**Title:** Relation of preconception eating behaviours to dietary pattern trajectories and gestational weight gain from preconception to late pregnancy[[1]](#footnote-1)

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**Abstract**

Studies examining preconception eating behaviours with longitudinal dietary patterns from preconception to late pregnancy as well as gestational weight gain (GWG) are limited. We derived dietary pattern trajectories from preconception to late-pregnancy, and related preconception eating behaviours to these trajectories and GWG. Preconception eating behaviours were assessed using the Three-Factor Eating Questionnaire measuring cognitive restraint (CR) – conscious restriction of food intake, emotional eating (EE) – overeating in response to negative emotions, and uncontrolled eating (UE) – overeating with a feeling of lack of control. Dietary intakes were measured at preconception, 20-21 and 34-36 weeks’ gestation with food frequency questionnaires. Dietary patterns were determined using factor analysis, and trajectories derived using group-based trajectory modelling. Inadequate and excessive GWG were defined according to Institute of Medicine guidelines based on weights at preconception and the last antenatal visit (median: 38 weeks’ gestation). Two dietary patterns were derived: ‘Fast Food, Fried Snacks and Desserts (FFD)’ and ‘Soup, Fish and Vegetables (SFV)’. Adherence trajectories from preconception to late-pregnancy were characterised as consistently high (“stable-high”) and low (“stable-low”). Women with higher UE scores had higher odds of being in the “stable-high” trajectory (n=34) of the FFD pattern [Odds Ratio (OR): 1.25, 95% Confidence Interval (CI): 1.03, 1.51], compared to “stable-low” (n=260). Percentages of women with inadequate, adequate or excessive GWG were 21.7% (n=70), 25.8% (n=83), and 52.5% (n=169), respectively; women with higher EE scores had a higher likelihood of excessive GWG [Relative Risk Ratio (RRR): 1.35, 95% CI: 1.02, 1.80], but this association was attenuated after adjusting for preconception body mass index. Eating behaviour interventions to improve dietary patterns among pregnant women may need to start as early as preconception, incorporating strategies to manage UE.

1. **Introduction**

Increasing evidence suggest that maternal nutrition before and during pregnancy is an important determinant of maternal and infant health outcomes (Triunfo & Lanzone, 2015). Adopting a healthy dietary pattern during this period has been associated with lower risks of excessive gestational weight gain (GWG), gestational diabetes (Ancira-Moreno et al., 2019; Mizgier et al., 2021), preterm birth, and low birth weight (Gresham et al., 2016; Tobias et al., 2012; Zhu et al., 2021). These have implications on offspring growth and development, and future risks of obesity and metabolic diseases (Koletzko et al., 2019; O'Reilly & Reynolds, 2013). Taken together, these findings support a need to adopt healthy dietary patterns both before and during pregnancy.

Previous research shows that women who are pregnant or are actively trying to conceive have higher motivation to improve their diet due to the awareness of the consequences of a poor diet on child’s health (Forbes et al., 2018). However, how closely women adhere to healthy dietary patterns at preconception and whether there are changes in adherence to healthy dietary patterns from preconception to pregnancy is unclear. Findings from UK and Spanish cohorts showed little change in dietary patterns adherence from preconception to pregnancy (Cucó et al., 2006; Dalrymple et al., 2022); in contrast, an Australian study reported improvements in dietary pattern (assessed by the Healthy Eating Index scores) from preconception to pregnancy (Gete et al., 2021). To date, no studies have examined dietary patterns longitudinally from preconception to pregnancy in Asian populations, who have different dietary patterns from Western counterparts; for example, the “vegetable-fruit-soy” dietary pattern of a Chinese cohort and the “traditional South Asian” dietary pattern characterised by high intakes of fruit and vegetables, nuts and legumes, herbs and spices, were beneficial for a number of health outcomes (Cao et al., 2022; Charitha Koneru et al., 2023).

Eating behaviors refer to the psychological factors that influence food choices and quantity of food intake (Bijlholt et al., 2020). Different from eating disorders (e.g., anorexia nervosa) which are serious mental illnesses (Bellodi & Erzegovesi, 2016), eating behaviors are present in every individual to varying extents (Bijlholt et al., 2020). Several constructs and psychometric measures have been developed to assess these individual differences in eating behaviour such as the Three Factor Eating Questionnaire (TFEQ) which has been widely evaluated in many populations. The TFEQ has three subscales: cognitive restraint (CR) – a tendency to consciously restrict food intake instead of using hunger and satiety cues to regulate intake; emotional eating (EE) – a tendency to overeat in response to negative emotions; and uncontrolled eating (UE) – a tendency to overeat with the feeling of being out of control (Stunkard & Messick, 1985).

