns

While food or nutrients are not consumed in isolation, to investigate the interaction between nutrients and foods,[14] we also studied the dietary pattern for each participant. The dietary pattern was identified by using a principal component analysis (PCA), which was based on the correlation between the thirty-two food groups. The factor loadings represented the correlation coefficients between the food groups and a particular pattern. The number of factors retained was determined by Eigenvalue greater than 1.0, and a scree plot. A varimax rotation was used. The factor scores for each pattern were calculated for each participant by summing the food intake weighted by the factor loadings A higher score for each dietary pattern represents better adherence to the specific dietary pattern. In addition, according to the distribution of factor scores, scores for each dietary pattern were categorized as T1, T2 and T3, and individuals grouped according to the tertiles of dietary pattern factor score for further analyses.

Dietary quality indices calculation

The dietary quality indices were calculated based on the food and nutrients intakes generated from the FFQ. These dietary quality indices were developed based on specific dietary recommendation and guidelines.

Dietary Approaches to Stop Hypertension (DASH) score

A score developed by Mellen et al[15] was used to assess accordance with the DASH dietary pattern, which is a diet rich in fruits, vegetables, and low-fat dairy foods and with reduced saturated and total fat. The score is entirely based on targeted intake of nine nutrients in the DASH diet, which includes total fat, saturated, protein, fibre, cholesterol, magnesium, calcium and potassium, and sodium. Individuals achieving the target of each nutrient receive 1 point; those achieving the intermediate target receive 0.5 point. The total DASH score is sum of the score for each targeted nutrient, with a range from 0 to 9. A higher DASH score indicates a better DASH diet accordance (Supplementary table 1).

Dietary Quality Index-International (DQI-I)

The DQI-I was developed by Kim et al.[16] DQI-I was calculated based on four major aspects: variety, adequacy, moderation, and overall balance of a healthy diet, and each includes its subcomponents. The calculation of DQI-I in the present study adapted the modification method suggested by Chan et al.[17] This was due to the inadequate information on empty calorie foods to calculate "moderation" score, therefore the ranges of "moderation" score was 0 to 24 instead of 0 to 30, and the DQI-I total score was 0 to 94 instead of 0 to 100 as in the original method (Supplementary table 2).

Mediterranean Diet Score (MDS)

Adherence to the Mediterranean diet was calculated based on the method proposed by Trichopoulou et al.[18] The MDS consists of 9 components, which include food group/nutrient index considered to be beneficial to health (vegetables, legumes, fruits and nuts, cereal, fish and monosaturated to saturated lipids ratio), those presumed to be detrimental to health (meat and dairy products) and ethanol consumption. Individuals consuming beneficial food components at or above the sex-specific median, or consuming detrimental food components below the median, receive 1 point. None of the pregnant women reported having consumed alcohol in the study. While changes in drinking habit during pregnancy is expected, the alcohol consumption component might not be relevant and was excluded in the calculation. Therefore, the total MDS score ranged from 0 (minimal adherence) to 8 (maximal adherence) instead of 0 to 9 (Supplementary table 3).

Clinical investigation and pregnancy outcome

Haematological investigations including haemoglobin (Hb) and other indices were taken at antenatal booking. Pregnancy complications and birth outcomes e.g., gestational diabetes mellitus (GDM), delivery method, birthweight, child's gestational age at delivery, weight at delivery were obtained from electronic health and medical records if available. GDM was diagnosed according to local adaptation of the World Health Organization 2013 criteria, using glucose values at 0 and 120 minutes.[19-21] Total gestational weight gain (GWG) was calculated using [bodyweight before delivery in kg] – [bodyweight at

first antenatal appointment in kg]. According to pre-pregnancy Body Mass Index (BMI) classification, participants' GWG were classified as 'inadequate', 'appropriate' or 'excessive', based on the Institute of Medicine (IOM) guideline for healthy pregnancy weight gain.[22]

Statistical methods

Statistical analyses were performed using SPSS version 24.0 (IBM, Armonk, NY, USA). Continuous variables (e.g., dietary quality indices score) are expressed as mean, median, and standard derivation. Categorical variables (e.g., education, GDM) are expressed as numbers and percentages. Pearson's correlation was used to examine (1) the correlation between dietary patterns and intake of nutrients and food groups; (2) the correlation between dietary patterns and dietary quality indices e.g., DASH, DQI-I, MDS. Multiple linear regression was used to assess the association of each dietary pattern score, health parameters e.g., BMI, blood pressure; pregnancy and birth outcomes e.g., GWG, birthweight. Multiple logistic regression with the adjustment for covariates (age, BMI before pregnancy, smoking, education, marital status, energy intake) was used to assess the association of each dietary pattern score and pregnancy outcomes e.g., GDM and GWG. The characteristics and dietary quality were compared between tertiles using analysis of variance (ANOVA) or Chi-squared test. For all analyses, statistical significance was set at $p<0.05$ (2-sided).

RESULTS

A total of 160 women were recruited to the study, but the analysis was restricted to 156 women who had completed the FFQ. Mean gestational age of respondents was 12.0±0.37 weeks at the time of dietary assessment. Mean age of the recruited women was 32.7±3.9 years and mean BMI before pregnancy was 22.6±3.8 kg/m^2. According to their pre-pregnancy BMI, the overall percentage of women with 'underweight', 'normal', 'overweight and obesity' were 9.0%, 68.6% and 22.4% (Table 1). The education level of women who had 'tertiary, university and above' was 58.3%. Compared to available data from the Population By-census from 2016, women recruited into the study had educational attainment broadly similar to women aged 25-44 from the same region evaluated in a recent by-census.[23]

Among the 156 women, 21 (13.6%) were later diagnosed with GDM. Birth data was not available for 18 births (1 miscarriage, 1 termination, 10 delivered in private hospitals, 6 lost to follow-up), leaving 138 women included in the birth outcome analysis. Only one-fourth of the women (n=40) had appropriate GWG; half of the women (n=78) had a reduced GWG, and 19 women (12.2%) had excessive GWG. For the delivery method, 56 (40.6%) of live births were caesarean delivery and two (1.4%) live births were macrosomic (Table 1).

The daily mean energy intake was 1938.7±562.4 kcal (protein: 18.5±3.2 % energy; carbohydrates: 45.4±6.4 % energy; fat: 37.1±4.9 % energy) in the study population. (Table 2) None of the woman had nutrient intakes which exceeded the tolerance upper intake level. The mean fibre intake of the study population was 13.9±4.9 g/day, compared to the WHO recommendation of 25 g/day,[24] with only 2.6% achieved the recommendation. Compared to the Chinese Dietary Reference Intakes (DRI),[25] the percentage of pregnant women with insufficient daily intake of vitamin C, calcium, iron, and zinc was 44.5%, 74.4%, 90.4%, and 32.7%. respectively. Furthermore, as much as 99% of the pregnant women had exceeded the recommended upper limit of sodium intake i.e. 1500 mg/day,[25] with the mean intake being 3984mg/day in the study population.

There were three dietary patterns defined, accounting for 23.5% of the total variation. (Figure 1) The first pattern was named as '*sweet and fast-food pattern*', which was characterized by intake of 'cakes, cookies, pies and biscuits', 'French fries and chip', 'sweet and desserts', and 'fast-food' accounting for 9.56% of the total variance. The second pattern was named as '*prudent pattern*', which was characterized by intake of 'nuts', 'fruit', and 'dark green leafy vegetables', explained 8.63% of the total variance. The last pattern was named as '*meat pattern*', which was characterized by intake of 'red meat and processed meat', 'refined grains', and 'poultry', contributed 5.32% of the total variance.

