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Identification and reproducibility of dietary patterns assessed with a FFQ among women planning pregnancy

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Abstract

Objective: To identify *a posteriori* dietary patterns among women planning pregnancy and assess the reproducibility of these patterns in a subsample using two dietary assessment methods.

Design: A semi-quantitative FFQ was administered to women enrolled in the Singapore PREconception Study of long-Term maternal and child Outcomes study. Dietary patterns from the FFQ were identified using exploratory factor analysis (EFA). In a subsample of women (*n* 289), 3-d food diaries (3DFD) were also completed and analysed. Reproducibility of the identified patterns was assessed using confirmatory factor analysis (CFA) in the subsample, and goodness of fit of the CFA models was examined using several fit indices. Subsequently, EFA was conducted in the subsample and dietary patterns of the FFQ and the 3DFD were compared.

Setting: Singapore.

Participants: 1007 women planning pregnancy (18–45 years).

Results: Three dietary patterns were identified from the FFQ: the 'Fish, Poultry/Meat and Noodles' pattern was characterised by higher intakes of fish, poultry/meat and noodles in soup; 'Fast Food and Sweetened Beverages' pattern was characterised by higher intakes of fast food, sweetened beverages and fried snacks; 'Bread, Legumes and Dairy' pattern was characterised by higher intakes of buns/ethnic breads, nuts/legumes and dairy products. The comparative fit indices from the CFA models were 0·79 and 0·34 for the FFQ and 3DFD of the subsample, respectively. In the subsample, three similar patterns were identified in the FFQ while only two for the 3DFD.

Conclusions: Dietary patterns from the FFQ are reproducible within this cohort, providing a basis for future investigations on diet and health outcomes.

Keywords
FFQ
Dietary patterns
A posteriori
Confirmatory factor analysis

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As milestones of a woman's reproductive lifespan, the stages of preconception, pregnancy and postpartum may bring about distinct dietary changes[1–5]. In general, increased intakes of healthier foods (e.g., fruits and vegetables) may be observed when women transit from preconception to pregnancy[2], while a sharp decline in consumption of these foods tended to occur at postpartum, although these remained at higher levels compared with the preconception stage[4,5]. A similar trend has been observed locally in Singapore, such that women increased fruit and vegetable intakes but decreased tea/coffee, soft drinks and seafood intakes during pregnancy, while at postpartum they consumed more ginger, garlic, fish and milk-based drinks but less of sweets, chocolate and seafood[1]. These dietary changes, seemingly unique to the local Asian population, were found to differ by ethnicity and were based on traditional beliefs, particularly at postpartum[1]. However, these data were collected from short questionnaires with pre-defined food items. In order to systematically observe changes in dietary patterns across several time points of a woman's reproductive lifespan and enable diet comparisons to be made, a culturally relevant and validated maternal FFQ is required.

Integrative approaches of examining diets in their entirety have been increasingly used[6,7], such as *a posteriori* or *a priori* dietary patterns. Although limited by their population specificity, *a posteriori* dietary patterns are valuable as they depict actual dietary intakes of populations at different stages across the lifespan[8]. Additionally, these unique and well-defined patterns provide realistic representations of consumption patterns in ethnically heterogeneous populations[8]. Studies examining *a posteriori* dietary patterns have observed that the patterns derived were generally qualitatively similar and reasonably valid across different dietary assessment methods[8–15]. In patterns identified among women planning pregnancy, *a posteriori* healthy dietary patterns (e.g., 'Vegetables and Meat'[3], 'Fruit and Low-fat Dairy'[16]) and less healthy dietary patterns (e.g., 'Sweetened Beverages and Sugars'[3], 'High-fat/sugar/takeaway'[17]) were observed, but the reproducibility of these patterns has not been examined. The few reproducibility studies on dietary patterns of Europeans have shown that the FFQ-derived patterns were reproducible in smaller samples of the same cohort[18,19] and similar dietary patterns were identified using two different dietary assessment methods[15].

To bridge the gap, we aimed to (1) identify *a posteriori* dietary patterns among an Asian cohort of women planning pregnancy using exploratory factor analysis (EFA) and (2) assess the reproducibility of these patterns in a subsample using two different dietary assessment methods (food frequency questionnaire (FFQ) and 3-d food diary (3DFD)). We hypothesised that the identified patterns would be reproducible in both dietary assessment methods, in a subsample.

