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Association between Maternal Food Group Intake and Birth Size

(Perkaitan antara Pemakanan Ibu Semasa Mengandung dengan Saiz Kelahiran Bayi)

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ABSTRACT

*Maternal nutrition is one of the dominant factors in determining fetal growth and subsequent developmental health for both mother and child. This study aimed to explore the association between maternal consumption of food groups and birth size among singleton, termed newborns. One hundred and eight healthy pregnant women in their third trimester, aged 19 to 40 years who visited the Obstetrics and Gynecology Clinic of Hospital Universiti Sains Malaysia completed an interviewed-administered, validated semi-quantitative food frequency questionnaire. The maternal socio-demographic, medical and obstetric histories and anthropometry measurements were recorded accordingly. The pregnancy outcomes, birth weight, birth length and head circumference were obtained from the medical records. The data were analyzed using multiple linear regression by controlling for possible confounders. Among all food groups, fruits intake was associated with higher birth weight (*p*=0.018). None of the food intake showed evident association with respect to birth length while only fruits intake was associated positively with head circumference (*p*=0.019). In contrast, confectioneries and condiments were associated with lower birth weight (*p*=0.013 and* p*=0.001, respectively). Also, condiments appeared to associate inversely with ponderal index (*p*=0.015). These findings suggest the potential beneficial effects of micronutrient rich food but detrimental effects of high sugar and sodium food on fetal growth. Such an effect may have long term health consequences to the lives of children.*

Keywords: Birth weight; food frequency questionnaire; maternal intake; pregnancy

ABSTRAK

*Pemakanan ibu adalah antara faktor utama dalam menentukan pertumbuhan dan kesihatan bayi dan ibu. Penyelidikan ini bertujuan untuk mengkaji perkaitan antara pemakanan ibu berdasarkan kepada kumpulan makanan dan saiz kelahiran bayi. Seratus lapan orang ibu mengandung yang berkunjung ke Klinik Obstetrik dan Ginekologi Hospital Universiti Sains Malaysia, berada dalam trimester ketiga kehamilan dan berumur 19–40 tahun telah ditemu duga dengan menggunakan borang soal selidik kekerapan pengambilan makanan yang telah divalidasi. Maklumat sosiodemografi, sejarah perubatan dan obstetrik serta pengukuran antropometri ibu direkodkan. Maklumat selepas kehamilan, berat bayi, panjang bayi dan lilitan kepala bayi diambil daripada rekod perubatan. Data dianalisis dengan kaedah regresi linear berganda. Antara semua kumpulan makanan, pengambilan buah-buahan mempunyai perkaitan dengan berat bayi yang lebih tinggi (*p*=0.018). Tiada kumpulan makanan yang menunjukkan hubung kait dengan panjang bayi, manakala hanya pengambilan buah-buahan mempunyai perkaitan positif dengan lilitan kepala (*p*=0.019). Sebaliknya, pengambilan konfeksi dan kondimen berkait dengan berat bayi yang lebih rendah (*p*=0.013 dan *p*=0.001). Pengambilan kondimen juga mempunyai perkaitan songsang dengan indeks ponderal (*p*=0.015). Keputusan ini menunjukkan bahawa pengambilan makanan mikronutrien tinggi membawa kesan baik manakala pengambilan makanan yang mengandungi gula dan garam tinggi membawa kesan buruk kepada pertumbuhan bayi. Kesan seperti ini mungkin akan mempengaruhi kesihatan kanak-kanak dalam jangka masa yang panjang.*

Kata kunci: Berat lahir; kehamilan; kekerapan pengambilan makanan; pemakanan ibu

Introduction

Pregnant women are considered as a vulnerable group due to their increased nutritional demands to support metabolic changes and fetal growth (Berti et al. 2010). An adverse maternal environment was proposed to induce fetal programming through physiologic, metabolic and structural adaptations to increase fetus survival chances (Barker 2004). These programming changes can be detrimental and may translate into pathology or chronic disease when conflict occurs in the postnatal environment (Cottrell & Ozanne 2008). Part of this association might be mediated through effects on birth outcomes. Size at birth is an important indicator to reflect fetus growth trajectory and has been shown to be associated with adult diseases. Infants who were born smaller, larger or with disproportionate body dimensions were shown to have increased risk of later diseases (Fall 2006).

