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Dietary pattern, nutrient intake, and oral symptoms in a sample of pregnant women in Malaysia

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ABSTRACT

Introduction: Nutritional requirements of pregnant women differ considerably from those of non-pregnant women. Nutritional status during pregnancy is critical to maintain health, including oral health, and to promote growth and development of the baby. This study assessed dietary pattern, nutrient intake, and oral symptoms among pregnant women. **Methods:** Seventy-one women with singleton pregnancy attending a public healthcare centre in Malaysia participated in this cross-sectional study. Dietary pattern and nutrient intake of the women were assessed using food frequency questionnaire and 3-day 24-hour diet recall, respectively. Information on sociodemographic and obstetric profiles, and oral symptoms were obtained from self-administered questionnaire. **Results:** White rice, chicken, green leafy vegetables, granulated sugar, and salt were foods most consumed. Intakes of iron, folate, vitamin C, vitamin D, calcium, iodine, zinc, and fluoride for most respondents were below Recommended Nutrient Intake (RNI). Cavitated tooth (46.5%), bleeding gums (35.2%), pain upon eating and drinking (23.9%), and bad breath (23.9%) were common oral symptoms reported. Significant association was found between complaint of brown, yellow, and white spots on tooth surface with vitamin A intake, and between complaint of bleeding gums with zinc intake. **Conclusion:** Intake of most nutrients by most respondents in this study was below the RNI. Oral symptoms were common and a few were associated with nutrient intakes.

Keywords: dietary intake, nutrients, oral health, pregnancy, pregnant women

INTRODUCTION

Pregnant women are vulnerable to nutritional inadequacy due to metabolic changes and increased nutritional requirements of the growing foetus (Marshall *et al.*, 2022). Inadequate nutrient intake in pregnant women has been shown to be associated with poor dietary pattern as they tend to continue their pre-pregnancy dietary intake instead of adjusting their diet to meet the changing nutrient requirements during pregnancy (Savard *et al.*, 2018). Additionally, women living in low- and middle-income countries are often unable to meet the high nutrient demands of pregnancy due to social-related issues, leading to a chronically poor diet (Lee *et al.*, 2013). Iron deficiency is one of most prevalent forms of malnutrition in pregnant women (Madanijah *et al.*, 2016; Savard *et al.*, 2018). Folate and calcium are other nutrients commonly reported to be deficient among pregnant women (Madanijah *et al.*, 2016; Savard *et al.*, 2018). Energy intake has also been

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shown to be insufficient among pregnant women in developing countries, mainly due to low dietary diversity and having a starch-based diet (Madanijah *et al*., 2016).

Inadequate intake of essential nutrients may affect not only the health of the foetus, but also the health of the mother (Marshall *et al*., 2022), including her oral health (Rahman & Walls, 2020). The relationship between nutrition and oral health is bi-directional. Nutrients play an important role in oral health maintenance and oral disease prevention, and the health of the oral cavity influences the type of foods that can be eaten and subsequent supply of nutrients (Rahman & Walls, 2020). Additionally, the early symptoms of nutrient deficiencies often manifest in the mouth (Rahman & Walls, 2020).

The prevalences of periodontal disease and dental caries have been shown to be high in pregnant women, and are significantly associated with the corresponding oral symptoms (Yunita Sari, Saddki & Yusoff, 2020). While the increased risk for these oral diseases during pregnancy are mainly attributed to the elevated levels of sex hormones oestrogen and progesterone (Silva de Araujo Figueiredo *et al*., 2017), a diet lacking in certain nutrients can also lead to the progression of oral diseases through decreased tissue homeostasis, lowered resistance to microbial biofilm, and impaired tissue healing (Rahman & Walls, 2020). The important link between nutrient and oral health underlines the need to investigate this association in pregnant women.

Evidence suggest that the intakes of micronutrients, such as calcium, iron, vitamin D, folic acid, and niacin, among pregnant women in Malaysia are lower than the national recommendations (Mohamed *et al*., 2022). These micronutrients are not only important for general growth, development, wellbeing, and disease prevention, they are also necessary in maintaining the health of the oral cavity structures (Rahman & Walls, 2020). In addition, vitamin D deficiency during pregnancy may affect calcification of the primary teeth that begins during the fourth month of intrauterine life, leading to enamel defects that may increase the subsequent risk of early childhood caries (Rahman & Walls, 2020). Therefore, in this study, dietary pattern, nutrient intake, and oral symptoms of pregnant women were determined. The association between nutrient intake and oral symptoms of the women was also examined. The findings can provide baseline information that can help restrategise nutrition and oral health programmes for pregnant women.

MATERIALS AND METHODS

Study design, population, and sample

This cross-sectional study was conducted from February 20, 2020 to March 15, 2020 among pregnant women attending a Maternal and Child Healthcare Clinic (MCHC) in Kota Bharu, Kelantan. Ethical approval for this study was obtained from the Universiti Sains Malaysia Human Research and Ethics Committee (USM/JEPeM/17120729) and the Ministry of Health Malaysia Medical Research Ethics Committee (NMRR-19-3398-51678). Women aged 19-50 years with singleton pregnancy were eligible to participate, while those with diabetes mellitus, hypertension, and hyperemesis gravidarum were excluded.

The sample sizes for all specific objectives of this study were calculated and the largest affordable sample size was obtained from the objective to determine oral symptoms of pregnant women using the formula to estimate a single proportion with a 95% confidence interval (CI). The proportion of pregnant women who complained of having cavitated tooth was estimated at 62.0% (Yunita Sari *et al*., 2020). At a precision of 0.1, a sample size of 91 was obtained. Anticipating a 10% non-response rate, a sample size of 100 was selected.