Methods

Study design and participants

We used data from the Singapore PREconception Study of long-Term maternal and child Outcomes (S-PRESTO) study, a prospective cohort study, which aims to examine the role of exposures before conception and during pregnancy on maternal and offspring metabolic health outcomes in later life[20]. In the S-PRESTO study, non-pregnant women actively trying to conceive were enrolled between February 2015 and October 2017, from the community (through social media and radio advertisements, door to door leaflets, posters in public places and general practitioners clinics) and at the largest local public maternity unit (KK Women's and Children's Hospital, Singapore). They were of Chinese, Malay, Indian ethnicity or any combination of these three ethnicities, aged 18–45 years, planned to conceive within 1 year from recruitment and to reside in Singapore for the next 5 years. Women were excluded if (1) diagnosed with type I or type II diabetes, (2) on systemic steroids, anticonvulsants or treatment for HIV, hepatitis B or C in the past month prior to enrolment, (3) already pregnant at the first screening visit, (4) had already been trying to conceive for over 18 months and (5) were on assisted fertility treatment (except clomiphene and letrozole) or on hormonal contraception treatment in the past month prior to enrolment. Further details of the current study have been published elsewhere[20].

Socio-demographic, lifestyle and other measures

At enrolment, trained research staff conducted in-person interviews with participants and collected information including socio-demographic (e.g., age, highest educational attainment) and lifestyle behaviours (e.g., physical activity for the past 7 d and daily total sitting time (at work and during leisure), alcohol consumption)[21]. Taken in triplicates, mean values for anthropometry measures were recorded. These measures included weight (measured to the nearest 0·1 kg using a SECA 803 weighing machine) and height (measured to the nearest 0·1 cm using a SECA 213 Portable Stadiometer), for the calculation of BMI[22]. BMI (expressed in kg/m^2) was calculated by dividing weight (in kg) by squared height (in m^2).

Development of a maternal FFQ for the Singapore PREconception Study of long-Term maternal and child Outcomes study

A FFQ was developed based on locally validated FFQ previously used in nationally representative samples of adults[23,24]. Additionally, food items commonly consumed during pregnancy and at postpartum were included. This information was obtained from a previous mother–offspring cohort (the Growing Up in Singapore Towards healthy Outcomes study – GUSTO), where food diaries and 24-h recalls from mothers during pregnancy and at postpartum were collected[25]. The semi-quantitative, interviewer-administered FFQ consisted of food and beverage items which captured details of cooking methods (such as boiled and deep fried) for certain food groups (e.g., vegetables, poultry, red meat and fish). Participants were instructed to consider their dietary intakes for the past month (prior to enrolment) when responding. For each food and beverage item, participants were asked to quantify their frequency of consumption in an open-ended format (using one of the four options: never/rarely, frequency per month, frequency per week or frequency per day)[26] before specifying the average amount consumed at each instance. Picture aids of various food portion sizes (for items such as vegetables, poultry) and standard-sized household tableware were used during the interview. Frequencies of the various food and beverage items were standardised to daily intakes and multiplied by standard portions of food/beverage (in g).

To estimate daily energy and nutrient intakes, a FFQ nutrient database was used. This database was generated using information from local food composition databases as well as information from the GUSTO maternal dietary records. For example, to obtain nutrient data for a FFQ item, a weighted average (weighting based on consumption frequency) was calculated based on the top three most commonly consumed foods under that item, from the GUSTO dietary records.

Upon completion of the FFQ during the enrolment visit, participants were given a 3DFD and guided on the recording of dietary intakes on two weekdays and one weekend day at home. To facilitate quantification of dietary intakes, picture aids of various food portion sizes and standard household tableware were included. Completed diaries were collected from participants at the subsequent study visit (second preconception visit occurring about 2–3 weeks later) and entered into a nutrient analysis software, Dietplan 7 (Forestfield Software Ltd), which contains local food composition databases.