The association of dietary pattern score and dietary quality indices, nutrients and food intakes were summarised in Table 3. There was null association between '*sweet and fast-food pattern*' and DASH, MDS, but inverse association with DQI-I (ρ=-0.20, p=0.01). The '*prudent pattern*' was positively associated with all three dietary quality indices (DASH, ρ=0.32, $p<0.01$; DQI-I ρ=0.40, $p<0.01$; and MDS, ρ=0.24, $p<0.01$). The '*meat pattern*' was positively associated with DASH (ρ=0.33, $p<0.01$), but inversely associated with DQI-I (ρ=-0.27, $p<0.01$) and null association with MDS. For food and nutrient intakes, the '*sweet and fast-food pattern*' was associated with intake of energy and sugar (ρ=0.50, $p<0.01$ and ρ=0.68, $p<0.01$); intake of 'cakes, cookies, pies, biscuits' and 'french fries and chip' (ρ=0.71, $p<0.01$, and ρ=0.69, $p<0.01$). The '*prudent pattern*' was associated with intake of fibre and vitamin C (ρ=0.65, $p<0.01$, and ρ=0.47, $p<0.01$); intake of 'fruit' and 'nuts' (ρ=0.73, $p<0.01$, and ρ=0.78, $p<0.01$). The '*meat pattern*' was associated with intake of energy and protein (ρ=0.670, $p<0.01$, and ρ=0.724, $p<0.01$); intake of 'red and processed meat' and 'refined grains' (ρ=0.71, $p<0.01$, and ρ=0.65, $p<0.01$).

In the linear regression analysis, there was an inverse association of the '*prudent pattern*' with systolic blood pressure (SBP) (B=-3.71, 95% CI -7.06, -0.36) and diastolic blood pressure (DBP) (B=-2.69, 95% CI -5.12, -0.26). (Supplementary table 4) We also investigated the association between the three dietary patterns with GDM and GWG, adjusting for covariates, in the logistic regression, but no association was observed. (Supplementary table 5)

According to the tertiles of dietary pattern factor scores, the social demographic characteristics were not different between tertiles of each dietary pattern. Only the total GWG was different between tertiles of '*prudent pattern*'. (Table 1) Furthermore, women with a higher score for '*prudent pattern*', suggesting better adherence to this pattern, was associated with higher scores for DASH, DQI-I or MDS; and higher intake of 'carbohydrate', 'fibre',

Table 1. Sociodemographic, maternal characteristics and birth outcome of Hong Kong Chinese pregnant women, by tertiles of dietary patterns

	All participants	Sweet and fast-food pattern				Prudent pattern			
	(n=156)	T1	T2	T3	*p*-value	T1	T2	T3	*p*-value
Age, year	32.7±3.9	33.1±3.4	32.8±4.2	32.1±3.9	0.39	33.3±3.7	31.7±3.2	33±4.5	0.09
15-24	3 (1.9)	0 (0)	1 (1.9)	2 (3.8)	-	0 (0)	2 (3.8)	1 (1.9)	-
25-44	152 (97.4)	51 (100)	50 (96.2)	51 (96.2)		51 (100)	50 (96.2)	51 (96.2)	
45-54	1 (0.6)	0 (0)	1 (1.9)	0 (0)		0 (0)	0 (0)	1 (1.9)	
Married	129 (82.7)	45 (88.2)	44 (84.6)	40 (75.5)	0.21	42 (82.4)	44 (84.6)	43 (81.1)	0.89
BMI at antenatal visit, kg/m^2	22.6±3.8	22.2±3.2	22.5±3.8	23.1±4.4	0.41	23.2±4.1	22.0±3.6	22.7±3.7	0.27
Underweight (<18.5)	14 (9.0)	5 (9.8)	4 (7.7)	5 (9.4)	0.37	3 (5.9)	6 (11.5)	5 (9.4)	0.70
Normal (18.5-22.9)	107 (68.6)	39 (76.5)	36 (69.2)	32 (60.4)		34 (66.7)	37 (71.2)	36 (67.9)	
Overweight and obese (≥23.0)	35 (22.4)	7 (13.7)	12 (23.1)	16 (30.2)		14 (27.5)	9 (17.3)	12 (22.6)	
Education									
Secondary and below	65 (41.7)	18 (35.3)	19 (36.5)	28 (52.8)	0.13	24 (47.1)	19 (36.5)	22 (41.5)	0.56
Tertiary, university and above	91 (58.3)	33 (64.7)	33 (63.5)	25 (47.2)		27 (52.9)	33 (63.5)	31 (58.5)	
Monthly family income, HK$									
<20,000	17 (10.9)	4 (7.9)	5 (9.6)	8 (15.1)	0.71	3 (5.9)	6 (11.5)	8 (15.1)	0.31
20,000 - 39,999	50 (32.1)	19 (37.2)	16 (30.8)	15 (28.3)		20 (39.2)	18 (34.6)	12 (22.6)	
≥40,000	89 (57.1)	28 (54.9)	31 (59.6)	30 (56.6)		28 (54.9)	28 (53.8)	33 (62.3)	
Employment									
Full/Part-time employment	127 (81.4)	44 (86.3)	41 (78.8)	42 (79.3)	0.55	42 (82.4)	41 (78.9)	44 (83.0)	0.84
Smoking									
Never	109 (85.2)	37 (90.2)	36 (83.7)	36 (81.8)	0.52	32 (80.0)	35 (85.4)	42 (89.4)	0.47
Ex-smoker/ Smoker	19 (14.8)	4 (9.7)	7 (16.3)	8 (18.1)		8 (20.0)	6 (14.6)	5 (10.7)	
Blood pressure									
SBP, mmHg	113±13	111±15	114±11	114±11	0.63	113±10	113±16	113 ±11	0.98
DBP, mmHg	68±8	68±8	70±8	67±8	0.40	70±8	69±10	67 ±6	0.49
Normotensive (SBP<140 & DBP<90)	92 (96.8)	32 (97.0)	31 (96.9)	29 (96.7)	1.00	25 (96.2)	31 (93.9)	36 (100.0)	0.35
GDM	21 (13.6)	7 (14.0)	9 (17.3)	5 (9.6)	0.52	4 (8.0)	9 (17.6)	8 (15.1)	0.34
GWG, kg	10.1±4.3	9.38±4.66	10.5±4.19	10.5±4.09	0.36	11.07±4.7	8.77±4.5	10.59±3.5	0.03*
Inadequate GWG	78 (50.0)	34 (73.9)	23 (50.0)	21 (46.7)	0.06	21 (48.8)	31 (67.4)	26 (54.2)	0.06
Appropriate GWG‡	40 (25.6)	7 (15.2)	17 (37.0)	17 (37.0)		11 (25.6)	12 (26.1)	17 (35.4)	
Excessive GWG	19 (12.2)	5 (10.9)	9 (13.0)	8 (17.8)		11 (25.6)	3 (6.5)	5 (10.4)	
Caesarean delivery§	56 (40.6)	22 (46.8)	18 (39.1)	16 (35.6)	0.53	20 (45.5)	19 (41.3)	17 (35.4)	0.61
Gestational age, week	38.8±2.3	39.1±1.1	38.4±2.7	38.9±2.6	0.28	39.0±2.4	38.8±1.9	38.7±2.5	0.79
Preterm delivery (<37.0 weeks of gestation)	5 (3.6)	0 (0.0)	3 (6.5)	2 (4.4)	0.23	1 (2.3)	2 (4.3)	2 (4.2)	0.84
Birthweight, g	3148±519	3117±326	3183±670	3146±515	0.36	3133±504	3089±492	3220±558	0.46
LBW (<2500)	7 (5.1)	1 (2.1)	4 (8.7)	2 (4.4)	0.17	2 (4.5)	2 (4.3)	3 (6.3)	0.88
Normal (2500-3999)	129 (93.5)	46 (97.9)	40 (87.0)	43 (95.6)		42 (95.5)	43 (93.5)	44 (91.7)	
Macrosomia (≥4000)	2 (1.4)	0 (0.0)	2 (4.3)	0 (0.0)		0 (0.0)	1 (2.2)	1 (2.1)	