Studies which examined cognitive restraint, emotional or uncontrolled eating in relation to food intake in non-pregnant adult women showed that higher cognitive restraint was associated with more healthful food choices such as higher intakes of fruit and vegetables (Aguirre et al., 2017; Contento et al., 2005), whilst higher emotional or uncontrolled eating has been associated with greater intakes of energy-dense foods such as fast food, desserts and sweet snacks (Camilleri et al., 2014; Jaakkola et al., 2013; Konttinen et al., 2010). However, to the best of our knowledge, no studies have examined the influence of cognitive restraint, emotional or uncontrolled eating at preconception on dietary intakes during preconception and pregnancy. Women who are actively trying to conceive may experience unique stressors (Guardino & Schetter, 2014) which may influence their eating behaviour and their motivation for adhering to a healthy diet during preconception and pregnancy (Mooney et al., 2021).

In recent years, there is an increasing recognition that interventions to reduce excessive GWG need to start prior to pregnancy (Lim et al., 2022; Samura et al., 2016). It is thus important to examine whether eating behaviours at preconception are related to GWG to determine if modifying these eating behaviours as part of preconception lifestyle interventions can contribute to achieving adequate GWG. A few studies showed no associations between restrained eating at preconception and GWG (Clark & Ogden, 1999; Conway et al., 1999; Heery et al., 2016; Mumford et al., 2008); but these studies relied on retrospective assessment of preconception eating behaviours which may be influenced by recall bias, and did not adjust for preconception body mass index (BMI) in their analysis which may confound the association between preconception restrained eating and GWG given that preconception BMI is a strong predictor of GWG (Samura et al., 2016). To date, no studies examined emotional and uncontrolled eating at preconception with GWG.

There are currently no studies from Asian populations examining the relationships of preconception eating behaviours with dietary intakes and GWG during pregnancy, which can help improve preconception interventions promoting healthy dietary patterns and adequate weight gain throughout pregnancy in Asian women. Therefore, this study aimed: 1) to identify trajectories of dietary patterns from preconception to late pregnancy in a multi-ethnic Asian cohort; and 2) to examine the associations of preconception eating behaviours, specifically cognitive restraint, emotional or uncontrolled eating, with these dietary pattern trajectories and GWG categories (adequate, excessive, inadequate).

1. **Methods**

**2.1 Study population**

The present study used data from the Singapore PREconception Study of long-Term maternal and child Outcomes (S-PRESTO) – a preconception, longitudinal cohort study which aims to examine the influence of preconception and pregnancy factors on the health of mother and offspring later in life (Loo et al., 2021). Participants were women of Chinese, Malay, or Indian ethnicity (or any combinations of these 3 ethnicities), aged 18 to 45 years, planning to conceive within 1 year of recruitment. Women were recruited during February 2015 – October 2017 through a preconception clinic in KK Women’s and Children’s Hospital (largest public maternity hospital in Singapore) and from the general population. Women were not eligible if they: 1) had type 1 or type 2 diabetes, 2) were taking systemic steroids, anticonvulsants, HIV or Hepatitis B or C medication in the past one month, 3) were actively trying to conceive for more than 18 months prior recruitment, 4) had been using oral or implanted contraceptives, or on fertility treatment (except clomiphene or letrozole) in the past one month. Further details regarding the S-PRESTO cohort study were published (Loo et al., 2021). All procedures of the S-PRESTO study received ethics approval from the SingHealth Centralised Institutional Review Board (reference 2014/692/D). Written informed consent was obtained from all participants at study recruitment.

The present study is based on the group of women with viable on-going singleton pregnancies who provided data for eating behaviours at preconception as well as data on dietary intakes at preconception, 20-21 and 34-36 weeks’ gestation, or GWG. We estimated that a minimum analysis sample of 201 women (or 67 for each GWG category) will be required to detect significant results at 80% power and 5% significance level (Stata 17.0, StataCorp, College Station, TX, USA). The sample size calculation was based on one study (Plante et al., 2019) comparing intuitive eating score for inadequate (mean 3.4, SD 0.5), adequate (mean 3.9, SD 0.5) and excessive GWG (mean 3.6, SD 0.6), as no studies demonstrated significant associations between restrained, emotional or uncontrolled eating (whether at preconception or pregnancy) and GWG categories. This equates to an effect size of d=0.22 which is considered a small effect size (Cohen., 1988).