Food grouping (FFQ and 3-d food diary)

The FFQ items were aggregated into forty-four pre-defined food groups (online supplementary material, Supplemental Table 1). To distinguish among the differing types of local staple consumed, distinct food groups for 'rice' (e.g., 'White rice', 'Flavoured rice' and 'Brown rice') and for 'noodles' (e.g., 'Noodles in soup' and 'Flavoured noodles') were created. Methods of cooking were also considered by differentiating foods cooked using healthier methods (lower fat content) (H) such as boiled, steamed from those cooked using less healthy (higher fat content) (LH) methods such as deep fried, in coconut curry, and accordingly noted (e.g., poultry and meat (H) *v.* poultry and meat (LH)). Food items recorded in the 3DFD were also classified into the identical forty-four food groups. For composite dishes, individual food items were identified and assigned to their respective food groups[27]. For all analyses involving the 3DFD, the averaged consumption of each food group was calculated across the 3 d.

Statistical analyses

For the current study, 1007 women with completed FFQ and a subsample of 289 participants (29 % of 1007 women), who also completed 3DFD, were selected for analyses. To examine if the subsample (*n* 289) was representative of the larger sample (*n* 1007), the socio-demographic and lifestyle characteristics between the two groups were compared using Pearson χ^2 tests.

Dietary patterns were first identified using EFA on the FFQ of the 1007 women with completed FFQ (Fig. 1, Step 1). Next, the reproducibility of these patterns was assessed using confirmatory factor analysis (CFA) in the FFQ and 3DFD of the subsample (Fig. 1, Step 2). To explain the suboptimal fit indices of the CFA models, exploratory factor analyses were next conducted and identified patterns from FFQ and 3DFD of the subsample were compared (Fig. 1, Steps 3 and 4). Further details are provided in the subsequent paragraphs.

Identification of dietary patterns from the FFQ (n 1007)

Suitability of the data for factor analysis was first assessed by the Kaiser–Meyer–Olkin measure of sampling adequacy and the Bartlett's test of sphericity[28,29]. EFA was used to identify *a posteriori* dietary patterns based on the forty-four food groups from women with completed FFQ (*n* 1007). To ensure that the dietary patterns derived were independent of one another and to improve interpretability[30], varimax rotation was next performed. Based on the break point of the Scree plot, eigenvalue of more than one and factor interpretability[30], an optimal number of factors was retained. Factor loadings, estimated using the principal factor method, represent correlation coefficients between food groups and their related dietary patterns; hence, a higher factor loading of a particular food group indicates greater contribution to a particular pattern. Subsequently, dietary pattern scores were calculated by summing the standardised daily intake of food groups weighted by the respective regressed factor loadings. Each participant had a score for each dietary pattern derived. Greater adherence to a particular pattern was indicated by a higher dietary pattern score.

Coefficients of congruence were determined to examine whether the patterns are congruent across socio-demographic factors[18,31]. These coefficients quantify the level of similarity between two dietary patterns compared, with values of above 0·50 considered as acceptable and values of close to 1 considered as excellent[3,18].

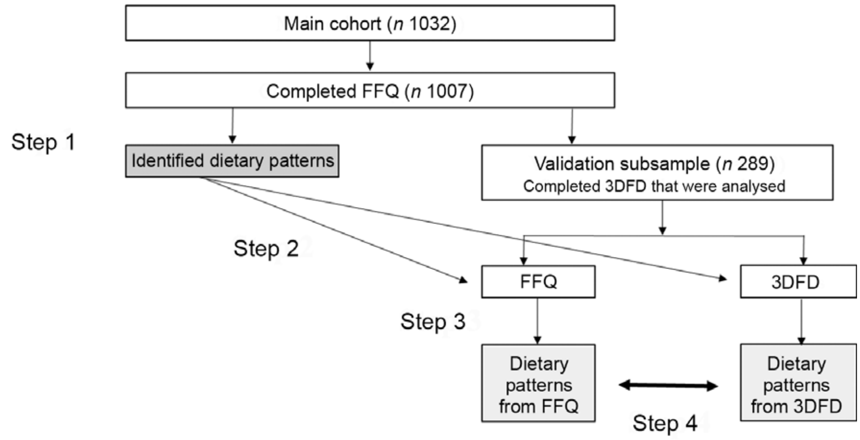

Fig. 1 Schematic of the analyses (Steps 1–4). Step 1: EFA was used for the generation of the dietary patterns from women with completed FFQ (*n* 1007). Step 2: The reproducibility of the identified patterns was assessed using CFA in the subsample (*n* 289). Step 3: EFA was used for the generation of dietary patterns in the subsample. This was conducted due to suboptimal global fit indices from the CFA analyses (especially the 3DFD). Step 4: Dietary patterns identified from each dietary assessment method are compared using congruence coefficients, quantifying the magnitudes of factor similarity between two patterns compared. EFA, exploratory factor analysis; CFA, confirmatory factor analysis