T: tertile; BMI: body mass index (calculated as weight in kilograms divided by the square of height in meters); SBP: systolic blood pressure; DBP: diastolic blood pressure; GDM: gestational diabetes; GWG: total gestational weight gain (calculated as [body weight before delivery in kg] – [body weight at first antenatal appointment in kg]); LBW: low birthweight.

Values are given as mean±standard deviation or number (percentage). By ANOVA or chi-square test, * $p<0.05$; ** $p<0.01$.

†Only included available data from the electronic health and medical records

‡Institutes of Medicine. Weight gain during pregnancy: reexamining the guidelines. Washington, DC: National Academies Press; 2009. According to preconception BMI class.

§Including elective caesarean delivery

Table 2. Daily nutrient intakes of Hong Kong Chinese pregnant women (n=156)

	Median	Mean	Number (%) of women meeting the recommendation	Daily recommended intake †	
Energy, kcal	1891 (1540, 2292)	1938±562			
Protein, g	87.0 (66.7, 108.9)	90.7±34.4			
Protein, % energy	18.2 (16.4, 20.6)	18.5±3.2			
Carbohydrate, g	210 (175, 255)	218±26			
Carbohydrate, % energy	46.2 (41.1, 50.1)	45.4±6.4			
Fat, g	76.9 (61.8, 96.3)	80.3±26.1			
Fat, % energy	36.8 (33.9, 40.2)	37.1±4.9			
Fibre, g	13.2 (10.6, 16.1)	13.9±4.9	4 (2.6)	≥ 25	AI ‡
Vitamin C, mg	106 (76, 141)	113±53	85 (55.5)	≥100	RNI
Calcium, mg	571 (444, 809)	658±344	40 (25.6)	≥ 800	RNI
Iron, mg	12.0 (9.7, 15.4)	13.0±4.5	15 (9.6)	≥ 20	RNI
Magnesium, mg	251 (211, 305)	263±81	15 (9.6)	≥370	RNI
Phosphorous, mg	1047 (804, 1251)	1077±373	132 (84.6)	≥720	RNI
Potassium, mg	2012 (1625, 2526)	2137±716	82 (52.6)	≥2000	AI
Sodium, mg	3851 (3001, 4667)	3984±1363	1 (0.6)	<1500	AI
Zinc, mg	9.3 (7.1, 11.7)	10.0±3.8	105 (67.3)	≥7.5	RNI

RNI: Recommended Nutrient Intake; AI: Adequate Intake. Nutrient intake was derived by FFQ; values expressed as median (25th, 75th percentile), or mean±standard deviation, or number (percentage).
†Chinese Nutrition Society, Chinese Dietary Reference Intakes Handbook (2013). 2014.
‡World Health Organization, Diet, nutrition and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation, in WHO technical report series 916. 2003: Geneva, Switzerland.

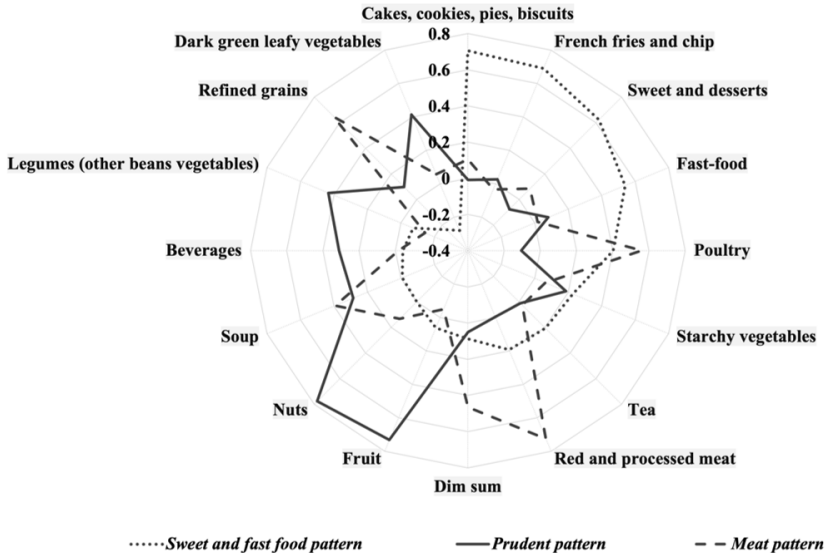

Figure 1. The three dietary patterns of Hong Kong Chinese pregnant women, by the principal component analysis. Factor loadings with absolute values ≥0.2 are included. Total variance explained 23.5%.

Table 3. The association of dietary patterns with dietary quality indices, nutrients and food intake

	Sweet and fast-food pattern	Prudent pattern	Meat pattern
Dietary quality indices			
DASH	0.145	0.323**	0.332**
DQI-I	-0.201*	0.400**	-0.266**
MDS	-0.147	0.243**	-0.123
Nutrient intake			
Energy, kcal	0.495**	0.163 *	0.670**
Protein, g	0.349**	0.084	0.724**
Protein, % of energy	-0.073	-.096	0.399**
Fat, g	0.489**	0.113	0.640**
Fat, % of energy	0.122	-0.019	0.095
Saturated fat, g	0.560**	0.036	0.596**
Saturated fat, % of energy	0.345**	-0.152	0.153
Carbohydrate, g	0.464**	0.242**	0.490**
Carbohydrate, % of energy	-0.055	0.115	-0.337**
Sugar, g	0.681**	0.207**	0.133
Fibre, g	0.122	0.651**	0.164 *
Cholesterol, mg	0.304**	0.095	0.614**
Vitamin C, mg	0.145	0.467**	0.114
Calcium, mg	0.215**	0.170 *	0.067
Iron, mg	0.341**	0.156	0.506**
Sodium, mg	0.248**	0.208**	0.425**
Zinc, mg	0.279**	0.096	0.699**
Food intake			
Red and processed meat, g	0.193 *	-0.004	0.725**
Poultry, g	0.402**	-0.105	0.559**
Fish and seafood, g	-0.019	0.092	0.105
Egg, g	0.082	0.610	0.188 *
Milk and milk products, g	0.152	0.125	-0.109
Soya, g	0.115	-0.211**	0.108
Legumes (other beans vegetables), g	-0.073	0.433**	-0.144
Refined grains, g	-0.236**	0.098	0.646**
Wholegrains, g	0.040	-0.085	-0.033
Cakes, cookies, pies, biscuits, g	0.706**	-0.009	0.104
Fruit, g	0.062	0.732**	-0.049
Dark green leafy vegetables, g	-0.280**	0.413**	0.057
French fries and chip, g	0.690**	0.026	-0.034
Fast-food, g	0.539**	0.081	0.017
Dim sum, g	0.088	0.050	0.465**
Nuts, g	0.000	0.776**	0.132
Sweet and desserts, g	0.623**	-0.076	0.084
Soup, g	-0.008	0.285**	0.393**

DASH: Dietary Approaches to Stop Hypertension scores; DQI-I: Dietary Quality Index-International; MDS: Mediterranean Diet Score. Pearson's correlation; *p*-values, $^{*}p<0.05$; $^{**}p<0.01$.