**2.2 Dietary assessments and dietary patterns**

Women’s dietary intakes were assessed during the first preconception study visit, and at 20-21 and 34-36 weeks’ gestation with a validated, 92-item, semi-quantitative food frequency questionnaire (FFQ) (Lim et al., 2021), which was administered by trained research staff. Participants were asked to indicate their frequency of consumption for each FFQ item in the past month in an open-ended format under these options: ‘never/rarely’, ‘frequency per month’, ‘frequency per week’ or ‘frequency per day’. Picture aids of various food portion sizes and standard-sized household tableware were used to help participants in estimating the average amount consumed. Daily energy intake was estimated using a local food composition database. Further details of the FFQ and its validation have been published (Lim et al., 2021).

The 92FFQ items were collapsed into 44 food groups based on similarities in nutrient composition and culinary use for subsequent analyses, with certain food groups (e.g., vegetables, meat) split into ‘healthy’ or ‘less healthy’ according to their cooking methods (**Supplementary Table 1**). Factor analysis with varimax rotation were conducted to derive dietary pattern(s) at each timepoint (Kline, 2014). The number of factors (or patterns) chosen to retain was based on the break point of the scree plot, Eigenvalues greater than 1, and interpretability of the factors (Kline, 2014). Factor loadings ≥0.30 were used to identify food groups with greater contributions to a particular dietary pattern based on the cut-off point commonly used in other studies (Wingrove et al., 2022). Three dietary patterns were consistently identified across all three timepoints: ‘Fast Food, Fried Snacks and Desserts’ (FFD), ‘Soup, Fish and Vegetables’ (SFV), and ‘Nuts and legumes, Salad and Fruit’ (NSF). Further details of the dietary patterns at each timepoint including factor loadings and percentage of total variance explained are presented in **Supplementary Table 2**. Each participant received a factor score for each of the derived dietary pattern (rather than separated into mutually exclusive, non-overlapping groups), with a higher score indicating greater adherence to a particular dietary pattern (Kim & Mueller, 1978). The three dietary patterns derived were comparable over all three time points (indicated by highly correlated factor loadings for the same dietary pattern – **Supplementary Table 3**), permitting derivation of dietary pattern trajectories over time.

**2.3 Eating behaviour**

At three months after the first preconception visit, participants’ current eating behaviour was assessed using the Three-Factor Eating Questionnaire (TFEQ) (Stunkard & Messick, 1985). Eating behaviours scores were calculated according to factor structure and criteria used in alternative versions of the TFEQ (Bond et al., 2001; Hyland et al., 1989), including the TFEQ-R18 as reported by Karlsson et al. (Karlsson et al., 2000), thus comprised of the following three subscales: cognitive restraint (CR), representing constant restriction of eating regardless of physiological signs of hunger and satiety; emotional eating (EE), which refers to overeating during depressed and melancholic states; and uncontrolled eating (UE), which refers to overeating relative to physiologic need and a feeling of lack of control when eating. These 18 questions correspond to the items found by Karlsson et al. (Karlsson et al., 2000), to have an appropriate fit in their population. The TFEQ-R18 factor structure has also been demonstrated previously to be the most appropriate and practical for use in measuring eating behaviour in Singaporean adults (Chong et al., 2016). Further details on scoring can be found in a previous publication (Chong et al., 2016).

**2.4 Anthropometry at preconception and pregnancy**

Weight and height at preconception were measured using a SECA 803 weighing scale (to the nearest 0.1 kg) and SECA 213 Portable Stadiometer (to the nearest 0.1 cm), respectively. Preconception BMI was calculated as weight in kilograms divided by height in meters squared (kg/m2), and women were classified as underweight, normal weight, overweight, or obese based on the World Health Organization’s recommended BMI cut-offs for Asian populations (WHO expert consultation, 2004). Total GWG was computed by subtracting the preconception weight from the weight measured within four weeks prior to the delivery date. This measurement was used to calculate the adequacy of GWG in accordance with the Institute of Medicine (IOM) 2009 recommendations (Institute of Medicine & National Research Council, 2009). To ensure that GWG was independent of gestational duration, a 2-step process was employed following established methodology (Darling et al., 2023; Perumal et al., 2023). First, we estimated the minimum and maximum amount of weight a woman was expected to gain up to the last observed weight measurement according to the IOM 2009 recommendations. The expected GWG for the first trimester was defined as 2 kg for women with underweight and women with normal weight, 1 kg for women with overweight and 0.5 kg for women with obesity following previous methods (Darling et al., 2023; Perumal et al., 2023). Minimum and maximum recommended rates of GWG for the second and third trimesters were based on the IOM 2009 guidelines for women with different BMI categories (Institute of Medicine & National Research Council, 2009). Subsequently, we categorized women into groups of adequate (reference group), inadequate or excessive GWG based on whether their actual GWG fell within the expected range, below the minimum, or above the maximum expected GWG, respectively.