Reproducibility of identified dietary patterns in the subsample using two dietary assessment methods (n 289)

To assess the reproducibility of the identified patterns from the FFQ, CFA was applied on the FFQ and 3DFD of the subsample(15,19,32,33). To retain the significant core of each identified pattern and ensure convergence is achieved, only food groups with factor loadings of at least 0·40 from the EFA from Step 1 were included(19,33). Commonly reported fit indices of the CFA models (root mean square error of approximation (RMSEA), standardised root mean square residual, goodness of fit index, comparative fit index (CFI), Bayesian information criterion) were evaluated(34). The recommended cut-offs, indicating a good model fit, are values of RMSEA < 0·08, standardised root mean square residual < 0·08, goodness of fit index ≥ 0·95, CFI ≥ 0·90 and smaller Bayesian information criterion values(34).

Dietary patterns in the subsample (n 289)

EFA was subsequently conducted to identify dietary patterns derived from each dietary assessment method (FFQ and 3DFD) in the subsample. Coefficients of congruence were also determined to compare the identified patterns from each dietary assessment method. Additionally, Spearman correlation coefficients of the forty-four food groups (used for EFA) were calculated to compare intakes between the two dietary assessment methods.

Statistical analyses were conducted using STATA 14·0 (StataCorp LP) and the 'lavaan' package in R for CFA. A two-sided *P*-value of < 0·05 indicates statistical significance.

Results

Characteristics of participants

Among the 1007 participants with available FFQ, a large proportion was below 35 years of age (85·6 %), of Chinese ethnicity (71·7 %), had higher educational attainment (62·4 %) and nulliparous (64·8 %) (online supplementary material, Supplemental Table 2). Participants who have never consumed alcohol or have never smoked made up 31·3 % and 89·4 % of the sample, respectively. While the majority had BMI within the normal range of 18·5–24·9 kg/m^2 (62·2 %), a large proportion of participants led sedentary lifestyles as reflected by the low overall physical activity levels (66·5 % were inactive or minimally active) and long sitting hours (40·1 % sat for >11 h daily). The subsample (*n* 289) is representative of the cohort with FFQ data (*n* 1007) with largely similar characteristics, except the subsample having a larger proportion of older women (*P* < 0·001) and a larger proportion who were physically inactive (*P* = 0·003) (online supplementary material, Supplemental Table 2).

Dietary patterns identified from FFQ (n 1007)

The Kaiser–Meyer–Olkin measure of sampling adequacy was 0·73 for FFQ. The Bartlett's test of sphericity indicated that there was more than one underlying factor in the FFQ (*P* < 0·001). Both tests showed that the study sample was suitable for factor analysis. Three dietary patterns were identified from the FFQ: 'Fish, Poultry/Meat and Noodles', 'Fast Food and Sweetened Beverages' and 'Bread, Legumes and Dairy' (Table 1). These dietary patterns collectively explained 74 % of the common variation in dietary intakes. The 'Fish, Poultry/Meat and Noodles' pattern was characterised by higher intakes of soups, fish, poultry/meat and noodles. The 'Fast Food and Sweetened Beverages' pattern was characterised by higher intakes of

Table 1 Factor loadings for the dietary patterns identified from FFQ using exploratory factor analysis for women with completed FFQ (*n* 1007) and the subsample (*n* 289)