'nuts', 'fruit', and 'dark green leafy vegetables', suggesting this pattern is a healthier diet. (Table 4) On the other hand, women with a higher score for '*sweet and fast-food pattern*' was associated with a higher DASH score, but lower score of DQI-I; and had a higher intake of 'energy', 'saturated fat', 'cholesterol', 'sodium', 'red and processed meat', 'refined grains', 'fast-food', 'French fries and potato chip', 'sweet and dessert', and 'cake, cookies, pies, and biscuits', but lower intake of 'dark green leafy vegetables'. Lastly, women with a higher score of '*meat pattern*' was associated with a higher DASH score, but a lower score of DQI-I; and had higher intake of 'energy', 'protein', 'cholesterol', 'sodium', 'red and processed meat', 'refined grains' and 'dim sum', but lower intake of 'milk and milk products'.

DISCUSSION

This is the first study to investigate the dietary pattern and nutritional intake of Chinese women in Hong Kong in early pregnancy. We observed a high prevalence of insufficient micronutrient intakes including vitamin C, calcium, and iron, as well as fibre, and excessive sodium intake among pregnant women in Hong Kong. We also found the predominant pattern '*sweet and fast-food pattern*', characterized by frequent intake of 'cakes, cookies, pies and biscuits', 'French fries and chip', 'sweet and desserts', 'fast-food' and low intake of 'dark green leafy vegetables', was the common dietary pattern, suggesting an unhealthy dietary behaviour of pregnant women in Hong Kong.

Nutrition supplements are widely available in Hong Kong, and we observed women in our study (93.6%) were often taking various types of nutrition supplement (mostly multi-vitamins and minerals and/or folate, fish oil or algae oil) at the time of interview. While nutrition supplements can help to support nutritional adequacy, it also raises our concern on the proper use of these nutrition supplements. Nutrition supplements can be purchased easily without prescription, and more than half of our study participants were taking 2 or more types of nutrition

Table 4. Dietary characteristics of Hong Kong Chinese pregnant women, by tertiles of dietary patterns

	All participants (n=156)	Sweet and fast-food pattern				Prudent pattern			
		T1	T2	T3	*p*-value	T1	T2	T3	*p*-value
Dietary Quality Indices									
DASH	3.79±1.34	3.7±1.4	3.5±1.3	4.2±1.3	0.04*	3.5±1.3	3.6±1.3	4.3± 1.2	<0.01**
DQI-I	50.6±7.1	52.3±7.0	51.0± 6.7	48.6± 7.1	0.02*	47.1±6.8	50.7±7.2	53.9±5.5	<0.01**
MDS	4.1±1.2	4.3±1.2	4.2±1.3	3.8±1.2	0.15	3.7±1.1	4.2±1.3	4.5±1.2	<0.01**
Nutrient intakes									
Energy, kcal	1939±562	1776±454	1699±478	2331±530	<0.01**	1917±517	1842±590	2054±567	0.15
Protein, % energy	18.5±3.2	18.3±2.8	18.7±3.4	18.4±3.2	0.80	19.4±3.6	18.3±3.2	17.8±2.5	0.04**
Carbohydrate, % energy	45.4±6.36	46.4±6.4	45.3±7.1	44.5±5.5	0.30	43.4±7.3	45.8±6.4	47.0±4.8	0.01**
Fat, % energy	37.1±4.9	36.2±5.5	37.0±5.2	38.1±3.7	0.14	37.9±5.4	36.9±4.8	36.6±4.4	0.36
SFA, % of energy	8.7±1.5	7.9±1.4	8.8±1.6	9.4±1.3	<0.01**	9.0±1.6	8.8±1.6	8.4±1.3	0.07
MUFA, % of energy	12.6±2.5	12.8±3.0	12.4±2.5	12.5±2.1	0.75	13.0±2.6	12.2±2.7	12.6±2.2	0.27
PUFA, % of energy	8.1±2.0	8.6±2.5	7.9±1.9	7.6±1.5	0.04*	8.3±2.0	8.1±2.2	7.7±1.8	0.33
MUFA/SFA	0.95±0.29	1.11±1.03	0.92±0.93	0.82±0.79	<0.01**	0.94±0.90	0.96±0.90	0.95±0.95	0.94
PUFA/SFA	1.46±0.29	1.63±1.62	1.43±1.41	1.34±1.29	<0.01**	1.45±1.45	1.42±1.33	1.52±1.52	0.15
Fibre, g	13.9±4.9	13.8±5.6	12.9±4.6	15.0±4.3	0.11	11.4±3.7	13.1±4.0	17.1±5.0	<0.01**
Fibre, g/1000kcal	7.4±2.3	7.8±2.4	7.8±2.1	6.6±2.3	0.01*	6.1±2.0	7.4±1.9	8.6±2.3	<0.01**
Sugar, g	63.2±29.3	49.2±21.1	54.7±16.8	85.0±33.2	<0.01**	54.7±21.2	60.4±33.6	74±66.7	<0.01**
Sugar, g/1000kcal	32.7±11.0	28.1±11.5	33.3±9.9	36.5±10.2	<0.01**	29.1±11.2	32.6±10.6	36.3±10.3	<0.01**
Cholesterol, mg	389±158	350±149	359±145	454±161	<0.01**	407±168	371±156	388±152	0.50
Cholesterol, mg/1000kcal	201±58	194±59	216±69	193±42	0.07	210±60	203±63	190±50	0.21
Vitamin C, mg	113±53	114±51	106±47	119±60	0.43	90±44	102±42	145±55	<0.01**
Vitamin C, mg/1000kcal	60.5±27.6	65.5±28.9	64.4±28.0	51.9±24.0	0.02	49.2±26.1	59.0±26.4	72.9±25.3	<0.01**
Calcium, mg	658±344	621±445	601±221	751±317	0.05*	595±254	680±443	698±303	0.26
Calcium, mg/1000kcal	344±151	350±208	358±106	325±122	0.51	315±119	376±204	341±110	0.12
Iron, mg	13.0±4.5	11.8±4.3	11.7±3.8	15.3±4.4	<0.01**	12.8±4.3	12.1±4.7	13.9±4.3	0.12
Iron, mg/1000kcal	6.7±1.3	6.6±1.6	6.9±1.3	6.6±1.2	0.35	6.7±1.6	6.6±1.1	6.8±1.3	0.66
Mg, mg	263±81	260±95	240±72	289±68	<0.01**	246±70	252±82	291±84	<0.01**
Mg, mg/1000kcal	138±26	145±27	143±25	126±21	<0.01**	130±27	139±26	144±23	0.02*
Mn, mg	2.5±0.9	2.6±1.0	2.2±0.8	2.6±0.8	0.02*	2.3±0.8	2.3±0.8	2.8±1.0	<0.01**
Mn, mg/100kcal	1.3±0.3	1.5±0.4	1.3±0.3	1.1±0.3	<0.01**	1.2±0.3	1.3±0.4	1.4±0.3	0.08
P, mg	1077±373	979±359	956±296	1290±366	<0.01**	1007±367	1035±395	1118±358	0.53
P, mg/1000kcal	554±89	544±102	566±87	552±76	0.44	599±95	561±101	643±67	0.52
K, mg	2137±716	2023±776	1914±623	2466±629	<0.01**	1974±646	2036±705	2393±733	<0.01**
K, mg/1000kcal	111±226	1130±260	1137±218	1067±194	0.21	1039±254	1119±214	1174±189	<0.01**