**2.5 Covariates**

At the preconception visit, in-person interviews were carried out by trained research staff to obtain self-reported socio-demographic information (age, ethnicity, highest education attained) from participants. Physical activity at preconception and at 34-36 weeks’ gestation was assessed using the short form of the International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003). Briefly, women reported the time spent walking and in moderate and vigorous intensity physical activities in the past 7 days; and subsequently classified into inactive, minimally active and active following the IPAQ data processing guideline (Bernard et al., 2019; Craig et al., 2003).

**2.6 Statistical analysis**

The dietary pattern scores at all three time points were used in group-based trajectory modelling (GBTM) to derive trajectories of dietary patterns from preconception to late pregnancy (34-36 weeks’ gestation). The GBTM method utilises a latent class model approach to identify subgroups of participants who follow a similar dietary pattern trajectory over time (Cao et al., 2020). The distribution model used was the censored normal distribution since the dietary pattern scores were continuous in nature. With reference to an established methodology (Jones et al., 2001), trajectory models were fitted by progressively increasing the number of trajectories from 1 to 3. The optimal number of trajectories were selected based on a lower Bayesian information criterion (BIC) value, a relative entropy closer to one, a minimum group size of 5%, Average Posterior Probabilities Assignment (APPA) >70%, and Odds Of Correct Classification (OCC) > 5% (Jones et al., 2001). The shape of trajectory was modelled as either intercept, linear, quadratic or cubic. To ensure model parsimony, non-significant quadratic and cubic terms were removed from models, but non-significant linear terms were retained as long as the BIC was lower than the model containing only the intercept term.

Scores for each eating behaviour subscales were compared according to participant characteristics, dietary pattern trajectories and GWG categories using t-test or one way ANOVA test.

The association of eating behaviour at preconception with dietary patterns trajectories were examined using binomial logistic regressions adjusting for age at recruitment, ethnicity, education, preconception BMI and physical activity. The association of eating behaviour at preconception with GWG categories were examined using multinomial logistic regressions which estimate the relative risk ratios (RRRs) for inadequate and excessive GWG, respectively, compared to adequate GWG (reference group) per 1-point increment in eating behaviours scores. The models were adjusted for age at recruitment, ethnicity, education, physical activity at preconception and 34-36 weeks gestation, energy intakes at preconception, 20-21 weeks and 34-36 weeks gestation, and trajectories of SFV (for cognitive restraint) or FFD (for emotional and uncontrolled eating) dietary patterns (Model 1); and then further adjusted for preconception BMI (Model 2). For significant association between eating behaviour and GWG, stratified analysis by preconception BMI category (under/normal weight, overweight/obese) was performed, including test for interaction.

Multiple imputation with chained equations (20 times) were performed for covariates with missing data: energy intakes at preconception (n=3), 20-21 weeks (n=15) and 34-36 weeks (n=17) gestation; physical activity at preconception (n=2) and 34-36 weeks (n=12); and preconception BMI (n=1). All statistical analysis were conducted in Stata 17.0 (StataCorp, College Station, TX, USA). Two-sided P-values less than 0.05 indicated statistical significance.

1. **Results**

A total of 1032 women were recruited into the S-PRESTO study; of whom 909 women completed the TFEQ at preconception. Among those who completed the TFEQ, 475 women had viable on-going singleton pregnancies. A total of 322 women were included in the analysis of eating behaviours and GWG, 294 women were included in analysis of eating behaviours and dietary patterns trajectories (**Figure 1**).

**3.1 Participant Characteristics**

Comparisons of scores for each eating behaviour subscales according to participant characteristics and dietary patterns trajectories are presented in **Table 1**. Women with higher scores in cognitive restraint were more likely to have higher educational level and be in the “stable-high” trajectory of the SFV dietary pattern, but scores did not significantly differ by age, ethnicity, preconception BMI, physical activity and energy intake at preconception, and FFD dietary pattern trajectories. Those with higher scores in emotional eating tended to be classified as minimally active at preconception and to have excessive GWG, while those with higher scores in uncontrolled eating tended to be younger, to have attained lower educational level, to be in the “stable-high” trajectory of the FFD dietary pattern. Women who were overweight and obese at preconception tended to have higher scores in emotional and uncontrolled eating. There are no significant differences in emotional eating scores by age, ethnicity, education, energy intake at preconception and dietary patterns trajectories, and in uncontrolled eating scores by ethnicity, physical activity and energy intake at preconception, and SFV dietary pattern trajectories.