Maternal dietary intake during pregnancy is one of the important modifiable factors that can exert substantial influence on the infant's birth size and subsequent long term health effects. Understanding this relationship may provide a basis to develop valuable dietary guideline during pregnancy for improving fetal growth (Fowles 2004). However, the association between maternal nutrition and fetal growth is complex. It is influenced by various biological and socio-economic factors which vary widely across populations and geographical areas (Rao et al. 2001). Thus, a culturally appropriate study based on the local epidemiology of prenatal condition is crucial to be carried out to determine the role of specific diet on birth outcomes which may differ from other places.

There have been a number of studies that focus on assessing maternal nutrient intake in relation to birth size (Borazjani 2011; Lagiou et al. 2004). As reviewed by Abu-Saad and Fraser (2010), energy, dietary protein or multinutrient supplements were shown to associate with increased birth weight. However, investigations of maternal food intake and birth size are scarce, particularly in the Asian setting. Therefore, the present study was done to examine the association between various food groups intake and birth size in an Asian country, Malaysia. Focusing on food intake rather than specific nutrient within the food item will provide a more effective way for dietary counseling and will enable other possible bioactive components of foods to be considered (Fowles 2004).

Healthy food consumption and eating pattern during pregnancy promotes fetal development (Fowles 2004). Therefore, we hypothesized that increased consumption of nutrient-rich foods from natural sources such as milk and dairy products, green leafy vegetables and fresh fruits, would promote fetal growth. In contrast, increased consumption of high sugar and sodium foods such as confectioneries and condiments would reduce fetal growth.

Materials and Methods

The data were undertaken from the preliminary study of an ongoing, prospective Universiti Sains Malaysia (USM) Birth Cohort Study, in the state of Kelantan, Malaysia. The Kelantan state comprises primarily Malay ethnicity, which is the majority of the Malaysian population. This was a cross-sectional study and the respondents were recruited using convenience sampling technique. The study sample consisted of pregnant women enrolled in the Obstetrics and Gynecology Clinic at the Hospital Universiti Sains Malaysia (HUSM), between November 2009 and March 2010. To fulfill the criteria of inclusion, women had to be Malaysian and Malay ethnicity, aged 19 to 40 years, with singleton pregnancy, gestational age of ≥28 weeks based on the last menstrual period (LMP) and confirmed by an early obstetric ultrasound. Ultrasound date was used when the LMP was unknown or differed by more than seven days from the date of an ultrasound scan. Women were not eligible if they had a history of chronic disease or pregnancy event in the current gestation at the time of recruitment.

Of 177 recruited pregnant women, 69 of them (39%) were excluded from the study due to incomplete questionnaires, development of gestational diabetes mellitus or hypertension near the time of delivery, not giving birth at the HUSM, preterm birth (<37 weeks of gestation) with multiple pregnancy or incomplete birth outcomes records because of neonatal intensive care unit admission. The final study sample consisted of 108 pregnant women. Sample size calculation indicated that 140 women were required to give 90% power to detect a 220 g difference in mean birth weight (SD 400 g) between the extreme thirds of food intake (two sided $\alpha = 0.05$). Present analysis may therefore reduced the statistical power (80%). This study was approved by the Human Research Ethics Committee of USM and written informed consent was obtained from all the participants.

Maternal socio-demographic, medical and pregnancy histories were obtained by standardized interviews and traced from clinical prenatal records. Maternal anthropometric measurements were taken in the clinic. Height was measured using a stadiometer (SECA, Germany) and weight at recruitment was measured using a digital weighing scale (SECA, Germany). Pre-pregnancy weight was based on the mothers' recall as reported by others (Gunderson & Abrams 2000; Thorsdottir et al. 2002). Body mass index (BMI) was calculated as pre-pregnancy weight-for-height^2 (kg/m^2). Maternal weight gain rate was calculated as the difference between weight measured at recruitment and pre-pregnancy weight, divided by gestational week at recruitment which is minus two weeks from the denominator (kg/week) (Stotland et al. 2006). This calculation was used as the gestational age was counted from the first day of the LMP, not the date of conception which generally occurs two weeks later. Weight gain rate was used in the analysis instead of total weight gain due to the wide range of gestational weeks (≥28 weeks of gestation) at recruitment. However, it should be noted that this only adjusted for some of the variation as women tend to gain more weight later in pregnancy than in the early gestation. The computed rates of weight gain were then compared with the guidelines from Institute of Medicine (2009).