T: tertile; DASH: Dietary Approaches to Stop Hypertension score; DQI-I: Dietary Quality Index-International; MDS: Mediterranean Diet Score; SFA: saturated fat; MUFA: monounsaturated fat; PUFA: polyunsaturated fat; Mg: magnesium; Mn: manganese; P: phosphorous; K: potassium.
Values are given as mean±standard deviation or number (percentage).
by ANOVA, * $p<0.05$; ** $p<0.01$.

Table 4. Dietary characteristics of Hong Kong Chinese pregnant women, by tertiles of dietary patterns (cont.)

	All participants (n=156)	Sweet and fast-food pattern				Prudent pattern			
		T1	T2	T3	*p*-value	T1	T2	T3	*p*-value
Nutrient intakes									
Sodium, mg	3984±1363	3655±1346	3831±1176	4452±1445	<0.01**	3770±1201	3852±1202	4320±1599	0.08
Sodium, mg/1000kcal	2110±628	2099±699	2303±579	1931±556	<0.01**	1998±505	2167±592	2162±755	0.30
Zinc, mg	10.0±3.8	9.3±3.3	8.9±3.3	11.8±4.1	<0.01**	10.2±3.9	9.4±3.7	10.4±3.7	0.35
Zinc, mg/1000kcal	5.1±1.0	5.1±0.9	5.2±1.2	5.0±1.0	0.53	5.3±1.3	5.3±1.3	5.0±0.9	0.31
Food intakes									
Red and processed meat, g	87.9±55.7	79.3± 47.8	72.7± 50.0	111.2± 61.2	<0.01**	98.4± 61.1	77.1± 54.9	88.6± 49.8	0.15
Poultry, g	57.0±52.5	37.8±29.5	48.3±35.9	83.9±70.2	<0.01**	67.9±65.2	49.7±43.5	53.5±45.7	0.18
Egg, g	30.2±21.1	27.6±18.2	31.5±24.2	31.6±20.5	0.55	33.0±20.0	28.3±21.7	29.4±21.7	0.51
Fish and seafood, g	52.4±47.6	60.8±65.8	46.8±34.1	50.0±36.7	0.29	54.7±63.7	50.8±38.1	51.9±37.6	0.91
Milk and milk products, g	115±108	101±104	112±90	133±127	0.29	98±89	137±116	110±116	0.18
Refined grains, g	328±135	383±148	289±113	313±127	<0.01**	334±139	312±129	336±138	0.59
Nuts, g	4.5±6.4	4.3±7.2	4.3±6.1	4.9±6.0	0.84	1.2±1.6	2.6±3.2	9.5±8.4	<0.01**
Fast food, g	21.3±21.2	10.3±8.9	17.4±15.3	35.7±26.4	<0.01**	19.0±18.6	21.1±20.2	23.7±24.5	0.24
Dim sum, g	32.3±36.4	33.9±44.3	26.0±30.2	36.8±33.3	0.29	30.2±27.0	29.7±23.9	36.8±51.6	0.54
French fries and chip, g	10.5±13.9	3.8±4.2	6.7±6.7	20.5±18.9	<0.01**	10.2±12.0	8.2±11.4	12.9±17.4	0.22
Sweet and Dessert, g	21.2±23.7	10.3±11.7	15.2±13.4	37.7±30.6	<0.01**	19.5±17.8	22.0±25.6	22.0±26.8	0.82
Cake, cookies, pies and biscuits, g	24.0±25.5	9.3±8.7	18.8±13.5	43.3±32.5	<0.01**	22.0±22.8	21.6±29.3	28.3±23.6	0.32
Fruit, g	184±104	183±112	179±97	190±105	0.87	109±59	167±60	273±103	<0.01**
Dark green leafy vegetables, g	64.4±41.7	80.3±51.3	61.9±35.0	51.5±32.1	<0.01**	53.5±31.9	60.1±34.4	79.1±51.9	<0.01**

T: tertile; DASH: Dietary Approaches to Stop Hypertension score; DQI-I: Dietary Quality Index-International; MDS: Mediterranean Diet Score; SFA: saturated fat; MUFA: monounsaturated fat; PUFA: polyunsaturated fat; Mg: magnesium; Mn: manganese; P: phosphorous; K: potassium.
Values are given as mean±standard deviation or number (percentage).
by ANOVA, * $p<0.05$; ** $p<0.01$.

Table 4. Dietary characteristics of Hong Kong Chinese pregnant women, by tertiles of dietary patterns (cont.)

	Meat pattern			
	T1	T2	T3	*p*-value
Dietary Quality Indices				
DASH	3.3±1.3	4.0±1.3	4.1±1.2	<0.01**
DQI-I	52.5±6.8	51.7±6.2	47.7±7.3	<0.01**
MDS	4.3±1.1	4.2±1.4	3.8±1.1	0.19
Nutrient intakes				
Energy, kcal	1587±445	1888±344	2327±599	<0.01**
Protein, % energy	17.2±3.5	18.8±2.8	19.4±2.7	<0.01**
Carbohydrate, % energy	47.1±6.9	46.2±6.0	43.0±5.6	<0.01**
Fat, % energy	37.3±4.7	36.0±5.1	38.1±4.5	0.07
SFA, % of energy	8.5±1.7	8.7±1.4	9.0±1.4	0.27
MUFA, % of energy	12.0±2.6	12.5±2.7	13.2±2.1	0.05*
PUFA, % of energy	8.6±2.4	7.7±1.7	7.9±2.0	0.07
MUFA/SFA	1.04±0.97	0.91±0.88	0.90±0.87	0.02*
PUFA/SFA	1.45±1.42	1.45±1.39	1.49±1.45	0.66
Fibre, g	13.2±4.6	13.9±4.4	14.6±5.6	0.39
Fibre, g/1000kcal	8.5±2.5	7.4±1.9	6.3±1.9	<0.01**
Sugar, g	60.2±23.3	64.5±25.3	64.8±37.4	0.68
Sugar, g/1000kcal	38.1±11.1	33.6±9.5	26.6±9.5	<0.01**
Cholesterol, mg	303±121	368±107	491±177	<0.01**
Cholesterol, mg/1000kcal	198±74	195±46	209±52	0.38
Vitamin C, mg	107±46	110±42	122±67	0.34
Vitamin C, mg/1000kcal	70.4±31.3	58.8±21.8	52.6±26.4	<0.01**
Calcium, mg	627±269	708±432	640±309	0.44
Calcium, mg/1000kcal	395±123	370±196	270±84	<0.01**
Iron, mg	11.1±3.6	12.7±3.9	15.1±4.9	<0.01**
Iron, mg/1000kcal	7.0±1.4	6.7±1.5	6.4±1.0	0.08
Mg, mg	229±64	263±74	297±90	<0.01**
Mg, mg/1000kcal	147±27	139±27	128±20	<0.01**
Mn, mg	2.2±0.8	2.4±0.8	2.9±0.9	<0.01**
Mn, mg/100kcal	1.4±0.3	1.3±0.4	1.2±0.3	0.12
P, mg	874±281	1066±295	1283±411	<0.01**
P, mg/1000kcal	555±101	560±99	547±62	0.72
K, mg	1862±555	2119±637	2420±823	<0.01**
K, mg/1000kcal	1189±234	1115±235	1033±182	<0.01**