**3.2 Trajectories of dietary patterns**

A 2-class linear model was identified as the optimal model for both the FFD and the SFV dietary patterns based on model fit criteria (**Supplementary Table 4**). For the FFD dietary pattern, the 2-class linear model had a high entropy (0.894), with the smallest class comprising 12.3% of the study sample, and the APPA and OCC values meeting the criteria of >70% and >5%, respectively; the 3-class linear model was rejected because <5% of the study sample was assigned to the smallest class. For the SFV dietary pattern, the 3-class linear model had a lower BIC, higher entropy, and its smallest class comprised 12.9% of the study sample; however, the OCC value for one of the 3 classes was <5%, hence a 2-class linear model was chosen because the BIC and entropy were not largely different from the 3-class linear model and the smallest class met the minimum group size of 5%. Quadratic- and cubic-shape trajectories were not considered as the quadratic and cubic terms in all models were not statistically significant (*P*>0.05). The NSF dietary pattern was removed from subsequent trajectory analyses because the smallest class for 2- or 3-class models had <5% of study sample.

The trajectories for each of the dietary patterns are shown in **Figure 2**. Two trajectories were derived for each dietary pattern, respectively; with one trajectory (“stable-high”) characterized by higher pattern scores (>0) across all time points indicating a consistently higher adherence to the pattern over time, and another trajectory (“stable-low”) characterized by lower pattern scores (<0) across all time points indicating a consistently lower adherence to the pattern over time. Approximately 12.3% (n=35) and 87.7% (n=287) were in the “stable-high” and “stable-low” trajectories of the FFD dietary pattern, respectively; whilst 39.9% (n=126) and 60.1% (n=196) were in the “stable-high” and “stable-low” trajectories of the SFV dietary pattern, respectively.

**3.3 Associations of preconception eating behaviour with dietary patterns trajectories**

Higher scores in uncontrolled eating were associated with higher odds of being in the “stable-high” trajectory of the FFD dietary pattern (OR: 1.25; 95% CI: 1.03, 1.51), compared to the “stable-low” trajectory (**Table 2**). No statistically significant associations were observed for cognitive restraint and emotional eating with the trajectories of the FFD dietary pattern. There were also no statistically significant associations between eating behaviours and SFV dietary pattern trajectories.

**3.4 Associations of preconception eating behaviour with GWG**

Approximately 21.7% (n=70), 25.8% (n=83), and 52.5% (n=169) of women had inadequate, adequate and excessive GWG, respectively. Women with higher scores in emotional eating had higher likelihood of excessive GWG (RRR: 1.35; 95% CI: 1.02, 1.80), compared to adequate GWG, but this association was attenuated after adjusting for preconception BMI (**Table 3**). The association between emotional eating and excessive GWG did not differ when stratified by preconception BMI category (under/normal weight: RRR 1.23, 95% CI: 0.84, 1.81; overweight/obese: RRR 1.02, 95% CI: 0.55, 1.88, *P*-interaction=0.943). No statistically significant associations were observed for cognitive restraint and uncontrolled eating with GWG categories.

1. **Discussion**

In this multi-ethnic Asian preconception cohort study, we derived FFD and SFV dietary patterns and we identified two stable trajectories, spanning from preconception to late pregnancy. The majority of participants had consistent low adherence to either dietary pattern (“stable-low” trajectory); while a smaller proportion of participants (12% and 40%, respectively) had consistent higher adherence to either dietary pattern (“stable-high” trajectory). Higher uncontrolled eating was associated with a higher likelihood of being in the “stable-high” trajectory of the FFD dietary pattern. Having a higher emotional eating score was associated with a higher likelihood of excessive GWG, but adjusting for preconception BMI attenuated the association.

To the best of our knowledge, this is the first study to longitudinally track women’s dietary patterns from preconception to late pregnancy in an Asian cohort. Our results suggest that most women tend not to significantly change their dietary patterns even after becoming pregnant. This aligns with findings from several studies showing minimal changes in women’s overall dietary pattern before and during pregnancy (Crozier et al., 2009; Dalrymple et al., 2022; Djossinou et al., 2020), but contrasts with the findings of a systematic review reporting an increase in fruit and vegetable consumption, and a decrease in fried and fast food consumption from before to during pregnancy (Hillier & Olander, 2017), perhaps because the included studies examined specific food groups instead of overall diet. While there may be changes in intakes of food groups, the changes may not be substantial enough to affect overall dietary pattern. Taken together, our finding suggests that to improve a women’s dietary pattern during pregnancy, interventions to support adoption of a favourable dietary pattern need to start as early as the preconception period.