Dietary information was collected via interview using a validated semi-quantitative food frequency questionnaire (FFQ) (Loy et al. 2011). The FFQ covered a list of 82 food and beverage categories with assigned standard portion size. Habitual food intake for the past six months were asked by indicating the number of frequency intake according to the options: 'per day', 'per week', 'per month' and 'never'. The response for each food category was converted into average daily intake by multiplying the reported frequency of intake per day, serving size, total number of serving and weight of food in one serving. The seasonal food consumption was based on the frequency of intake during that respective period. Total energy intake was referred to the Malaysian Nutrient Composition of Foods (Tee et al. 1997) and U.S. Department of Agriculture (USDA 2009) nutrient database. All dietary data were computed using the Nutritionist Pro™ software (Axxya Systems LLC., USA).

Information on the infant's delivery characteristics (i.e. infant's gestational age, sex, health status and delivery method) and anthropometric measures (birth weight, birth length and head circumference) at birth were obtained from the hospital obstetric records. Birth weight and birth length were measured using baby weighting scale (SECA 334, Germany) and recorded by the nurses in the labor room. Ponderal index was calculated as infant's weight-for-length^3 (kg/m^3).

Statistical evaluations were done using the PASW® Statistics 18 (SPSS, Inc., Chicago, IL, USA). Characteristics of the study sample were described by frequency and percentage. Maternal and neonatal anthropometry profiles were described by mean and standard deviation (SD). Maternal total energy and food intake were expressed as median and inter-quartile range due to skewed distributions shown in all food groups.

In evaluating food intake, two food categories were removed from the fruits group analysis, which were pickled fruit and dried fruit as the aim was to examine natural fresh fruits. In addition, the result of fruits intake and birth size was distorted when incorporating these two fruit categories which resulted in a dilution effect. The remaining 80 food categories were then further classified into 11 main groups which were mutually exclusive, including cereals and cereal products, meat, poultry and fish, milk and dairy products, nuts and legumes, green leafy vegetables, vegetables, fruits, beverages, confectioneries, condiments, fats and oils (Table 1). Because consumptions of all food groups were positively correlated with total energy intake, thus adjustment for energy intake was undertaken for all food groups to control for confounding. It is problematic to simply adjust for total energy intake in a standard multivariate model. Correlations between these two variables (energy and food intake) increase the variance around the regression coefficients and may inflate standard errors (Mackerras 1996; Moore et al. 2004). Thus, energy adjustment using residual method was used to avoid this problem (Mackerras 1996; Willett 1998; Willett et al. 1997).

The association between maternal food group intake (independent variable) and birth size (dependent variable) was examined using multiple linear regression. Potential confounding variables were considered based on previously reported determinant factors of fetal growth in the literature. The variables that evidenced significant association ($p<0.05$) with birth size or food intake in univariate analysis were selected as confounders. Food intake was logarithmically transformed to reduce the leverage of outlying values in univariate analysis. The included confounders were maternal employment (categorically), monthly household income (categorically), pre-pregnancy weight (continuously), weight gain rate (continuously), parity (continuously), gestational age at delivery (continuously) and infant's sex (categorically). All of these confounders were included simultaneously in the baseline regression model. Food intake was then retransformed into food residual (energy-adjusted food intake) and entered alternatively in the model. Finding at $p<0.05$ for a two-sided test was considered statistically significant. Multicollinearity was checked by variance inflation factor (VIF) and the fit of regression model was ascertained by examination of model assumptions.

RESULTS AND DISCUSSION

Table 2 shows the distributions of the study sample by maternal and delivery characteristics. The mean age of the women was 29.7 (SD 4.8) years while the mean gestational age at recruitment was 33.66 (SD 3.95) weeks.

TABLE 1. Classification of food categories into food groups

Food group	Food item
Cereals and cereal products	Rice, glutinous rice, bread, oatmeal, noodles, maize
Meat, poultry and fish	Beef, chicken, liver, egg, marine fish, river fish, canned fish, shrimp, cutlet fish, cockles, anchovies, fish cake, salted fish, fish cracker
Milk and dairy products	Whole milk, skimmed milk, low fat milk, yogurt, cheese
Nuts and legumes	Peanut, dhal, red bean, mung bean, cashew nut, chick pea, soy product
Green leafy vegetables	Mustard leaves, swamp cabbage, kale, spinach, sweet potato shoot, fern shoot, indian pennywort, 'ulam raja'
Vegetables	Cabbage, cauliflower, string bean, four-angled bean, potato, carrot, sweet potato, cucumber, gourd, tomato
Fruits	Apple, orange, banana, pear, papaya, watermelon, honeydew, pineapple, mango, guava, water apple, rambutan, durian, mangosteen, jackfruit, grape
Beverages	Tea, coffee, juice, malt drink, syrup drink
Confectioneries	Cake, cookies, chocolate, candy, sweetened condensed milk
Condiments	Chili paste, shrimp paste, chili sauce, tomato sauce, soy sauce, fish sauce, oyster sauce
Fats and oils	Margarine, peanut butter, coconut milk, cooking oil