T: tertile; DASH: Dietary Approaches to Stop Hypertension score; DQI-I: Dietary Quality Index-International; MDS: Mediterranean Diet Score; SFA: saturated fat; MUFA: monounsaturated fat; PUFA: polyunsaturated fat; Mg: magnesium; Mn: manganese; P: phosphorous; K: potassium.
Values are given as mean±standard deviation or number (percentage).
by ANOVA, *p<0.05; **p<0.01.

Table 4. Dietary characteristics of Hong Kong Chinese pregnant women, by tertiles of dietary patterns (cont.)

	Meat pattern			
	T1	T2	T3	*p*-value
Nutrient intakes				
Sodium, mg	3552±1174	3827±1134	4554±1552	<0.01**
Sodium, mg/1000kcal	2304±664	2047±508	1985±605	0.02*
Zinc, mg	7.5±2.3	9.8±2.8	12.5±4.1	<0.01**
Zinc, mg/1000kcal	4.8±1.1	5.2±1.0	5.4±0.9	0.02*
Food intakes				
Red and processed meat, g	45.3±25.7	84.0±44.0	133±54	<0.01**
Poultry, g	32.3±28.3	55.9±45.7	81.7±59.3	<0.01**
Egg, g	27.4±18.4	27.2±19.8	35.9±23.9	0.06
Fish and seafood, g	50.3±64.5	52.1±32.2	54.8±41.5	0.89
Milk and milk products, g	126±156	136±107	85±98	0.04*
Refined grains, g	233±83	315±106	431±130	<0.01**
Nuts, g	4.0±5.5	3.7±4.5	5.7±8.4	0.25
Fast food, g	22.5±27.9	17.1±17.2	24.3±16.7	0.20
Dim sum, g	19.1±15.1	28.3±20.1	48.9±53.6	<0.01**
French fries and chip, g	12.0±18.2	7.4±9.9	12.0±12.3	0.15
Sweet and Dessert, g	18.1±20.9	23.8±25.9	21.7±24.0	0.47
Cake, cookies, pies and biscuits, g	20.3±20.4	23.5±20.3	28.1±33.1	0.29
Fruit, g	197±106	179±90	177±115	0.55
Dark green leafy vegetables, g	64.6±42.6	63.1±36.2	65.4±46.3	0.96

T: tertile; DASH: Dietary Approaches to Stop Hypertension score; DQI-I: Dietary Quality Index-International; MDS: Mediterranean Diet Score; SFA: saturated fat; MUFA: monounsaturated fat; PUFA: polyunsaturated fat; Mg: magnesium; Mn: manganese; P: phosphorous; K: potassium.
Values are given as mean±standard deviation or number (percentage).
by ANOVA, *p<0.05; **p<0.01.

supplements. Ingestion of multiple nutrition supplements may lead to over consumption and cause harmful side effects, e.g., nausea, diarrhoea, constipation, or stomach cramps. More importantly, nutrition supplements should not be regarded as substitutes for whole foods and healthy diet. Therefore, understanding their habitual dietary intake remains important when advising use of nutrition supplementation.

Sodium is often hidden in many Chinese condiments, sauces (e.g., soya sauce, oyster sauce, and shrimp paste) and processed foods (e.g., instant noodles, processed meat, processed fish, and snacks), that are consumed habitually in Hong Kong and likely associated with the excess sodium intake. Besides, we observed a change in dietary macronutrient composition, towards an unhealthy pattern. Compared to the available data of women in similar age group in 1995,[26] while the overall energy intake was comparable (1939.7 kcal/day vs 1891.0 kcal/day), we observed a reduction in the percentage of carbohydrate intake from 50.0% to 45.5% and an increase in the percentage of fat intake from 32.0% to 37.1%. The shift from carbohydrate to fat, a high percentage of insufficient fibre intakes, and excessive sodium intake, suggest an unfavourable dietary habit among women in Hong Kong. The unfavourable dietary habit may be also associated with the frequency by which people in Hong Kong tend to eat outside of their homes. According to the Population Health Survey 2014/15, ~30% of women aged 25 - 44, reported eating out for breakfast, ~60% reported eating out for lunch, and ~10% reported eating out for dinner, 5 times or more per week.[27] Compared to home cooked meals, a habit of eating out is often associated with increased intake of energy, fat, sugar and salt.[28,29] The habit of eating out may partly be reflected in the predominant dietary pattern '*sweet and fast-food pattern*' identified in our study, where 'cakes, cookies, pies and biscuits', 'French fries and chip', 'sweet and desserts', 'fast-food' are mostly purchased from food outlets. Eating out is often considered as a socialising activity in Hong Kong. A good nutritional knowledge is important for choosing healthy foods, while we do not want to prevent women from socialising with friends and family members, our finding suggests that nutrition education on mindful food choices and practice may be useful and helpful.

In contrast, our second most common dietary pattern identified was the '*prudent pattern*', which represented a relatively better dietary quality, as determined by a positive association with DASH, DQI-I, and MDS. Specifically, also supported by our sensitivity analysis, the subgroup of '*prudent pattern*' had a significantly higher intake of healthy foods, e.g., 'fruit' and 'vegetable', and lower intake of unhealthy food, e.g., fast-food, compared to subgroup of '*sweet and fast-food pattern*' and 'meat pattern'. Fruit and vegetable are good sources of vitamins, minerals, antioxidants and dietary fibre, which have been shown to have beneficial effects on cardiometabolic health and lowering of blood pressure in many previous studies.[30-32] Our exploratory analysis demonstrated similar findings, where the 'prudent pattern' was associated with lower SBP and DBP. Although we did not observe significant association between '*prudent pattern*' with GDM and GWG, this is likely due to our much smaller sample size, we should not rule out the potential benefits of the major dietary components of '*prudent pattern*', including 'fruit' and 'dark green leafy vegetables', where the consumption of fruit and vegetable were associated with a reduced risk of GDM,[33,34] lower glucose levels,[34] and reduced risk of excessive GWG among obese women.[35]

Given the high public awareness of fruit and vegetable as important components of a healthy balanced diet, we should probably further the education on the importance of fresh fruit consumption and choosing fruit types with low glycaemic index,[36] that are higher in dietary fibre. Dietary fibre improves insulin sensitivity, which is important for metabolic regulation.[37] It also provides a feeling of fullness, thereby preventing overconsumption. A systematic review on dietary interventions for Chinese women with GDM also highlighted that a diet with low glycaemic index, low glycaemic load and fibre enrich was associated with better glycemia control and pregnancy outcomes.[38]