The SFV dietary pattern, which is characterised by higher intakes of clear soup, fish, vegetables, and poultry or meat prepared using healthier cooking methods, akin to a “healthy” diet. This pattern is unique to our population as no studies in the Western population identified soup as part of a “healthy” dietary pattern. In Asia, especially in Chinese, consuming dishes in clear soup is common and identified as a healthy cooking method (Wang et al., 2020). In contrast, the FFD pattern resembles a “less-healthy diet” because foods that loaded highly in this pattern (fast food, deep fried local snacks and desserts) were comparable to those reported in the ‘Western’ or ‘unhealthy’ dietary patterns found in Western populations (Askari et al., 2014; Coura et al., 2022).

We found that a higher level of uncontrolled eating was associated with a greater likelihood of being in the “stable-high” trajectory of the FFD pattern. This finding is reminiscent of studies in non-pregnant adolescents and adults showing a higher level of uncontrolled eating to be associated with choosing energy-dense or fatty foods such as fries and pastries (de Lauzon et al., 2004; Keskitalo et al., 2008) as well as with higher energy and fat intakes (Jaakkola et al., 2013; López-Cepero et al., 2021). It is postulated that individuals with higher uncontrolled eating tended to have greater sensitivity to foods perceived as rewarding and pleasurable (Bryant et al., 2008), which are often foods higher in energy and fat (Drewnowski, 1997). This suggests that strategies to overcome uncontrolled eating may be an important target for decreasing adherence to “less-healthy” dietary patterns in women trying to conceive. For example, interventions incorporating mindful/intuitive eating have resulted in improved diet quality in adult men and women (Grider et al., 2021).

A higher level of emotional eating was associated with a greater likelihood of excessive GWG. This association did not seem to be mediated by energy intake and dietary patterns as adjustment for these factors did not attenuate the association. However, the association is no longer significant after adjustment for preconception BMI, implying that the influence of emotional eating on excessive GWG is largely explained by preconception BMI. Previous research in non-pregnant populations has shown high correlations in emotional eating and overweight and obesity (Dakanalis et al., 2023). Likewise, in our study, women with overweight and obesity at preconception had higher scores in emotional eating. The literature has shown that women with overweight and obesity at preconception were at higher risk of excessive GWG (Samura et al., 2016); it is thus possible that preconception BMI had a stronger relationship with GWG than emotional eating, thereby attenuating the association between emotional eating and excessive GWG. We did not observe differences in associations by preconception BMI categories, contrary to the study by Garduño-Alanis et al. (Garduño-Alanis et al., 2020) showing higher emotional eating to be associated with higher GWG among women with normal preconception BMI but not women with overweight and obesity; however, this study was conducted in women with type 2 or gestational diabetes, and assessed eating behaviours during pregnancy instead of at preconception.

The strengths of this study include assessments of eating behaviour at preconception and dietary intakes of women at multiple time points from preconception to late pregnancy, as well as identification of cultural-specific dietary patterns which is not achievable with the use of *a priori* approaches (i.e., dietary indices). An additional strength is the use of the TFEQ version (TFEQ-R18) which has an appropriate fit to our local population. Several limitations should be noted. The exploratory approach of deriving dietary patterns limits generalisability, however, the SFV and FFD patterns are akin to the "healthy" and "less-healthy" dietary patterns of other cohorts (Chia et al., 2019). Due to their data-driven nature, the dietary patterns at each time point differs to a certain extent, but results showed high correlation for the same dietary pattern derived at separate time points. Including women who were actively trying to conceive could mean that dietary changes may have occurred prior to study recruitment, which may explain why we did not see a change in diet in this cohort. Temporality of the association cannot be established because eating behaviour were measured after assessment of preconception diet. Dietary intake was self-reported and may be influenced by social desirability bias; those who have higher cognitive restraint may over-report intakes of healthy foods and under-report intakes of unhealthy foods. Although a sample size of 322 participants met the minimum analysis sample and is acceptable for GBTM (Nagin, 2005), the sample size calculation was based on the assumption that the means and variances in restrained, emotional and uncontrolled eating scores according to GWG categories are similar to those of intuitive eating scores. Furthermore, our sample size was not based on a power calculation to identify trajectories of dietary patterns which is also a primary aim of the study. Instead, the sample size was selected to be able to detect a small effect size of d=0.22 differences between GWG categories and eating behaviours. Therefore, smaller effects than this would not have been detectable in the present study and future more appropriately powered studies will be required. Lastly, it is possible for eating behaviours to change during pregnancy which may impact on GWG, but we did not assess changes.