	Fish, Poultry/Meat and Noodles*		Vegetables, Fruits, Poultry/Meat and Soups†	Fast Food and Sweetened Beverages*		Bread, Legumes and Dairy*		Bread, Pasta and Dairy†
Food groups	FFQ (*n* 1007)	FFQ (*n* 289)	3DFD (*n* 289)	FFQ (*n* 1007)	FFQ (*n* 289)	FFQ (*n* 1007)	FFQ (*n* 289)	3DFD (*n* 289)
Soups	0·50	0·54	0·39					
Dim sum	0·42	0·41						
Desserts in soup	0·39	0·41						
Oily and non-oily fish (H)	0·37	0·34	0·26					
Poultry and meat (H)	0·35	0·32	0·32					
Seafood and canned fish	0·35	0·38						
Eggs	0·32							
Noodles in soup	0·31							
Sausages/ham/bacon		0·39		0·31				
Pasta		0·31						0·31
Innards		0·30						
Fast food			–0·32	0·57	0·44			
Poultry and meat (LH)				0·48	0·43			
Sweetened beverages				0·47	0·35			
Flavoured rice			–0·25	0·44	0·37			
Fried snacks				0·38	0·37			
Flavoured noodles			–0·24	0·34				
White rice				0·31				
Fresh fruits			0·40	–0·30	–0·34			
Vegetables (H)			0·58	–0·37	–0·53			
Oily and non-oily fish (LH)					0·40			
Malted beverages					0·35			–0·22
Nuts and legumes			0·32			0·45	0·52	
Buns with sweet/savoury fillings and ethnic bread (fried and steamed)						0·44	0·37	
Vegetables (LH)						0·44	0·50	
Savoury/sweet snacks (steamed/baked), pastries and cakes						0·43	0·42	
Chocolate						0·36		
Bread spreads						0·34		0·42
Full fat milk						0·34	0·42	
Yogurt/cultured/dairy drinks						0·33		0·21
Plain/cream biscuits						0·31		
Canned/dried fruits			0·30			0·31	0·45	
Ice cream						0·30		0·24
Cereals, oats, cereal drinks and other cereals							0·38	
Vegetable salad							0·33	
Soy products			0·38					
White bread								0·62
Cheese			0·21					0·35
Common variance explained	23	17	19	25	17	26	17	13

*Only factor loadings with absolute values of 0·30 and above were shown.
†Only factor loadings with absolute values of 0·20 and above were shown.

Table 2 Measures of global fit for confirmatory factor analysis of the identified patterns in the validation subsample (n 289)

Fit indices	Recommended cut-offs indicating a good fit	FFQ (n 289)	3DFD (n 289)
Root mean square error of approximation (RMSEA)	<0·08	0·070	0·065
Standardised root mean square residual	<0·08	0·081	0·073
Goodness of fit index	≥0·95	0·941	0·946
Comparative fit index (CFI)	>0·90	0·787	0·343
Bayesian information criterion	Smaller values indicate a better model fit	27 546	30 923

Table 3 Factor congruence between dietary patterns identified from the FFQ and 3DFD of the subsample (n 289)

Dietary patterns (n 289)		
FFQ	3DFD	Congruence coefficient
Fish, Poultry/Meat and Noodles	Vegetables, Fruits, Poultry/Meat and Soups	0·24
	Bread, Pasta and Dairy	0·16
Fast Food and Sweetened Beverages	Vegetables, Fruits, Poultry/Meat and Soups	−0·64
	Bread, Pasta and Dairy	0·19
Bread, Legumes and Dairy	Vegetables, Fruits, Poultry/Meat and Soups	0·30
	Bread, Pasta and Dairy	0·31

fast food, sweetened beverages and processed meat, and lower intakes of cooked vegetables and fresh fruits. The ‘Bread, Legumes and Dairy’ pattern consisted of mainly plant-based foods and dairy products such as higher intakes of nuts, legumes, full fat milk, yogurt and dairy-based drinks. These patterns were reasonably congruent across socio-demographic factors such as maternal age and ethnicity among the 1007 women (online supplementary material, Supplemental Table 3).

Reproducibility of identified dietary patterns in the subsample using two dietary assessment methods (n 289)

On the basis of several fit indices (especially the CFI and Bayesian information criterion), the identified patterns (‘Fish, Poultry/Meat and Noodles’, ‘Fast Food and Sweetened Beverages’ and ‘Bread, Legumes and Dairy’) had a better model fit in the FFQ as compared with the 3DFD of the subsample (CFI for FFQ = 0·79; CFI for 3DFD = 0·34 and smaller Bayesian information criterion value for the FFQ compared with the 3DFD) (Table 2). To explain the poorer reproducibility of the identified patterns in the 3DFD, dietary patterns were identified for each dietary assessment method in the subsample.