TABLE 2. Maternal and delivery characteristics (*n*=108)

Characteristic	*n*	%
Maternal age (years)		
19 – 24	17	15.7
25 – 29	38	35.2
30 – 34	35	32.4
35 – 40	18	16.7
Maternal employment		
Working	65	60.2
Unemployed	43	39.8
Maternal education		
Precollege	53	49.1
College/ University	55	50.9
Monthly household income (Ringgit Malaysia)		
< 1500	25	23.1
1500 – 3500	52	48.2
> 3500	31	28.7
Parity status		
Primipara	35	32.4
Para 2	35	32.4
Multipara	38	35.2
History of miscarriages		
Yes	28	25.9
No	80	74.1
Type of delivery		
Normal	71	65.7
Caesarean section	37	34.3
Infant's gender		
Boy	54	50.0
Girl	54	50.0

The majority of women were employed and in the middle income category. None of the women reported smoking and alcohol intake due to cultural and religious restrictions. Table 3 shows the anthropometry profiles for 108 pairs of healthy mothers and full- termed newborns. Prior to pregnancy, 6.5% of women were underweight (BMI<18.5 kg/m^2), 53.7% of women were normal weight (BMI 18.5-24.9 kg/m^2), whereas 25.9% and 13.9% of women were overweight (BMI 25-29.9 kg/m^2) and obese (BMI≥30 kg/m^2), respectively. Overall, pre-pregnant nutritional status of women was within normal BMI category (18.5-24.9 kg/m^2). Although maternal pre-pregnancy weight was based upon recall, it had been shown that these data were reliable for women of normal weight and therefore minimized the risk of under- or overestimation (Gunderson & Abrams 2000; Kuskowska-Wolk et al. 1989; Thorsdottir et al. 2002). The average weight gain rate for women who were underweight, normal and obese was within adequate category, respectively, except for overweight women who showed excessive rate of weight gain according to Institute of Medicine (2009). The termed newborns were delivered on an average of 38.73 (SD 1.01) weeks and male infants were generally larger than female infants although the corresponding difference was not statistically significant. The distribution of birth weight was slightly lower than the mean birth weight of 3.32kg which was derived from the Malaysian Family Life Survey II (Mahmud & Sallam 1999). A total of 3.7% of infants had low birth weight (<2.50 g) and this proportion was similar to that for infants born to healthy Malay women in Kota Bharu, Kelantan reported by Norkhafizah et al. (2004). Infants with optimal (2.5-4.0 kg) and high (>4.0 kg) birth weights were comprised of 90.7% and 5.6%, respectively.

Table 4 shows the estimated intake of energy and food during pregnancy. Mean energy intake (2189.63 kcal/day) was adequate as compared with the Recommended Nutrient Intake (RNI) for Malaysian pregnant women (NCCFN 2005). Table 5 shows the regression models for birth size in terms of food intake and confounders. The B regression coefficients for the birth size were the changes in outcome that corresponded with a 1 g increase in the food intake. The results showed that fruits intake appeared to be positively associated with birth weight. An increase of 10 g of fruits was associated with an increase in birth weight of 6.2 g. In contrast, each 10 g increase in confectioneries or condiments intake reduced birth weight by 20 g (p=0.013) and 52.1 g (p=0.001), respectively. With respect to birth length, no significant association was observed with any food group. Head circumference was positively associated with intake of fruits (B=0.002,

TABLE 3. Maternal and neonatal anthropometry profiles

Variables	Maternal anthropometry (n=108)	Neonatal anthropometry	
		Boys (n=54)	Girls (n=54)
	Mean (SD)	Mean (SD)	
Weight (kg)	59.66 (12.77)[a]	3.28 (0.42)	3.12 (0.48)
Height (m)	1.55 (0.06)	0.52 (0.02)	0.52 (0.02)
Body mass index (kg/m^2)	24.78 (5.25)[a]	23.04 (2.90)[b]	22.73 (3.11)[b]
Weight gain rate (kg/week)			
Underweight (<18.5 kg/m^2)	0.46 (0.10)	-	-
Normal weight (18.5-24.9 kg/m^2)	0.38 (0.17)	-	-
Overweight (25-29.9 kg/m^2)	0.35 (0.17)	-	-
Obese (≥30 kg/m^2)	0.23 (0.13)	-	-
Head circumference (cm)	-	33.46 (1.76)	33.30 (1.60)