We recognise the variation of GDM prevalence and dietary composition in different Chinese populations, that may influence maternal dietary intervention and strategy. For instance, as a result of different screening approach and diagnostic criteria applied, the prevalence of GDM was ranged from 1–20% in Asia,[39] and the incidence rate was reported as 14.8% in Mainland China.[40] Moreover, we observed a less favourable dietary composition among women in Hong Kong with a less energy consumption from carbohydrate (46.2% of energy) and a higher energy consumption from fat (36.8% of energy), whereas women from the Mainland China had a higher energy intake from carbohydrate (48.7%–57.0% of energy) and lower energy intake from fat (32.2%–34.0% of energy).[33,41,42] Our study population also had insufficient and the lowest intakes of fruit and vegetable (mean intake: ~184 g/day and ~115g/day) compared to other Chinese populations (ranged from 286 g/day–440 g/day of fruit intake and 250 g/day–462 g/day of vegetable intake).[33,41,42] Beside, the cultural differences on diet and attitude towards pregnancy, and clinical characteristics of women across ethnic groups may influence glycaemic regulation, compliance and effectiveness of dietary education.[43] For example, a previous study found Chinese migrants in Australia have a different perception of nutritional needs and supplementation use in pregnancy, compared to Australian women of European ancestry.[44] In our study, we also observed traditional antenatal practices and taboos are common in Chinese women in Hong Kong. For example, fruit and some kinds of vegetable are often considered as 'cold food',[45,46] that women are sometimes advised to avoid during pregnancy and the postpartum period. Therefore, we should pay attention to the individual cultural beliefs and attitudes, and variations in dietary composition, to determine an optimal dietary intervention strategy, especially in countries with diverse backgrounds.

One interesting point observed was that fat intake did not differ between the higher and lower tertiles of any of the dietary patterns. Even for the 'prudent pattern' considered as a healthier dietary pattern, women with the higher or lower score for this pattern, both exceeding the recommended fat intake of 20–30% of energy. Similarly,

the other two dietary patterns were also associated with an appropriately high fat intake, accounting for 36–38% of energy. We noticed that the high fat intake was attributed by different type of foods, with various fat composition, e.g., 'red and processed meat' contains higher saturated fat in the '*meat pattern*'; and 'nuts' contains higher unsaturated fat (monosaturated and polyunsaturated fat) in the '*prudent pattern*'. Given there is emerging evidence on different health impact of fat quality, the fat composition in diet may be important and warrants further evaluation in this population.

Our study has several strengths, including this being the first prospective study to examine the nutritional intake from early pregnancy and explore the relationship between maternal dietary patterns and pregnancy and birth outcomes among Hong Kong women. All dietary assessments were conducted face to face, using a validated FFQ, with visual aids to minimise the measurement errors. Furthermore, all the participants were recruited randomly at the antenatal clinic at one of the major public hospitals, which helps reduce selection bias. We acknowledge several limitations of our study. Firstly, we recognise the potential influence of morning sickness in assessing maternal diet, especially during early pregnancy, though this is a common constraint in studies on maternal nutrition. Hence, we have tried to minimise the influence of morning sickness in early pregnancy, and focused on dietary intake over the 3 months preceding the assessment. Secondly, we were not able to study certain nutrients of concerns, e.g., iodine,[3,4] vitamin D,[5,47] that has been highlighted, due to lack of understanding on the use of supplementation and iodised salt, and missing information on iodine and vitamin D in our food composition database. Our study had a smaller sample size, compared to other similar studies.[2,34,48] We also cannot avoid recall bias, which is a common constraint of retrospective dietary assessment. Furthermore, the self-reporting dietary assessment is prone to under-reporting, e.g., consumption of high energy dense food or unhealthy food. These limitations are well recognised and present in many similar studies.

In conclusion, this was the first study to examine the dietary pattern and nutritional intake among pregnant women in Hong Kong. The findings highlighted that suboptimal dietary intake is very common among pregnant women in Hong Kong. There is a need to encourage dietary assessment and to provide practical recommendations in early pregnancy, which will contribute towards a healthier pregnancy.

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Dr Ruth SM Chan unfortunately passed away during the course of preparation and publication of this article. We would like to dedicate this work to the memory of Dr Chan, who had been a staunch supporter of promoting healthy nutrition in pregnancy and all stages of the lifecourse, as well as an outstanding investigator and researcher in nutrition who has contributed tremendously to improve understanding of the nutritional needs of our local population.

AUTHOR DISCLOSURES

All authors have disclosed no conflicts of interest. KT is supported by the Chinese University of Hong Kong Faculty Postdoctoral Fellowship Scheme. This study was supported by the Diabetes and Endocrine Research Fund of the Chinese University of Hong Kong.

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Supplementary table 1. The nutrients targets for Dietary Approaches to Stop Hypertension (DASH) scores

Nutrient	DASH target (1 point)	DASH intermediate target (0.5 point)
Saturated fat, % of energy	≤6	≤11
Total fat, % of energy	≤27	≤32
Protein, % of energy	≥18	≥16.5
Cholesterol, mg/1000kcal	≤71.4	≤107.1
Fibre, g/1000kcal	≥14.8	≥9.5
Magnesium, mg/1000kcal	≥238	≥158
Calcium, mg/1000kcal	≥590	≥402
Potassium, mg/1000kcal	≥2238	≥1534
Sodium, mg/1000kcal	≤1143	≤1286

Adapted from Mellen PB, Gao SK, Vitolins MZ, Goff DC, Jr. Deteriorating dietary habits among adults with hypertension: DASH dietary accordance, NHANES 1988-1994 and 1999-2004. Arch Intern Med. 2008;168(3):308-14.

Supplementary table 2. The scoring criteria of Dietary Quality Index International

Component	Score range	Points, criteria	The recommendation		
			L	M	H
Variety	0-20				
Overall food group variety (meat/poultry/fish/egg; dairy/beans; grains; fruits; vegetable)	0-15	15, ≥1 serving from each food group/day 12, Any 1 food group missing/day 9, Any 2 food groups missing/day 6, Any 3 food groups missing/day 3, ≥4 food groups missing/day 0, None from any food groups			
Within-group variety for protein source (meat, poultry, fish, dairy beans, eggs)	0-5	5, ≥3 different sources/day 3, 2 different sources/day 1, From 1 source/day 0, None			
Adequacy	0-40				
Vegetables group,† serving/day	0-5	5, ≥100% recommendation 3, 50-100% recommendation 1, <50% recommendation 0, 0% recommendation	≥3	≥4	≥5
Fruit group,† serving/day	0-5	5, ≥100% recommendation 3, 50-100% recommendation 1, <50% recommendation 0, 0% recommendation	≥2	≥3	≥4
Grain group,† serving/day	0-5	5, ≥100% recommendation 3, 50-100% recommendation 1, <50% recommendation 0, 0% recommendation	≥6	≥9	≥11
Fibre,† g/day	0-5	5, ≥100% recommendation 3, 50-100% recommendation 1, <50% recommendation 0, 0% recommendation	≥20	≥25	≥30
Protein, % of energy	0-5	5, ≥100% recommendation 3, 50-100% recommendation 1, <50% recommendation 0, 0% recommendation	≥10		

Adapted from Kim S, Haines PS, Siega-Riz AM, Popkin BM. The Diet Quality Index-International (DQI-I) provides an effective tool for cross-national comparison of diet quality as illustrated by China and the United States. J Nutr. 2003;133(11):3476-84.
CHO, Carbohydrate; P, Protein; F, Fat; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid; SFA, saturated fatty acid.
†Based on daily energy intake: L, <1700 kcal; M, ≥1700-2699 kcal; H, ≥2700
‡Based on the recommended daily intake for Chinese population. Chinese Nutrition Society, Chinese Dietary Reference Intakes Handbook (2013). 2014

Supplementary table 2. The scoring criteria of Dietary Quality Index International (cont.)