Dietary patterns in the subsample (n 289)

Dietary patterns (‘Fish, Poultry/Meat and Noodles’, ‘Fast Food and Sweetened Beverages’ and ‘Bread, Legumes and Dairy’) similar to those in the FFQ of the large sample were identified in the FFQ of the subsample. They explained 51 % of the common variance in dietary intakes. Conversely, two patterns, explaining 32 % of the common variance in dietary intakes, were observed from the 3DFD of the subsample. They appeared to be variants of two dietary patterns found in the FFQ and have been named as ‘Vegetables, Fruits, Poultry/Meat and Soups’ and ‘Bread, Pasta and Dairy’ (Table 1). In this subsample, a third 3DFD pattern was omitted due to poor interpretability. The third FFQ ‘Fast Food and Sweetened Beverages’ pattern did not resemble any of those identified from the 3DFD.

The ‘Vegetables, Fruits, Poultry/Meat and Soups’ pattern of the 3DFD appeared somewhat similar to the FFQ ‘Fish, Poultry/Meat and Noodles’ pattern except that it included additional key food groups such as vegetables, fruits and soya products. Similarly, the ‘Bread, Pasta and Dairy’ of the 3DFD shared similarities with the FFQ ‘Bread, Legumes and Dairy’ pattern in the subsample, except that pasta, white bread and cheese were included as additional food groups. However, the congruence coefficients of patterns identified in the subsample were below the acceptable cut-off of 0·50 (ranged from −0·64 (FFQ ‘Fast Food and Sweetened Beverages’ and 3DFD ‘Vegetables, Fruits, Poultry/Meat and Soups’) to 0·31 (FFQ ‘Bread, Legumes and Dairy’ and 3DFD ‘Bread, Pasta and Dairy’)] (Table 3), suggesting that patterns identified from the FFQ and 3DFD of the subsample cannot be considered similar.

In the subsample, a comparison of the food group intakes from the two dietary assessment methods explained the dissimilar patterns identified from the FFQ and 3DFD (Table 4). In general, the FFQ captured a wider variety of foods consumed as compared with the 3DFD, with a larger number of food groups having median intakes of null in the latter. Spearman correlation coefficient was lowest for desserts in soup (0·12) and highest for coffee/tea/decaffeinated drinks (0·66).

Discussion

Three dietary patterns (‘Fish, Poultry/Meat and Noodles’, ‘Fast Food and Sweetened Beverages’ and ‘Bread,

Table 4 Comparison of intakes of food groups for women with completed FFQ (*n* 1007) and the subsample (*n* 289)