Research tools and variables

Dietary pattern was assessed using a validated food frequency questionnaire (FFQ) by Loy *et al.* (2011), designed specifically for pregnant women in Malaysia. The FFQ comprised of 82 food items, organised into 10 food groups, as follows: 1) Cereal and cereal products, 2) Meat and eggs, 3) Milk and milk products, 4) Nuts, 5) Vegetables, 6) Fruits and fruit juices, 7) Beverages, 8) Fats, 9) Sweet and baked goods, and 10) Condiments. The frequency of food intake was assessed based on habitual intake over the past six months using a 7-point scale as follows: 1 = never or rarely, 2 = once a month, 3 = 2 to 3 times a month, 4 = once a week, 5 = 2 to 3 times a week, 6 = once daily, and 7 = 2 to 3 times daily. The serving or portion size of each food item taken was also captured. Samples of household utensils and measuring instruments were provided to increase the accuracy of serving and portion sizes estimation.

Dietary pattern was determined as food consumption frequency for each food item using a formula by Reaburn, Krondl, & Lau (1979) as follows: Food consumption frequency score = (R1S1 + R2S2 +R3S3 + R4S4 + R5S5 + R6S6 + R7S7) / 7, where S1-S7 referred to the rating scale, while R1-R7 referred to the percentage of respondents selecting the respective rating, with 7 as the maximum rating. The food items were categorised into mostly consumed foods (score of 80.0-100.0), moderately consumed foods (score of 30.0-79.9), and less consumed foods (score of 10.0-29.9) as recommended by Zainal Badari *et al.* (2012). Additionally, the amount of food intake (g) for each food group was calculated using the following formula: Amount of food (g) per day = frequency of intake (conversion factor) x serving size x total number of servings x weight of food in one serving (Norimah *et al.*, 2008).

A 3-day 24-hour diet recall was used to measure nutrient intake. Detailed information about all foods and beverages consumed by the respondents in 2 weekdays and 1 weekend were analysed using the Nutritionist Pro™ software to get the nutrient values. The nutrient values obtained were compared to the Recommended Nutrient Intake (RNI) for Malaysian pregnant women (Ministry of Health Malaysia, 2017) and were categorised as follows: 1) Inadequate, for values below the estimated average requirement, 2) Adequate, for values between the estimated average requirement and tolerable upper intake level, and 3) Excessive, for values exceeding the tolerable upper intake level.

A structured self-administered questionnaire was used to capture the respondents' current experience of symptoms associated with periodontal disease (bleeding gums, swollen gums, gum pain, red gums, loose tooth, bad breath, gum abscess, receding gums, and longer appearing tooth) and dental caries (spontaneous pain, pain upon eating/drinking sweet and hot or cold food/beverages, pain upon biting, cavitated tooth, brown, black, or white spots on tooth surface). Additionally, sociodemographic profile (maternal age, ethnicity, education level, employment status, monthly household income) and obstetric profile (stage of gestation and parity) of the respondents were obtained.

Data collection

A non-proportionate stratified random sampling method was used to capture equal number of samples from the first, second, and third trimesters of pregnancy. Following the establishment of eligibility, simple random sampling was used to select respondents from each stratum. Potential respondents who came for antenatal care follow-up at the MCHC were individually approached by the main author. The women were informed of the importance, objectives, procedures, and other essential information regarding this study. Written informed consent was obtained from all women who agreed to participate.

Further instructions about the study procedures were provided prior to data collection. Administration of the FFQ, structured questionnaire, and interview for Day 1 of the 3-day 24-hour diet recall were done immediately at the MCHC, while interviews for Day 2 and Day 3 of the diet recall were conducted via telephone calls. Data collection was conducted fully by the main author.

Statistical analysis

Data analysis was performed using IBM SPSS Statistics for Windows software, version 24.0 (Armonk, New York, USA). Descriptive statistics for dietary pattern, nutrient intake, oral symptoms, and other variables were determined; mean and standard deviation (*SD*) for continuous variables, and frequency and percentage for categorical variables. Spearman's correlation analysis was used to determine the association between amount of food intake and nutrient intake values. Chi-square test was used to determine the associations between selected nutrients (vitamin A, calcium, and zinc) and dental caries symptoms, and the associations between selected nutrients (vitamin C, iron, and zinc) and periodontal disease symptoms. A Fisher's Exact test was used when the conditions for chi-square test were not met. The level of significance was set at 0.05.

RESULTS

Characteristics of respondents

Owing to the COVID-19 lockdown, data collection period had to be shortened. As of March 15, 2020, we only managed to recruit 71 respondents. Mean age of the respondents was 29.4±4.4 years. Most respondents were from the Malay ethnicity (95.8%), received at least post-secondary education (97.2%), and unemployed (62.0%). Median monthly household income was MYR 2000 (*IQR* 1800). Most respondents were in the third trimester (43.7%), followed by second (32.4%) and first (23.9%) trimesters of pregnancy. More than half of the respondents (74.6%) had given birth at least once previously.

Food intake pattern of respondents

Food consumption frequency scores for all food items based on pregnancy trimester are shown in Table 1. White rice (from the cereal and cereal products group) was the most consumed food by respondents in all trimesters, while chicken (from the meat and eggs group) was the most consumed food by respondents in the second and third trimesters. Other most consumed food items by respondents included mustard green, water spinach, Chinese broccoli, spinach, cassava leaves, and fern (cooked) from the vegetable food group in the third trimester, granulated sugar from the sweet and baked goods food group in the second trimester, and salt from the condiment food group in the second and third trimesters. Most food items from the milk and milk products, as well as from other food groups (nuts, vegetables, fruits and fruit juices, beverages, fats, sweet and baked goods, and condiments) were only moderately consumed by respondents in all trimesters.