Component	Score range	Points, criteria	The recommendation		
			L	M	H
Iron,‡ mg/day	0-5	5, ≥100% recommendation 3, 50-100% recommendation 1, <50% recommendation 0, 0% recommendation	≥20		
Calcium,‡ mg/day	0-5	5, ≥100% recommendation 3, 50-100% recommendation 1, <50% recommendation 0, 0% recommendation	≥800		
Vitamin C,‡ mg/day	0-5	5, ≥100% recommendation 3, 50-100% recommendation 1, <50% recommendation 0, 0% recommendation	≥100		
Moderation	0-24				
Total fat	0-6	6, ≤20% total energy/day 3, >20-30% total energy/day 0, >30% total energy/day			
Saturated fat	0-6	6, ≤7% total energy/day 3, >7-10% total energy/day 0, >10% total energy/day			
Cholesterol	0-6	6, ≤300 mg/day 3, >300-400 mg/day 0, >400 mg/day			
Sodium	0-6	6, ≤2400 mg/day 3, >2400-3400 mg/day 0, >3400 mg/day			
Overall balance	0-10				
Macronutrient ratio, % of energy (Carbohydrate: Protein: Fat)	0-6	6, CHO 55-65: P 10-15: F 15-25 4, CHO 52-68: P 9-16: F 13-27 2, CHO 50-70: P 8-17: F 12-30 0, Otherwise			
Fatty acid ratio	0-4	4, PUFA/SFA:1-1.5 and MUFA/SFA: 1-1.5 2, PUFA/SFA:0.8-1.7 and MUFA/SFA: 0.8-1.7 0, Otherwise			

Adapted from Kim S, Haines PS, Siega-Riz AM, Popkin BM. The Diet Quality Index-International (DQI-I) provides an effective tool for cross-national comparison of diet quality as illustrated by China and the United States. J Nutr. 2003;133(11):3476-84.
CHO, Carbohydrate; P, Protein; F, Fat; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid; SFA, saturated fatty acid.
†Based on daily energy intake: L, <1700 kcal; M, ≥1700-2699 kcal; H, ≥2700
‡Based on the recommended daily intake for Chinese population. Chinese Nutrition Society, Chinese Dietary Reference Intakes Handbook (2013). 2014.

Supplementary table 3. The scoring criteria of Mediterranean Diet Score

Component	Point, Criteria
Vegetables, g/day	1, ≥ medium 0, < medium
Legumes, g/day	1, ≥ medium 0, < medium
Fruits, g/day	1, ≥ medium 0, < medium
Cereal, g/day	1, ≥ medium 0, < medium
Fish, g/day	1, ≥ medium 0, < medium
Dairy, g/day	1, < medium 0, ≥ medium
Meats, g/day	1, < medium 0, ≥ medium
Poultry, g/day	1, < medium 0, ≥ medium
MUFA/SFA ratio	1, < medium 0, ≥ medium

Adapted from Trichopoulou A, Costacou T, Bamia C, Trichopoulos D. Adherence to a Mediterranean diet and survival in a Greek population. N Engl J Med. 2003;348(26):2599-608. MUFA: monounsaturated fatty acid; SFA: saturated fatty acid.

Supplementary table 4. Adjusted linear regression analysis of dietary patterns with health parameters

Health parameters	Sweet and fast-food pattern		Prudent pattern		Meat pattern	
	Coefficient	95% CI	Coefficient	95% CI	Coefficient	95% CI
BMI †	-0.25	-1.12, 0.61	-0.48	-1.16, 0.20	-0.36	-1.39, 0.67
SBP ‡	-3.49	-7.64, 0.67	-3.71	-7.06, -0.36	-4.82	-10.40, 0.76
DBP ‡	-0.81	-3.82, 2.20	-2.69	-5.12, -0.26	-1.02	-5.07, 3.03
GWG §	-0.13	-1.14, 0.88	0.10	-0.71, 0.92	0.39	-0.80, 1.58
Birthweight §	15.89	-123.5, 158.3	55.3	-58.8, 169.3	106.7	-59.9, 273.4
Gestational age §	-0.17	-0.78, 0.45	-0.14	-0.63, 0.35	0.29	-0.42, 1.01

BMI: body mass index (calculated as weight in kilograms divided by the square of height in meters); SBP: systolic blood pressure; DBP: diastolic blood pressure; GWG: total gestational weight gain (calculated as [body weight before delivery in kg] – [body weight at first antenatal appointment in kg]).
†Adjusted for age, smoking habit, family income, education level, marital status, energy intake, other dietary patterns;
‡Adjusted for age, BMI before pregnancy, smoking habit, family income, education level, marital status, energy intake, other dietary patterns;
§Adjusted for age, BMI before pregnancy, smoking habit, family income, education level, marital status, energy intake, delivery method, other dietary patterns.

Supplementary table 5. Logistic regression analysis of dietary patterns with Gestational Diabetes Mellitus (GDM) and Gestational Weight Gain (GWG)

	Sweet and fast-food pattern				Prudent pattern				Meat pattern			
	OR	95% CI	aOR	95% CI	OR	95% CI	aOR	95% CI	OR	95% CI	aOR	95% CI
GDM†												
Without GDM	Reference											
With GDM	1.08	0.67, 1.74	1.16	0.58, 2.31	0.76	0.51, 1.13	0.77	0.58, 2.31	1.69	0.97, 2.93	1.76	0.72, 4.28
GWG‡												
Appropriate§	Reference											
Inadequate	0.68	0.46, 1.02	0.82	0.47, 1.42	1.06	0.71, 1.58	1.18	0.76, 1.84	1.07	0.73, 1.59	1.36	0.71, 2.62
Excessive	0.93	0.55, 1.56	0.85	0.38, 1.89	0.62	0.30, 1.28	0.60	0.28, 1.30	1.45	0.86, 2.45	1.62	0.65, 4.03

GDM: gestational diabetes mellitus; GWG: gestational weight gain (calculated as [body weight before delivery in kg] – [body weight at first antenatal appointment in kg]); OR: Odd Ratio; aOR: adjusted Odd Ratio.
†Adjusted for age, body mass index before pregnancy, smoking habit, family income, education level, marital status, energy intake, other dietary patterns;
‡Adjusted for age, smoking habit, family income, education level, marital status, energy intake, delivery method, other dietary patterns;
§Institutes of Medicine. Weight gain during pregnancy: reexamining the guidelines. Washington, DC: National Academies Press; 2009, according to pre-pregnancy BMI class.