	Women with available FFQ (*n* 1007)		Women in the subsample (*n* 289)				
Food groups (g/d)	Median	IQR	FFQ median	FFQ IQR	3DFD median	3DFD IQR	Spearman rho†
Fish, Poultry/Meat and Noodles							
Coffee/tea/decaffeinated drinks	179	277	179	286	150	283	0·66
Brown rice	0	29	0	29	0	0	0·49
Soya products	27	42	22	40	0	28	0·38
Poultry and meat (H)	76	74	73	62	30	50	0·33
Eggs	27	33	21	25	16	33	0·28
Oily and non-oily fish (H)	26	42	28	42	10	40	0·28
Porridge	20	62	26	70	0	0	0·27
Soups	38	80	33	67	47	118	0·26
Sausages/ham/bacon	2	4	2	4	0	0	0·25
Noodles in soup	120	181	106	179	29	193	0·24
Dim sum	7	11	10	11	0	20	0·21
Pasta	6	12	6	12	0	0	0·20
Seafood and canned fish	5	8	5	6	0	10	0·17
Innards	0	2	0	2	0	0	0·12
Desserts in soup	18	34	20	40	0	0	0·12
Fast Food and Sweetened Beverages							
Malted beverages	27	71	27	71	0	83	0·43
Fresh fruits	97	133	101	126	28	104	0·40
White bread	9	24	9	25	0	20	0·39
Sweetened beverages	36	98	36	98	83	183	0·37
White rice	143	129	120	143	67	100	0·35
Vegetables (H)	166	161	158	154	62	74	0·34
Flavoured noodles	53	96	50	85	83	173	0·27
Flavoured rice	24	28	23	28	0	100	0·22
Fast foods	36	44	35	40	0	33	0·22
Fried snacks	5	9	5	9	0	11	0·18
Poultry and meat (LH)	11	23	8	18	0	30	0·14
Oily and non-oily fish (LH)	0	7	0	8	0	0	−0·01*
Bread, Legumes and Dairy							
Cereals, oats, cereal drinks and other cereals	9	36	9	34	0	18	0·43
Yogurt/cultured/dairy drinks	28	64	29	64	0	33	0·41
Bread spreads	2	4	2	4	0	3	0·40
Vegetable salad	10	27	10	27	0	13	0·40
Cheese	1	3	1	3	0	0	0·36
Wholemeal bread	8	21	8	22	0	0	0·36
Plain/cream biscuits	5	14	5	14	0	11	0·34
Full fat milk	9	71	0	71	0	0	0·34
Buns with sweet/savoury fillings and ethnic bread (fried and steamed)	21	35	19	29	11	39	0·34
Nuts and legumes	1	5	1	5	0	2	0·30
Low fat milk/formula milk	0	36	0	36	0	0	0·24
Fruit juice	21	43	16	43	0	0	0·21
Chocolate	1	2	1	1	0	0	0·19
Vegetables (LH)	0	10	0	8	0	0	0·16
Canned/dried fruits	0	1	0	1	0	0	0·14
Ice cream	5	8	5	11	0	0	0·11*
Savoury/sweet snacks (steamed/baked), pastries and cakes	11	16	11	16	9	38	0·11*

IQR, interquartile range; H, healthy, LH, less healthy.
*$P > 0·05$.
†Spearman correlation coefficients were calculated between intakes from the FFQ and 3DFD in the subsample (*n* 289)

Legumes and Dairy') were identified from the FFQ. In the subsample, these patterns were reproducible in the FFQ, but less so in the 3DFD, where two variant patterns emerged. In this cohort, *a posteriori* dietary patterns identified from the FFQ were reproducible and reasonably congruent across several socio-demographic factors within this cohort of women planning pregnancy.

Dietary patterns identified from FFQ (n 1007)

The 'Fish, Poultry/Meat and Noodles' pattern in the S-PRESTO cohort is in line with our local diets consisting of higher carbohydrates and protein, with low intakes of fruits and vegetables[35,36]. This contrasts to the patterns reported among Spanish or Australian women planning pregnancy where vegetables or fruits tended to be eaten in combination with animal protein (e.g., 'Vegetables and Meat' pattern (consisting of a variety of vegetables, meat)[3], 'High-protein/fruit' (consisting of fish, meat, fresh fruits) and 'Fruit and Low-fat Dairy' (consisting of fresh fruits, yogurt)[16,17]).

The 'Fast Food and Sweetened Beverages' pattern in the S-PRESTO cohort consisted of discretionary foods which are high in fat and sugar (e.g., fast food, sweetened beverages, fried snacks). This is similar to the 'Sweetened Beverages and Sugars' (consisting of sweetened beverages, sugars, low intakes of vegetables, fresh fruits), 'Meat, High-fat and Sugar' (consisting of cakes, sweet biscuits, meat pies) and 'High-fat/sugar/takeaway' (consisting of takeaway foods, potato chips, refined grains) patterns observed among Australian and Spanish women planning pregnancy[3,16,17].

A unique 'Bread, Legumes and Dairy' pattern, made up of foods mainly from plant sources (e.g., nuts and legumes, buns and ethnic bread and a variety of cooked vegetables prepared using coconut curry), was observed in the S-PRESTO cohort. To our knowledge, this combination of foods has not been reported in other preconception cohorts to date, probably due to the lack of sampling on minority ethnic groups (e.g., Malay and Indian ethnicities). Taken together, while the dietary patterns of S-PRESTO women shared common foods that were identified in other populations of women planning pregnancy, they highlighted diverse consumption patterns within an Asian setting.