Nutrient intakes of respondents

Energy and nutrient intakes of the respondents are shown in Table 2. A total of 13 nutrients were extracted from the respondents' diet. The analysis of mean nutrient intake was done according to the availability of Recommended Nutrient Intake (RNI) values. Analysis for energy and zinc were done according to the trimester of pregnancy as there were differences in RNI between different

Table 1. Food consumption frequency score based on pregnancy trimester

Food consumption	*Trimester 1*		*Trimester 2*		*Trimester 3*	
	Food item (food group)	*Score*	*Food item (food group)*	*Score*	*Food item (food group)*	*Score*
Mostly consumed foods (80.0-100.0)	White rice (G1)	86.55	White rice (G1)	98.14	White rice (G1)	97.70
			Chicken (G2)	80.75	Chicken (G2)	83.41
			Salt (G10)	82.51	Mustard green, water spinach, Chinese broccoli, spinach, cassava leaves, fern (cooked) (G5)	81.16
			Granulated sugar (G9)	80.00	Salt (G10)	80.61
Moderately consumed foods (30.0-79.9)	Biscuit (G9)	78.20	Biscuit (G9)	69.53	Cabbage, broccoli (cooked) (G5)	76.10
	Granulated sugar (G9)	78.13	Garlic, shallot (G5)	68.83	Biscuit (G9)	75.59
	Indian mackerel, yellowstripe scad, sardine, skipjack tuna, Spanish mackerel, threadfin bream (G2)	77.31	White bread, wholemeal, bun (G1)	67.70	Granulated sugar (G9)	73.27
	Salt (G10)	77.29	Mustard green, water spinach, Chinese broccoli, spinach, cassava leaves, fern (cooked) (G5)	67.60	White bread, wholemeal, bun (G1)	72.81
	Chicken (G2)	74.79	Cabbage, broccoli (cooked) (G5)	67.06	Garlic, shallot (G5)	72.43
	Malt drink (Milo®, Horlick®) (G7)	74.01	Malt drink (Milo®, Horlick®) (G7)	66.97	Indian mackerel, yellowstripe scad, sardine, skipjack tuna, Spanish mackerel, threadfin bream (G2	72.35

Table 1. Food consumption frequency score based on pregnancy trimester *(continued)*

Food consumption	*Trimester 1*		*Trimester 2*		*Trimester 3*	
	Food item (food group)	*Score*	*Food item (food group)*	*Score*	*Food item (food group)*	*Score*
	White bread, wholemeal, bun (G1)	73.95	Indian mackerel, yellowstripe scad, sardine, skipjack tuna, Spanish mackerel, threadfin bream (G2)	66.46	Turmeric (G10)	70.99
	Local dishes (G9)	69.74	Soy sauce, dark soy sauce (G10)	65.84	Malt drink (Milo®, Horlick®) (G7)	70.13
	Mustard green, water spinach, Chinese broccoli, spinach, cassava leaves, fern (cooked) (G5)	67.16	Chili sauce, tomato ketchup (G10)	65.19	Egg (G2)	68.74
	Fried rice, *nasi lemak, nasi dagang, nasi kerabu, nasi minyak* (G1)	66.39	Tea (G7)	62.04	Fried rice, *nasi lemak, nasi dagang, nasi kerabu, nasi minyak* (G1)	68.66
	Tea (G7)	65.60	Fried rice, *nasi lemak, nasi dagang, nasi kerabu, nasi minyak* (G1)	60.87	Local dishes (G9)	67.27
	Meat (G2)	65.55	Turmeric (G10)	59.64	Chili sauce, tomato ketchup (G10)	63.61
	Soy sauce, dark soy sauce (G10)	65.54	Local dishes (G9)	59.50	Tea (G7)	61.20
	Turmeric (G10)	65.54	Egg (G2)	59.00	Coconut water, young coconut flesh (G7)	59.93
	Banana, banana fritter (G6)	63.89	Chili paste, *sambal belacan* (G10)	58.34	Soy sauce, dark soy sauce (G10)	59.59
	Cabbage, broccoli (cooked) (G5)	63.80	UHT cow's milk, goat's milk (full cream, low fat) (G3)	56.47	Banana, banana fritter (G6)	58.99
	Condensed milk (G9)	62.21	Apple (G6)	54.54	Potato, sweet potato, carrot (G5)	57.63

Table 1. Food consumption frequency score based on pregnancy trimester *(continued)*

Food consumption	*Trimester 1*		*Trimester 2*		*Trimester 3*	
	Food item (food group)	*Score*	*Food item (food group)*	*Score*	*Food item (food group)*	*Score*
	Egg (G2)	61.36	Oyster sauce (G10)	53.99	Cucumber, luffa (boiled), tomato (G5)	57.60
	Garlic, shallot (G5)	61.36	Noodles, rice vermicelli, flat rice noodles, *laksa* (G1)	52.80	Dates (G6)	56.73
	Chili sauce, tomato ketchup (G10)	61.33	Coconut milk (G8)	52.16	Oyster sauce (G10)	56.67
	Orange (G6)	58.83	Anchovy sauce (*budu*) (G10)	52.11	Watermelon (G6)	55.84
	Apple (G6)	56.33	Coconut water, young coconut flesh (G7)	51.49	Meat (G2)	55.76
	Sweets (G9)	56.33	Condensed milk (G9)	51.41	Apple (G6)	55.36
	Oyster sauce (G10	56.30	Skimmed milk (vanilla, chocolate) (G3)	49.07	Noodles, rice vermicelli, flat rice noodles, *laksa* (G1)	54.84
	Chocolate (G9)	56.29	Raisin (G6)	47.81	Chili paste, *sambal belacan* (G10)	53.51
	Watermelon (G6)	56.27	Cucumber, luffa (boiled), tomato (G5)	47.17	Skimmed milk (vanilla, chocolate) (G3)	52.93
	UHT cow's milk, goat's milk (full cream, low fat) (G3)	55.51	Powdered milk (full cream) (G3)	45.87	Raisin (G6)	50.64
	Noodles, rice vermicelli, flat rice noodles, *laksa* (G1)	55.46	Meat (G2)	45.34	Condensed milk (G9)	50.24
	Mango (G6)	55.43	Mango (G6)	45.23	Coconut milk (G8)	49.90
	Cucumber, luffa (boiled), tomato (G5)	54.61	Orange (G6)	44.67	Guava (G6)	49.37

Table 1. Food consumption frequency score based on pregnancy trimester *(continued)*