[a] Pre-pregnancy status
[b] Ponderal index (kg/m^3)

TABLE 4. Maternal energy and food intakes during pregnancy

Food intake (g/day)[a]	Lower quartile	Median	Upper quartile
Total energy intake (kcal/day)	1654.84	2030.66	2634.58
Cereals and cereal products	340.63	449.02	553.89
Meat, poultry and fish	100.35	168.69	259.17
Milk and dairy products	22.00	50.50	105.00
Nuts and legumes	10.55	50.55	116.54
Green leafy vegetables	12.28	21.63	36.20
Vegetables	25.01	43.36	69.91
Fruits	85.87	145.47	253.30
Beverages	116.75	230.57	402.28
Confectioneries	29.01	49.75	87.26
Condiments	6.08	17.34	30.58
Fats and oils	17.96	25.97	36.21

[a] Based on absolute value

TABLE 5. Maternal food intake during pregnancy and infant's birth size[a]

Food group	Birth weight (g)		Birth length (cm)		Head circumference (cm)		Ponderal index (kg/m^3)	
	B	P	B	P	B	P	B	P
Cereals and cereal products	-0.366	0.227	0.001	0.950	-0.001	0.201	-0.003	0.225
Meat, poultry and fish	-0.018	0.965	-0.001	0.702	0.001	0.372	0.001	0.706
Milk and dairy products	-0.258	0.435	0.002	0.233	-0.001	0.507	-0.004	0.050
Nuts and legumes	0.070	0.854	-0.006	0.251	0.005	0.852	0.014	0.318
Green leafy vegetables	-0.563	0.646	0.001	0.846	0.004	0.436	-0.005	0.591
Vegetables	0.120	0.837	-0.002	0.577	0.001	0.919	0.005	0.217
Fruits	0.618	0.018	0.002	0.306	0.002	0.019	0.003	0.164
Beverages	0.041	0.836	-0.001	0.602	0.001	0.496	0.001	0.333
Confectioneries	-1.999	0.013	-0.007	0.145	0.001	0.987	-0.005	0.378
Condiments	-5.208	0.001	-0.008	0.356	-0.004	0.514	-0.026	0.015
Fats and oils	-0.304	0.879	0.007	0.529	0.001	0.968	-0.012	0.362

[a] Adjusted for maternal employment, monthly household income, pre-pregnancy weight, weight gain rate, parity, infant's sex and gestation. Food group intake adjusted for total energy

p=0.019) while ponderal index was inversely associated with intake of condiments (B=-0.026, p=0.015).

In this paper, we found that three food groups were associated with infant's birth weight compared to other birth-size parameters. Although being a proxy and crude health measurement, birth weight manifests the summary measures of the interactive factors (i.e. maternal environment and genetic) and remains as a global indicator for infant's health (Christian 2010; Harding 2001). Based on the results, birth weight was positively associated with intake of fruits, but inversely associated with intake of confectioneries and condiments.

Fruits are rich in vitamins and antioxidants. Women who took more fruits during pregnancy delivered infants with higher birth size. The positive association between fruit intake and birth weight was also evidenced in other studies. Studies conducted among under-nourished Indian and well-nourished Danish pregnant women showed that increased consumption of micronutrient-rich fruits was associated with increased birth weight (Mikkelsen et al. 2006; Rao et al. 2001), although causal-inference relationships were inconclusive. Vitamin C which is plentiful in fruits had been found to be associated with increased birth weight (Mathews et al. 1999). Other unexamined rich sources of phytonutrients in fruits are believed to confer antioxidative protective effect on birth outcomes by combating maternal-foetal oxidative stress during pregnancy. The vast majority of studies indicated that oxidative stress was conducive to poor foetal growth, resulting from transplacental oxygen deficiency (Kim et al. 2005; Saker et al. 2008).