Reproducibility of identified dietary patterns in the subsample using two dietary assessment methods (n 289)

CFA has been used in nutrition studies to examine the robustness of empirically derived patterns[15,19,32,37], and by reducing the subjectivity and ambiguity involved in exploratory approaches[19,33,37]. In line with these studies with reported CFI values of 0·64–0·71 and RMSEA values of 0·105–0·805[15,18], we found that the identified patterns from the large sample were reproducible in the subsample when the same dietary assessment method (FFQ) was used (CFI = 0·787, RMSEA = 0·070). Unlike two other studies, where 7-d weighed diet record readily identified patterns obtained from the FFQ[15], the identified patterns were less reproducible when 3DFD was used in the current study (CFI = 0·343, RMSEA = 0·065). A shorter, limited reference period (3 d) and a less precise measurement of intakes (non-weighed) in the current study could have contributed to the poorer reproducibility of the identified patterns in the 3DFD of the subsample. An exploration of the dietary patterns captured by each dietary assessment method in the subsample further substantiated these findings.

Dietary patterns in the subsample (n 289)

Differences in the patterns identified could be largely due to the fundamental differences between the two dietary assessment methods. Firstly, the FFQ is a closed-ended checklist of foods that captured estimated intakes of each given item, while the 3DFD is a detailed, open-ended record of the actual foods consumed. During the 3DFD dietary analyses, recorded foods and individual components of composite foods are often re-coded to match the closest corresponding FFQ food items. This lack of 'one-to-one correspondence' between foods captured by the FFQ and those in the 3DFD could have led to the differing patterns observed[38].

Secondly, the dietary assessment methods had differing reference periods for the recording of intakes (FFQ: intakes in the past month; 3DFD: 3 d of a selected week after FFQ administration), which is likely to have resulted in a larger variation of foods captured by the FFQ in the subsample (FFQ: 51 %; 3DFD: 32 % of the variation explained). As changes in diet were unlikely within the short interval between the administration of the FFQ and 3DFD, differences in intakes captured could be largely due to the dietary assessment methods used[38].

Thirdly, women planning pregnancy could have reduced their intakes of discretionary foods (such as fast food, fried snacks) upon intending to conceive[39]. These foods (mainly found in the FFQ 'Fast Food and Sweetened Beverages' pattern) are thus less likely to be consumed over the course of 3 d, hence were not captured by the 3DFD. In view of the differences between the two dietary assessment methods, we suggest the use of the FFQ-derived dietary patterns (instead of 3DFD ones), based on their better reproducibility and ability to reflect habitual intakes, for future diet-related investigations on health outcomes in this cohort.

Strengths of the current study include having a relatively large sample size (*n* 289) as compared with other dietary validation studies with sample sizes ranging from 92 to 203 participants[9,13,14,40–42] and the reproducibility of these patterns was examined using CFA, giving additional credence to the results[43]. However, several limitations are worth noting. Firstly, we regarded the FFQ patterns to be reflective of the habitual dietary intakes in this cohort, though it is also prone to reporting errors and biases. Nonetheless, the FFQ has been widely used as a measure for diet association studies[38]. Secondly, it is possible that the behavioural effect of reporting dietary intakes may obscure the true dietary intakes of participants and hence the patterns identified (e.g., socially desirable reporting of diets during interviewer-administered FFQ or simplifying food intakes to reduce reporting burden for the 3DFD)[44]. While this cannot be avoided entirely, we expect both dietary assessment methods to be similarly affected. Thirdly, no or low intakes for specific food groups could be a concern when identifying the patterns, especially so for the 3DFD. To address this, we performed EFA on the thirteen food groups where at least 50 % of the women had intakes recorded in the 3DFD. However, only two patterns were identified and they provided little information on the overall diets. As such, the number of food groups used in all analyses was standardised for consistency, an approach that was adopted by similar studies[8].

Conclusion

We have identified three dietary patterns (‘Fish, Poultry/Meat and Noodles’, ‘Fast Food and Sweetened Beverages’ and ‘Bread, Legumes and Dairy’) among Asian women planning pregnancy. In general, the three dietary patterns assessed by the FFQ were reproducible and reasonably congruent across several socio-demographic characteristics, providing a basis for future investigations on the overall diet and health outcomes in this cohort.

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Supplementary material

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