Food consumption	*Trimester 1*		*Trimester 2*		*Trimester 3*	
	Food item (food group)	*Score*	*Food item (food group)*	*Score*	*Food item (food group)*	*Score*
	Keropok ikan & keropok lekor (G2)	53.78	Rose syrup drink (G7)	44.00	UHT cow's milk, goat's milk (full cream, low fat) (G3)	49.34
	Papaya (G6)	53.00	Guava (G6)	42.20	Anchovies (G2)	48.85
	Malaysian flatbread (*roti canai*), *dhal*/curry gravy (G1)	52.94	Dates (G6)	42.19	Mango (G6)	47.99
	Coconut milk (G8)	52.93	Chocolate (G9)	42.17	Chocolate (G9)	47.96
	Potato, sweet potato, carrot (G5)	52.11	Watermelon (G6)	41.60	Orange (G6)	47.13
	Chili paste, *sambal belacan* (G10)	52.09	Banana, banana fritter (G6)	40.30	Long bean, winged bean (G5)	46.63
	Rose syrup drink (G7)	51.31	Prawn (G2)	39.13	*Keropok ikan & keropok lekor* (G2)	46.54
	Yellow pear (G6)	51.27	*Keropok ikan & keropok lekor* (G2)	38.51	Anchovy sauce (*budu*) (G10)	44.70
	Honeydew (G6)	51.23	Malaysian flatbread (*roti canai*), dhal/curry gravy (G1)	38.51	Prawn (G2)	43.78
	Dates (G6)	49.60	Anchovies (G2)	38.51	Malaysian flatbread (*roti canai*), dhal/curry gravy (G1)	43.78
	Anchovies (G2)	49.58	Papaya (G6)	38.49	Rose syrup drink (G7)	42.87
	Anchovy sauce (*budu*) (G10)	48.80	Margarine (G8)	37.87	Squid (G2)	42.86
	Prawn (G2)	48.74	Potato, sweet potato, carrot (G5	37.74	Papaya (G6)	42.40
	Raisin (G6)	47.83	Sweets (G9)	37.73	Soy drink (G4)	40.63

Table 1. Food consumption frequency score based on pregnancy trimester *(continued)*

Food consumption	*Trimester 1*		*Trimester 2*		*Trimester 3*	
	Food item (food group)	*Score*	*Food item (food group)*	*Score*	*Food item (food group)*	*Score*
	Coconut water, young coconut flesh (G7)	47.06	Soy drink (G4)	36.00	Grape (G6)	39.57
	Grape (G6)	46.29	Long bean, winged bean (G5)	35.33	Margarine (G8)	36.97
	Guava (G6)	45.46	Squid (G2)	34.78	Sweets (G9)	36.47
	Skimmed milk (vanilla, chocolate) (G3)	43.71	Yellow pear (G6)	34.73	Honeydew (G6)	36.13
	Groundnut, horse bean, mung bean, dhal, cashew nut (G4)	43.69	Honeydew (G6)	34.16	Salted egg (G2)	35.51
	Ready-made cereal (G1)	42.86	Grape (G6)	32.84	Yellow pear (G6)	35.09
	Peanut butter (G8)	42.84	Water guava (G6)	32.29	Chicken liver, cow liver (G2)	34.56
	Water guava (G6)	42.03	Fish ball (G2)	31.68	Groundnut, horse bean, mung bean, dhal, cashew nut (G4)	34.16
	Squid (G2)	42.02	Groundnut, horse bean, mung bean, dhal, cashew nut (G4)	31.03	Yoghurt (G3)	32.21
	Salted egg (G2)	41.26	Chicken liver, cow liver (G2	30.43	Coffee (G7)	31.27
	Long bean, winged bean (G5)	41.23	Catfish, silver catfish (G2)	30.43	Blood clam (G2)	30.90
	Soy drink (G4)	41.20			Fish ball (G2)	30.88
	Powdered milk (full cream) (G3)	41.17			Corn (G1)	30.41
	Pegaga, ulam raja (G5)	40.39				
	Margarine (G8)	40.37				

Table 1. Food consumption frequency score based on pregnancy trimester *(continued)*

Food consumption	*Trimester 1*		*Trimester 2*		*Trimester 3*	
	Food item (food group)	*Score*	*Food item (food group)*	*Score*	*Food item (food group)*	*Score*
	Ais batu kacang (ABC) (G9)	40.36				
	Catfish, silver catfish (G2)	38.66				
	Corn (G1)	37.82				
	Yoghurt (G3)	35.36				
	Cheese (G3)	35.31				
	Blood clam (G2)	33.67				
	Pineapple (G6)	33.64				
	Coffee (G7)	33.63				
	Stuffed green chili peppers (*solok lada*) (G2)	32.81				
	Pickles (G6)	32.79				
	Fish ball (G2)	32.77				
	Chicken liver, cow liver	31.93				
	Rambutan (G6)	31.14				
	Canned sardine & tuna (G2)	30.25				
Less consumed foods (10.0-29.9)	*Langsat, duku, dokong* (G6)	29.47	White glutinous, fermented rice, grated coconut (G1)	29.81	Salted fish (G2)	29.95
	Salted fish (G2)	29.41	*Ais batu kacang (ABC)* (G9)	29.74	*Pegaga, ulam raja* (G5)	29.54
	Jackfruit (G6)	28.60	Peanut butter (G8)	27.91	*Ais batu kacang (ABC)* (G9)	28.94
	Cempedak, cempedak fritter (G6)	28.59	Blood clam (G2)	27.90	Canned sardine & tuna (G2)	28.57

Table 1. Food consumption frequency score based on pregnancy trimester *(continued)*