Food groups of green leafy vegetables, milk and dairy product which are also rich in micronutrients did not show the expected association. These food groups have been reported to demonstrate positive association with birth outcomes by previous studies (Olsen et al. 2007; Ramon et al. 2009). Only one study showed consistent result with our findings (Petridou et al. 1998). A possible explanation was perhaps due to the good pre-pregnant nutritional status of women that conferred a marked protective effect against stress factors which reduced birth weight. This directly impaired the detection of any significant association with the small amount of additional vegetables intake in the present population. A similar phenomenon was shown by the weaker influence of green leafy vegetables and milk products on birth weight in better nourished women (Kanade et al. 2008; Mikkelsen et al. 2006) compared with under-nourished women (Rao et al. 2001).

As suggested by Berti et al. (2010), the bioavailability of nutrients is dependent upon maternal nutritional status other than food composition. In addition, different combinations of food sources in the food group that exhibits different micronutrient content may contribute to the inconsistent results. Also, it can be due, at least, to some extent, to secondary factors that differ across the studies such as maternal background characteristics and assessing methods for dietary variables (Abu-Saad & Fraser 2010).

Confectioneries refer to a set of food items that are rich in sugar. High intake of confectioneries was associated with reduced birth weight. A consistent finding was reported by Lenders et al. (1997), showing high sugar diets consumption was at increased risk for delivering small-for-gestational-age infants among pregnant adolescents. Similarly, sucrose intake was found to associate negatively with birth weight. As suggested by Watson and McDonald (2010), diet low in refined sweet foods such as confectionery should be chosen for pregnant women to improve birth outcomes. The effect of sugar intake on birth weight was suggested to be mediated through factors affecting insulinemia, insulin resistance and cellular integrity (Lenders et al. 1994, 1997). Hyperinsulinemia was found to affect blood flow and blood pressure by changing prostaglandin activity, sympathetic nervous system activity and cellular ion exchange (Axelrod 1991; DeFronzo & Ferrannini 1991). All these factors might interact with each other and eventually contribute to reduced placental blood flow and adverse fetal growth (Lenders et al. 1997).

Condiments are sauces or seasonings added to the food to improve flavour. Women who reported a greater intake of condiments during pregnancy had infants with lower birth weight and ponderal index. However, we did not find any strong evidence in support of these inverse associations. We found that the majority of past studies did not focus on assessing condiments intake as a sole food group in relation to birth outcomes. Throughout the analyses, condiments intake was the only food group which showed significant association with body proportion (ponderal index) of the infant. In comparison to birth weight, body proportion at birth was suggested as a more critical risk indicator for adult disease (Fall 2006; Phillips et al. 1994). These findings, therefore, may reflect the detrimental impact of high condiments intake upon fetal growth which increases the later disease risk of an infant.

Although condiments are known as rich in sodium (Lin et al. 2003) and commonly low in nutritional value, the role of sodium and other components in the food are not fully identified in human pregnancy. Furthermore, there are contradictory results concerning sodium intake during pregnancy in relation to birth weight (Doyle et al. 1989; Lagiou et al. 2004; van der Maten 1995). The contributing factors and underlying mechanisms for intake of condiments and birth size are therefore remained elucidated. However, raised blood pressure was found to be associated with decreased ponderal index at birth among children and adults (Barker et al. 1992; Law et al. 2001). As shown in the results, decreased ponderal index might attributable to women with relatively high blood pressure which do not amount to PIH or use of medication, even though women with PIH were excluded from the analysis. There are several limitations in this study. Since this was a local study and homogenous for one ethnic population, it has limited the result generalizability to other locations and ethnic groups. Although significant results were shown in our sample, cautious interpretations of the present findings are needed due to the small sample size included in the analyses. Also, the FFQ may not be comprehensive enough to reflect the overall food group intake such as processed meat (e.g. hot dog, burger meat and nuggets) among pregnant women as the food list has been shortened at the FFQ validation phase (Loy et al. 2011). In addition, the underlying mechanisms for an association between intake of condiments and birth size have yet to be elucidated and need to be further investigated by considering the confounding effect of blood pressure which did not address in the present study.

CONCLUSION

Overall, our work agreed that maternal diet during pregnancy exerts, at most, a small impact on birth size among the reasonably well-nourished women. However, the findings suggest that dietary intake during pregnancy have the potential to affect fetal growth trajectory and determine the size at birth of infants born at full-term. Consumption of micronutrient-rich food exerts beneficial impact upon an infant's growth. Detrimental effect on infant's growth is likely from consumption of high sugar and sodium food.

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