In conclusion, we found that the dietary patterns of women in this multi-ethnic Asian cohort showed relatively stable trajectories from preconception to late pregnancy. As such, interventions to improve diet in women during pregnancy should consider targeting women starting from the preconception period. Additionally, the current findings suggest that incorporating strategies to overcome negative eating behaviour (e.g., emotional and uncontrolled eating) may be necessary for effective interventions to improve overall diet in women at preconception and during pregnancy as well as to achieve adequate GWG, although further research is warranted before implementing these strategies in the general Asian populations.

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**Authors’ contributions:** JL,JSL and MFFC designed the research. JL and JSL performed statistical analysis and wrote the manuscript. MFFC reviewed and edited the manuscript. JSL and MFFC had primary responsibility for final content. MTC contributed to collection and cleaning of dietary data. SLL contributed to cleaning and derivation of gestational weight gain data. JKYC, FY, YSC, KMG, JGE and SYC led the S-PRESTO study. All authors were involved in data interpretation, critically reviewed the manuscript for intellectual content, read and approved the final manuscript.

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| --- |
| **Table 1**: Comparisons of preconception eating behaviour scores according to participant characteristics and dietary patterns trajectories |
|  | **n** | **Cognitive restraint** | **P** | **Emotional eating** | **P** | **Uncontrolled eating** | **P** |
| Age at recruitment |  |  |  |  |  |  |  |
| < 30 years | 151 | 2.50 ± 1.81 | 0.082 | 0.83 ± 1.13 | 0.252 | 2.46 ± 2.23 | 0.035 |
| ≥ 30 years | 173 | 2.85 ± 1.81 |  | 0.70 ± 0.98 |  | 1.98 ± 1.90 |  |
| Ethnicity |  |  |  |  |  |  |  |
| Chinese | 248 | 2.69 ± 1.82 | 0.921 | 0.77 ± 1.07 | 0.277 | 2.20 ± 2.00 | 0.349 |
| Malay | 43 | 2.63 ± 1.79 |  | 0.88 ± 1.14 |  | 2.65 ± 2.47 |  |
| Indian | 17 | 3.00 ± 1.97 |  | 0.47 ± 0.87 |  | 1.82 ± 2.32 |  |
| Multi-racial | 15 | 2.27 ± 1.87 |  | 0.60 ± 0.83 |  | 1.40 ± 1.68 |  |
| Highest Education |  |  |  |  |  |  |  |
| ≤ Post-secondary | 90 | 2.29 ± 1.76 | 0.016 | 0.81 ± 1.07 | 0.602 | 2.82 ± 2.35 | 0.001 |
| ≥ Tertiary | 233 | 2.83 ± 1.83 |  | 0.74 ± 1.06 |  | 1.97 ± 1.91 |  |
| Preconception BMI |  |  |  |  |  |  |  |
| Under-/Normal weight | 202 | 2.69 ± 1.87 | 0.888 | 0.58 ± 0.93 | <0.001 | 1.95 ± 1.93 | 0.004 |
| Overweight/Obese | 120 | 2.66 ± 1.73 |  | 1.07 ± 1.19 |  | 2.63 ± 2.25 |  |
| Physical activity at preconception |  |  |  |  |  |  |  |
| Inactive | 56 | 2.63 ± 1.90 | 0.404 | 1.05 ± 1.15 | 0.022 | 2.43 ± 2.07 | 0.246 |
| Minimally active | 145 | 2.79 ± 1.74 |  | 0.70 ± 1.00 |  | 2.14 ± 2.03 |  |
| Active | 120 | 2.59 ± 1.89 |  | 0.72 ± 1.08 |  | 2.18 ± 2.16 |  |
| Energy intake at preconception |  |  |  |  |  |  |  |
| ≤ Median (7903.6 kJ) | 160 | 2.67 ± 1.89 | 1.000 | 0.66 ± 0.96 | 0.065 | 2.01 ± 2.02 | 0.068 |
| > Median (7903.6 kJ) | 160 | 2.67 ± 1.74 |  | 0.87 ± 1.14 |  | 2.43 ± 2.13 |  |
| FFD dietary pattern trajectory |  |  |  |  |  |  |  |
| Stable-low | 260 | 2.62 ± 1.78 | 0.932 | 0.77 ± 1.06 | 0.393 | 2.04 ± 1.98 | 0.001 |
| Stable-high | 34 | 2.65 ± 1.92 |  | 0.94 ± 1.23 |  | 3.24 ± 2.37 |  |
| SFV dietary pattern trajectory |  |  |  |  |  |  |  |
| Stable-low | 176 | 2.43 ± 1.79 | 0.026 | 0.78 ± 1.08 | 0.785 | 2.02 ± 2.12 | 0.097 |
| Stable-high | 118 | 2.91 ± 1.76 |  | 0.81 ± 1.08 |  | 2.42 ± 1.95 |  |
| Gestational Weight Gain |  |  |  |  |  |  |  |
| Adequate | 83 | 2.67 ± 1.73 | 0.982 | 0.57 ± 0.86 | 0.033 | 2.07 ± 1.90 | 0.580 |
| Excessive | 169 | 2.69 ± 1.79 |  | 0.93 ± 0.94 |  | 2.31 ± 2.02 |  |
| Inadequate | 70 | 2.64 ± 1.89 |  | 0.76 ± 0.83 |  | 2.07 ± 2.23 |  |
| BMI, body mass index; FFD, Fast Food, Fried Snacks and Desserts; SFV, Soup, Fish and Vegetables |
| Values are mean ± SD. P-values are for t-test or one-way ANOVA |
| Missing data: preconception BMI (n=1), physical activity at preconception (n=2), energy intake at preconception (n=3) |