Food consumption	*Trimester 1*		*Trimester 2*		*Trimester 3*	
	Food item (food group)	*Score*	*Food item (food group)*	*Score*	*Food item (food group)*	*Score*
	White glutinous, fermented rice, grated coconut (G1)	27.73	*Pegaga, ulam raja* (G5)	27.24	White glutinous, *tapai*, grated coconut (G1)	28.11
	Mangosteen (G6)	25.26	Corn (G1)	26.71	Stuffed green chili peppers *(solok lada)* (G2)	25.81
	Durian (G6)	21.00	Ready-made cereal (G1)	24.22	Catfish, silver catfish (G2)	25.81
			Coffee (G7)	24.19	Ready-made cereal (G1)	25.35
					Water guava (G6)	25.29
			Salted fish (G2)	22.36	Pineapples (G6)	24.43
			Canned sardine & tuna (G2)	22.98	Jackfruit (G6)	23.99
			Stuffed green chili peppers *(solok lada)* (G2)	23.54	Peanut butter (G8)	22.16
			Rambutan (G6)	22.29	*Cempedak, cempedak* fritter (G6)	21.20
			Salted egg (G2)	21.70	Powdered milk (full cream) (G3)	20.49
			Cempedak, cempedak fritter (G6)	21.11	Cheese (G3)	20.50
			Mangosteen (G6)	21.09	Rambutan (G6)	20.30
			Cheese (G3)	20.50	*Langsat, duku, dokong* (G6)	18.93
			Yoghurt (G3)	20.49	Mangosteen (G6)	18.93
			Pickles (G6)	20.46	*Durian* (G6)	18.90
			Jackfruit (G6)	19.24	Pickles (G6)	18.41
			Pineapple (G6)	18.61		
			Durian (G6)	17.36		
			Langsat, duku, dokong (G6)	16.14		

Food groups: G1=Cereal and cereal products, G2= Meat and eggs, G3= Milk and milk products, G4= Nuts, G5= Vegetables, G6=Fruits and fruit juices, G7= Beverages, G8= Fats, G9= Sweet and baked goods, G10=Condiments trimesters. For other nutrients, the RNI values were similar for all trimesters and thus, only one mean was derived for all trimesters.

The frequency of respondents with adequate energy intake reduced as the trimester increased. At the first trimester, the intake of energy was adequate for most respondents (82.4%). At the second trimester, only about half had adequate energy intake (52.2%) and at the third trimester, the energy intake was inadequate for most respondents (71.0%). Only slightly more than half of the respondents had adequate carbohydrate intake (54.9%) and vitamin A intake (52.1%). While most respondents had adequate protein intake (85.9%), the intakes of iron, folate, vitamin C, vitamin D, calcium, iodine, zinc, and fluoride were below the RNI values. The intake of zinc was deficient at all trimesters.

Associations between food and nutrient intakes

The associations between food and nutrient intakes are shown in Table 3. The amount of milk and milk products consumed had a significant, positive association with the levels of folate (p=0.003) and vitamin C (p=0.020). The level of folate intake was also positively associated with the amount of vegetables consumed (p=0.014). A significant, positive association was found between the level of vitamin D with the amount of beverage (p=0.040) and confections

Table 2. Energy and nutrient intakes of pregnant women (n=71)

Nutrient	*RNI*	*Nutrient Intake Mean±SD*	*Frequency (%)*		
			Inadequate	*Adequate*	*Excessive*
Energy (kcal)	1690†	1916±282	3 (17.6)	14 (82.4)	0 (0.0)
	1890‡	2040±344	11 (47.8)	12 (52.2)	0 (0.0)
	2080§	1972±226	22 (71.0)	9 (29.0)	0 (0.0)
Carbohydrate (%)	50-65 ^{a¶}	50.4±6.7	32 (45.1)	39 (54.9)	0 (0.0)
Fat (%)	25-30 ^{a¶}	31.7±5.1	0 (0.0)	0 (0.0)	71 (100.0)
Protein (%)	10-20 ^{a¶}	17.9±2.8	0 (0.0)	61 (85.9)	10 (14.1)
Iron (mg)	29¶	19.1 (14.2, 22.6)^{b}	66 (93.0)	5 (7.0)	0 (0.0)
Folate (µg)	600¶	74.9 (46.0, 104.9)^{b}	71 (100.0)	0 (0.0)	0 (0.0)
Vitamin A (µg)	800¶	805.5 (560.2,1095.0)^{b}	34 (47.9)	37 (52.1)	0 (0.0)
Vitamin C (mg)	80¶	44.5 (27.6, 73.2)^{b}	60 (84.5)	11 (15.5)	0 (0.0)
Vitamin D (µg)	15¶	1.7±1.2	71 (100.0)	0 (0.0)	0 (0.0)
Calcium (mg)	1000¶	589.2±189.9	70 (98.6)	1 (1.4)	0 (0.0)
Iodine (µg)	200¶	0.0 (0.0, 13.0)^{b}	71 (100.0)	0 (0.0)	0 (0.0)
Zinc (mg)	5.5†	4.3±1.8	13 (76.5)	4 (23.5)	0 (0.0)
	7‡	4.5±2.0	20 (87.0)	3 (13.0)	0 (0.0)
	10§	4.1±1.7	31 (100.0)	0 (0.0)	0 (0.0)
Fluoride (mg)	3¶	0.8 (0.0, 12.7)^{b}	71 (100.0)	0 (0.0)	0 (0.0)

[a]% based on total energy intake (TEI)
[b]Median (25th, 75th), Kolmogorov-Smirnov p<0.050
[†]RNI for first trimester
[‡]RNI for second trimester
[§]RNI for third trimester
[¶]Similar RNI for all trimesters

Table 3. Associations between food and nutrient intakes

Variable	Correlation coefficient†									
	Cereal and cereal products	Meat and eggs	Milk and milk prod-ucts	Nuts	Vegetables	Fruits and juices	Beverages	Fats	Sweet and baked goods	Condiments
Protein	0.11	-0.07	0.14	-0.03	0.14	-0.01	-0.18	-0.04	0.30	0.01
Carbohydrate	0.12	0.19	0.37	0.17	0.26	0.12	0.21	0.09	0.19	0.16
Fat	0.07	-0.11	-0.04	-0.03	-0.06	-0.01	-0.19	-0.06	-0.05	-0.18
Iron	0.07	0.30	-0.06	-0.04	0.15	-0.08	-0.02	-0.10	0.03	-0.05
Folate	0.20	0.15	0.34*	-0.06	0.29*	0.24	-0.20	-0.12	0.12	0.19
Vitamin A	0.04	0.05	0.05	-0.12	0.20	0.10	-0.26	-0.00	-0.09	0.11
Vitamin C	0.01	-0.04	0.28*	0.10	0.18	0.10	-0.05	0.02	0.19	0.23
Vitamin D	0.16	0.05	-0.28	-0.03	0.04	0.00	0.24*	0.16	0.32*	-0.01
Calcium	0.16	-0.02	0.16	-0.15	-0.02	0.01	-0.15	-0.05	-0.02	0.13
Iodine	0.04	-0.05	-0.17	-0.27	-0.18	0.08	-0.05	0.09	-0.00	-0.13
Zinc	0.16	0.04	0.21	-0.23	0.15	0.03	-0.25	-0.12	-0.03	0.09
Fluoride	0.17	-0.01	-0.11	-0.14	-0.00	0.02	-0.14	-0.01	-0.04	-0.07

†Spearman's rho
*$p<0.05$

consumed (p=0.007).

Oral symptoms of pregnant women

The most common oral symptom reported was cavitated tooth (46.5%), followed by bleeding gums (35.2%), pain upon eating/drinking sweet, hot or cold food/beverage (23.9%), bad breath (23.9%), brown, black, or white spots on tooth surface (19.7%), spontaneous pain (15.5%), swollen gums (15.5%), gum pain (12.7%), and pain upon biting (11.3%). Other less common problems were red gums (5.6%), receding gums (4.2%), loose tooth (1.4%), and longer appearing tooth (1.4%). None of the respondents reported having gum abscess.

Associations between nutrient intakes and oral symptoms

The associations between selected nutrients (vitamin A, calcium, and zinc) and dental caries symptoms, and the associations between selected nutrients (vitamin C, iron, and zinc) and periodontal disease symptoms, except gum abscess, are presented in Table 4 and Table 5, respectively. Significant associations were found between vitamin A and the presence of brown, yellow and white spots on tooth surface (χ^2=4.89, p=0.030), and between zinc and bleeding gums (χ^2=6.49, p=0.047).

DISCUSSION

Findings of our study provided further evidence that most pregnant women are not getting the recommended amount of essential nutrients. Intakes of iron, folate, vitamin C, vitamin D, calcium, iodine, zinc, and fluoride were deficient in most respondents, in agreement with previous studies (Madanijah *et al.*, 2016; Saunders *et al.*, 2019; Savard *et al.*, 2018). Despite folate being naturally present in a wide variety of foods, including beef liver, fruits and fruit juices, nuts, beans, peas, and vegetables, that were highly consumed by respondents in the third trimester, all women in our study did not receive adequate amount of folate. Consumption of margarine, the only food mandated to be fortified with vitamin D in Malaysia (Ministry of Health Malaysia, 2018), was moderate, and all our respondents did not meet the RNI of 15 µg per day, compared to 67.7% reported in a previous local study by Lee *et al.* (2021). In addition, the consumption of foods rich in iron, vitamin C, calcium, iodine, zinc, and fluoride, such as animal liver, fish, dairy products, eggs, and yellow and orange fruits, was only low to moderate, consistent with the inadequacy of these respective nutrients. Although the respondents' mean daily intake of vitamin A met the RNI value, probably attributable to the high consumption of green leafy vegetables that are rich in vitamin A among respondents in the third trimester, almost half of them (47.9%) had inadequate vitamin A intake.

Energy requirements of pregnant women increase progressively during pregnancy to support growth of the foetus, while maintaining health of the mother (Marshall *et al.*, 2022). However, most

Table 4. Associations between nutrient intakes and symptoms of dental caries

Variable	*Vitamin A*			*Calcium*			*Zinc*		
	Frequency (%)			*Frequency (%)*			*Frequency (%)*		
	Adequate	*Inadequate*	$\chi^2(df)$	*Adequate*	*Inadequate*	$\chi^2(df)$	*Adequate*	*Inadequate*	$\chi^2(df)$
Spontaneous pain									
Yes	6 (54.5)	5 (45.5)	0.03(1)†	0 (0.0)	11 (100.0)	0.34(1)‡	1(9.1)	10 (90.9)	0.01(1)†
No	31 (51.7)	29 (48.3)		1 (1.7)	59 (98.3)		6 (10.0)	54 (90.0)	
Pain upon eating/drinking sweet and hot or cold food/beverages									
Yes	11 (64.7)	6 (35.3)	1.42(1)†	1 (5.9)	16 (94.1)	2.91(1)‡	3 (17.6)	14 (82.4)	1.53(1)†
No	26 (48.1)	28 (51.9)		0 (0.0)	54 (100.0)		4 (7.4)	50 (92.6)	
Pain upon biting									
Yes	5 (62.5)	3 (37.5)	0.39(1)‡	7 (87.5)	1 (12.5)	4.48(1)‡	0 (0.0)	8 (100.0)	0.99(1)†
No	32 (50.8)	31 (49.2)		63 (100.0)	0 (0.0)		7 (11.1)	56 (88.9)	
Cavitated tooth									
Yes	18 (54.5)	15 (45.5)	0.15(1)†	1 (3.0)	32 (97.0)	1.55(1)‡	2 (6.1)	31 (93.9)	1.04(1)‡
No	19 (50.0)	19 (50.0)		0 (0.0)	38 (100.0)		5 (13.2)	33 (86.8)	
Brown, black, or white spots on tooth surface									
Yes	11 (78.6)	3 (21.4)	4.89(1)†*	0 (0.0)	14 (100.0)	0.44(1)‡	2 (14.3)	12 (85.7)	0.34(1)†
No	26 (45.6)	31(54.4)		1 (1.8)	56 (98.2)		5 (8.8)	52 (91.2)	

†Chi-square test, ‡Fisher's Exact test
*$p<0.05$

Table 5. Associations between nutrient intakes and symptoms of periodontal disease