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| **Table 2:** Associations of preconception eating behaviour with dietary patterns trajectories from preconception to late-pregnancy in the Singapore Preconception Study of Long-Term Maternal and Child Outcomes (S-PRESTO) study |
|  |  | **Cognitive restraint** | **Emotional eating** | **Uncontrolled eating** |
| **Dietary patterns trajectories** | n | OR (95% CI) | P | OR (95% CI) | P | OR (95% CI) | P |
| FFD |  |  |  |  |  |  |  |
| Stable-low | 260 | 1.00 |  | 1.00 |  | 1.00 |  |
| Stable-high | 34 | 1.10 (0.88, 1.38) | 0.381 | 1.04 (0.71, 1.54) | 0.825 | 1.25 (1.03, 1.51) | 0.023 |
| SFV  |  |  |  |  |  |  |  |
| Stable-low | 176 | 1.00 |  | 1.00 |  | 1.00 |  |
| Stable-high | 118 | 1.14 (0.99, 1.32) | 0.070 | 0.98 (0.77, 1.24) | 0.848 | 0.96 (0.71, 1.11) | 0.133 |
| FFD, Fast Food, Fried Snacks and Desserts; SFV, Soup, Fish and Vegetables |
| Models adjusted for age, ethnicity, education, and preconception body mass index and physical activity |

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| **Table 3:** Associations of preconception eating behaviour with gestational weight gain status in the Singapore Preconception Study of Long-Term Maternal and Child Outcomes (S-PRESTO) study |
|  |  | **Cognitive restraint** | **Emotional eating** | **Uncontrolled eating** |
| **Gestational Weight Gain** | n | RRR (95% CI)a | P | RRR (95% CI)b | P | RRR (95% CI)b | P |
| Adequate | 83 | 1.00 |  | 1.00 |  | 1.00 |  |
| Inadequate | 70 |  |  |  |  |  |  |
| Model 1 |  | 0.98 (0.81, 1.18) | 0.831 | 1.15 (0.82, 1.61) | 0.419 | 0.92 (0.77, 1.09) | 0.333 |
| Model 2 |  | 0.96 (0.80, 1.16) | 0.705 | 1.13 (0.79, 1.60) | 0.506 | 0.90 (0.75, 1.08) | 0.245 |
| Excessive | 169 |  |  |  |  |  |  |
| Model 1 |  | 0.98 (0.84, 1.15) | 0.848 | 1.35 (1.02, 1.80) | 0.038 | 1.01 (0.88, 1.16) | 0.901 |
| Model 2 |  | 0.94 (0.80, 1.11) | 0.472 | 1.14 (0.84, 1.55) | 0.399 | 0.94 (0.80, 1.09) | 0.409 |
| Model 1 adjusted for age, ethnicity, education, physical activity, energy intake at preconception, 20-21 weeks’ and 34-36 weeks’ gestation, and aSoup, Fish, Vegetables or bFast Food, Fried Snacks and Desserts dietary patterns trajectories |
| Model 2 adjusted for Model 1 and preconception body mass index |

1. GWG, gestational weight gain; S-PRESTO, Singapore PREconception Study of long-Term maternal and child Outcomes; FFQ, food frequency questionnaire; FFD, Fast Food, Fried Snacks and Desserts; SFV, Soup, Fish and Vegetables; NSF, Nuts and legumes, Salad and Fruit; TFEQ-51, 51-item Three-Factor Eating Questionnaire; CR, cognitive restraint; EE, emotional eating; UE, uncontrolled eating; BMI, body mass index; IOM, Institute of Medicine; IPAQ, International Physical Activity Questionnaire; GBTM, group-based trajectory modelling; BIC, Bayesian information criterion; APPA, Average Posterior Probabilities Assignment; OCC, Odds Of Correct Classification; RRR, relative risk ratio [↑](#footnote-ref-1)