Variable	Vitamin C			Iron			Zinc		
	Frequency (%)		$\chi^2(df)$	Frequency (%)		$\chi^2(df)$	Frequency (%)		$\chi^2(df)$
	Adequate	Inadequate		Adequate	Inadequate		Adequate	Inadequate	
Bleeding gums									
Yes	2 (8.0)	23 (92.0)	1.66(1)†	2 (8.0)	23 (92.0)	0.53(1)‡	0 (0.0)	25 (100.0)	6.49(1)‡*
No	9 (19.6)	37 (80.4)		3 (6.5)	43 (93.5)		7 (15.2)	39 (84.8)	
Swollen gums									
Yes	2 (18.2)	9 (81.8)	0.72(1)†	2 (18.2)	9 (81.8)	1.92(1)‡	0 (0.0)	7 (11.7)	1.42(1)†
No	9 (15.0)	51 (85.0)		3 (5.0)	57 (95.0)		11(100.0)	53 (88.3)	
Gum pain									
Yes	3 (33.3)	6 (66.7)	2.51(1)†	1 (11.1)	8 (88.9)	0.23(1)‡	0 (0.0)	9 (100.0)	1.13(1)†
No	8 (12.9)	54 (87.1)		4 (6.5)	58 (93.5)		7 (11.3)	55 (88.7)	
Red gums									
Yes	0 (0.0)	4 (100.0)	1.39(1)‡	0 (0.0)	4 (100.0)	0.60(1)‡	0 (0.0)	4 (100)	0.86(1)‡
No	11 (16.4)	56 (83.6)		5 (7.5)	62 (92.5)		7 (10.4)	60 (89.6)	
Loose tooth									
Yes	1 (100.0)	0 (0.0)	3.81(1)‡	0 (0.0)	1 (100.0)	0.15(1)‡	0 (0.0)	1 (100.0)	0.21(1)‡
No	10 (14.3)	60 (85.7)		5 (7.1)	65 (92.9)		7 (10.0)	63 (90.0)	
Bad breath									
Yes	3 (17.6)	14 (82.4)	0.79(1)†	1 (5.9)	16 (94.1)	0.48(1)‡	3 (17.6)	14 (82.4)	1.53(1)†
No	8 (14.8)	46 (85.2)		4 (7.4)	50 (92.6)		4 (7.4)	50 (92.6)	
Receding gums									
Yes	1 (33.3)	2 (66.7)	0.62(1)‡	0 (0.0)	3 (100.0)	0.45(1)‡	1 (33.3)	2 (66.7)	1.31(1)‡
No	10 (14.7)	58 (85.3)		5 (7.4)	63 (92.6)		6 (8.8)	62 (91.2)	
Longer appearing tooth									
Yes	0 (0.0)	1 (100.0)	0.34(1)‡	0 (0.0)	1 (100.0)	0.15(1)‡	1 (100.0)	0 (0.0)	4.77(1)‡
No	11 (15.7)	59 (84.3)		5 (7.1)	65 (92.9)		6 (8.6)	64 (91.4)	

†Chi-square test, ‡Fisher's Exact test
*p<0.05

pregnant women did not change their food intake as recommended and continued to consume a low nutrient density pre-pregnancy diet (Savard *et al.*, 2018). In this study, the number of women who met their energy requirements reduced as pregnancy progressed. The mean daily intake of energy was highest in the second trimester and decreased to below the RNI level in the third trimester as energy intake was deficient for most respondents. Similar findings were reported by Savard *et al.* (2018) among pregnant women in Canada.

The westernisation of Asian diet has resulted in rapid changes in the pattern of food consumption from the traditional carbohydrate-rich staple foods to high protein and energy-dense diets consisting mainly of livestock and dairy products, vegetables and fruits, and fats and oils (Drewnowski & Poulain, 2018). Only about half (54.9%) of the pregnant women in this study had adequate carbohydrate intake and this finding is comparable to the result of Saunders *et al.* (2019) among pregnant women in Norway at 56.1%. The source of carbohydrate for our respondents was mainly from the highly consumed white rice. The food intake pattern of our respondents seemed to concur with the reported shift in the Malaysian dietary patterns characterised by increasing intakes of refined grains, animal-based foods, added fat, and sugar-sweetened beverages, as well as fast food (Goh *et al.*, 2020). Our findings showed that animal products, fats, sugar-sweetened beverages such as rose syrup drink, and refined grain products such as white bread, white rice, and foods made with white flour including ready-made cereals and flatbreads, as well as sweet and baked goods were mostly or moderately consumed by the women.

Despite changes in food sources, the changing landscape of nutrition from dietary plant proteins to proteins of animal origin has not affected the adequacy of protein in the diet (Drewnowski & Poulain, 2018), and this was reflected from our findings that protein intake was adequate for most respondents and excessive for some. The increase of protein in everyday diet, particularly from animal origin, and the increase of fat, with decreasing carbohydrate energy, are a major concern worldwide due to their contribution to the increased prevalence of chronic diseases such as obesity, diabetes, cancer, and cardiovascular diseases (Billingsley, Carbone, & Lavie, 2018).

The high intake of salt by our respondents in the second and third trimesters, most likely in the cooking to make dishes more palatable, should therefore also be a matter of concern. While consumption of a moderate amount of salt during pregnancy can help maintain a normal balance of fluids and minerals in the body, excessive salt intake in the diet may increase the risk of hypertension, which is a major risk factor for cardiovascular diseases and kidney diseases (Asayama & Imai, 2018). In addition, high consumption of granulated sugar in the second trimester, in addition to sugar-sweetened beverages, sweet and baked goods, and high fat products may put respondents and their foetus at risk of metabolic impairments with subsequent poor health (Zambrano & Nathanielsz, 2017).

In this study, the amount of milk and milk products consumed by the respondents had a significant, positive association with their mean daily intake of folate. Milk and milk products, such as cheese and yoghurt, are not only excellent sources of protein, carbohydrates, fat, vitamins A, B2 and B12, and minerals, such as calcium, magnesium, phosphorus, and potassium, but also good dietary sources of folate. The level of folate intake among our respondents was also positively associated with the amount of vegetables they consumed.

Vegetables commonly consumed by the Malaysian population, such as cabbage, cauliflowers, carrot, cucumber, cabbage, chilli, lady's finger, spinach, tomato, tapioca shoot, and pumpkin, contain folate in the range of between 2-8 µg per 100 g (Chew, Khor & Loh, 2012).

Besides folate, the amount of milk and milk products consumed by our respondents had a significant, positive association with their mean daily intake of vitamin C. The content of vitamin C in milk varies depending on the source and may also change with season. The content was found to be higher in goat's milk, with a mean of 5.48 mg per 100 ml and lower in cow's milk, ranging 1.65-2.75 mg per 100 g (Morrissey & Hill, 2009). Although milk and milk products are not important sources of vitamin C, consumption of vitamin C fortified dairy products could have contributed to the finding.

In this study, the level of vitamin D was positively associated with the consumption of sweet and baked goods, probably from the yeast used in baking (Kessi-Pérez *et al.*, 2022) and from cocoa or chocolate that are among the common flavouring ingredients used in baked goods (Benedik, 2022). In addition, vitamin D was found to be positively associated with the consumption of beverages, most likely from fortified beverages. Plant-based beverages like malt drinks and soy drinks are among the most common beverages fortified with vitamin D (Benedik, 2022) and these were moderately consumed by our respondents.

The most common symptom associated with dental caries reported by the women in this study was cavitated tooth (46.5%). This finding is consistent with the result of a previous local study among pregnant women by Yunita Sari *et al.* (2020), with a higher proportion of 62.0%. Although not all carious lesions progress to cavitation, the visible breakdown of tooth surface is the endpoint of the disease process when there is an extensive loss of minerals. It may take months or years for a carious lesion to become cavitated, if ever, as not all lesions progress at the same rate (Pitts *et al.*, 2017). During pregnancy, surges in oestrogen and progesterone levels make women more susceptible to developing gingivitis (Silva de Araujo Figueiredo *et al.*, 2017). Bleeding gums is a common symptom of gingivitis, the earliest stage of periodontal disease. Gum bleeding was the most common periodontal disease symptom reported by our respondents (35.2%), in agreement with findings among pregnant women in other population groups (Stelmakh, Slot & van der Weijden, 2017).

Vitamin A is crucial in the maintenance of healthy teeth, skeletal and soft tissue, mucous membranes, and skin by preserving the integrity of the epithelial tissues. Vitamin A also supports the immune function, foetal development, and vision. Although there is currently no evidence of the association between vitamin A and dental caries in human, vitamin A deficiency has been shown to cause salivary gland atrophy (Rahman & Walls, 2020), which can result in reduced salivary flow, leading to increased risk for caries (Llena-Puy, 2006). In this study, a significant association was found between vitamin A status and the presence of brown, yellow and white spot lesions on tooth surfaces, which are the early signs of caries.

Zinc is a trace element that plays a critical role in human health maintenance, particularly related to the immune system (Chasapis *et al.*, 2012). With its numerous roles in basic cellular functions, zinc deficiency has been associated with increased susceptibility to infection and delayed healing that can affect many organ systems of the body, including the oral cavity (Bhattacharya, Misra & Hussain, 2016). Zinc deficiency can therefore be a potential risk factor for periodontal disease (Bhattacharya *et al.*, 2016), which begins with gingivitis, the localised inflammation of the gingiva, causing the gums to become swollen and red, and may also bleed. Zinc was found to have a significant association with gingival bleeding symptom among our respondents.

Our findings contributed to the body of evidence that showed that pregnant women were not getting the recommended amount of nutrients. However, in our study, the nutrient levels were obtained only from the respondents' food intake, not taking into consideration additional supplements that may be taken by the women. Nevertheless, the levels of important nutrients necessary to keep the mother and baby healthy, such as folate, vitamin D, and calcium, were very much below the RNI such that additional supplementation of vitamins and minerals may still be inadequate to meet their nutritional requirements during pregnancy.

Our study also added to the growing literature supporting the link between nutrients and oral health. However, caution should be exercised when interpreting findings of this study as the use of self-perceived oral health problems may be less accurate than clinical diagnosis by dental professionals. Additionally, dietary assessment was done only once in this cross-sectional study and may not reflect the participants' dietary pattern throughout the pregnancy. We were also unable to control the effects of potential confounders in the association between nutrient intakes and oral symptoms as some symptoms were reported only by a few, if any, creating substantial imbalance in the outcome variables and precludes the use of multivariable analysis.

Our study population was limited to pregnant women in Kelantan, and we managed to recruit only about 70% of the required sample size. This may compromise the extent to which the study findings can be generalised to pregnant women in Malaysia and even to the target population. Hence, we consider our study as foundational and hopefully will provide the basis for further work in this area. We recommend for larger studies that employ an appropriate experimental design to test the hypothesis of the association between nutrients and oral health of pregnant women.

CONCLUSION

Most pregnant women in this study did not consume adequate amount of recommended nutrients. Significant association was found between the intake of certain nutrients and the amount of food consumed. Oral symptoms were common among the women and the presence of certain symptoms was associated with adequacy of nutrient. Intake of a balanced healthy diet with selections of foods that contain vitamins and minerals essential for pregnancy is the best way to get the nutrients needed by the mother, as well as the baby. A more focused dietary counselling and intervention is therefore indicated to reduce the health risks of malnutrition during pregnancy, which can be lifelong and even life-threatening.

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Authors' contribution

Ibrahim Z, contributed to the conception and design of the study, data acquisition, management and analyses, data interpretation, preparation of the manuscript, revised and approved the final manuscript; Saddki N and Hasan R, contributed to the conception and design of the study, data interpretation, critically reviewed the manuscript, revised and approved the final manuscript.

Conflict of interest

The authors declare no conflict of interest.

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