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Development and validation of an iodine specific food frequency questionnaire to estimate iodine intake in pregnant women.

Running title: Iodine specific food frequency questionnaire

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Abstract

Adequate iodine is important during pregnancy to ensure optimal growth and development of the offspring. This study aimed to develop and validate an iodine specific food frequency questionnaire (I-FFQ) for use in pregnant women. A 44-item I-FFQ was developed and administered to 122 pregnant women at study entry (<20 weeks gestation) and 28 weeks gestation. Iodine intake estimated from the I-FFQ was compared between the two time points for reproducibility. Correlation between iodine intake estimated from the I-FFQ and intake from a four day weighed food record, urinary iodine from a 24 hour and a spot urine sample, and thyroid function from a blood sample were assessed at 28 weeks gestation. Iodine intake from the I-FFQ at study entry and at 28 weeks gestation was strongly correlated ($r=0.622$, $p<0.001$). A moderate correlation was shown between intake from the I-FFQ and the four day weighed food record ($r=0.349$, $p<0.001$) which was strengthened with the addition of iodine supplements ($r=0.876$, $p<0.001$). There was a strong agreement ($k=0.799$, $p<0.001$) between the two dietary measures in the ability to classify the women as adequate (≥220µg/day) or inadequate (<220µg/day) intake but the limits of agreement from the Bland-Altman plot was low. Iodine intake from the I-FFQ correlated with 24 hour urinary iodine excretion ($r=0.488$, $p<0.001$) but did not correlate with spot urinary iodine concentration. In conclusion, the I-FFQ provides a valid tool to estimate iodine intake in pregnant women and can be used to screen women whose iodine intake is below the recommendations.

Introduction

Iodine is crucial in the formation of thyroid hormones, triiodothyronine (T3) and thyroxine (T4), and is essential for mammalian life [1]. Worldwide, iodine deficiency has emerged as a major public health issue because it is one of the most common micronutrient deficiencies, affecting developing as well as industrialised countries [2]. This is of particular concern during pregnancy as iodine deficiency can lead to spontaneous abortion, premature births, impaired growth and adverse neurological development as well as cretinism and infant mortality in severe iodine deficiency [1, 3].

Iodine requirement is thought to increase during pregnancy with the World Health Organisation (WHO) recommending that pregnant women increase their intake to 250µg/day compared with 150µg/day for women of child bearing age [2]. This increased requirement is due to the transfer of thyroid hormone from the mother to the fetus as well as the greater renal clearance of iodine [4, 5]. However, the recommended intake of iodine varies between industrialised countries, ranging from 140µg/day in the UK (no increment from non-pregnant women)[6] to 220µg/day in Australia, New Zealand and the United States [7, 8]. Assessment of iodine intake is challenging as iodine content of foods is influenced by a number of factors including fertilisers, irrigation, sanitising and industrial agents, rainfall, season and location [9] and it is difficult to accurately estimate the intake of iodine from the use of iodised salt in cooking and at the table [10]. As a result, urinary iodine concentration is often used as an indicator of iodine status with the WHO/UNICEF/ICCIDD defining a median urinary iodine concentration of ≥150 µg/L, based on the recommended dietary intake, as sufficient iodine intake in pregnancy [11]. However, UIC is reflective of recent iodine intake and has large intra-individual variation [12], limiting its use as an assessment of usual dietary iodine intake. Given the importance of iodine during pregnancy, an accurate assessment of habitual iodine intake is needed.

Dietary assessment poses challenges as many tools rely on memory, accurate estimation of intake and time commitment [13]. Food frequency questionnaires (FFQs) are used to assess longer term habitual intake, which is useful for nutrients such as iodine that are less common in the food supply [13]. FFQs are less time consuming, have a low burden on participants and lower cost compared with the more traditional dietary assessment method of weighed food records [13]. However, FFQs must be appropriate for the population in question, considering usual foods and food patterns. It is known that during pregnancy eating habits often change,

which may be a reflection of dietary recommendations, avoidance of foods as well as pregnancy related sickness [14]. Thus, the dietary assessment method must be tailored to suit this population.

Previous studies have developed and validated general FFQs and these have been used to assess iodine intake in pregnancy [15, 16]**.** However, general FFQs are often long and time consuming. Additionally, much of the information captured in a general FFQ would not be relevant when the focus is on iodine intake. We are interested in developing an iodine specific food frequency (I-FFQ) that can be used in large scale studies to assess iodine intake as well as a simple tool to identify women with inadequate intake and who may be at risk of iodine deficiency.

To our knowledge there are only three published I-FFQs that have been developed and validated, two for use in non-pregnant adult women in Denmark [17] and the UK [18] and one for use in the elderly [19]. These questionnaires were validated for use in those specific populations, reflecting the common food habits and practices of the population and thus limiting their use in pregnancy. The aim of this study was to develop an I-FFQ for use in pregnancy and assess its reproducibility and validity against iodine intake from a weighed food record; (2) urinary iodine from a 24 hour and a spot urine sample and (3) blood biomarkers of iodine status.

Methods

Subjects

Participants were recruited from women who were participating in the Pregnancy Iodine and Neurodevelopment in Kids (the PINK study) in Adelaide, Australia. A total of 122 women from the Women's and Children's Hospital were recruited between August 2011-April 2012 from the antenatal clinic at their first antenatal appointment. Eligible women were less than 20 weeks gestation with no history of thyroid disease. Ethics approval was obtained from the Women's and Children's Health Network (WCHN) Human Research Ethics Committee and all women provided written informed consent.

Development of the I-FFQ

The I-FFQ was developed to determine the women's average iodine intake over the past month. The food items were selected based on the most up to date Australian food

composition database that is based on analytical data, NUTTAB 2010 [20]. For food items that were not listed in NUTTAB, the AUSNUT 2007 was used to supplement the list, which incorporates nutrient data from a range of sources including recipes, international food composition tables as well as calculated and imputed data [21].

Foods were included in the I-FFQ if they had an iodine content of $\geq$ 5% of the recommended dietary intake (RDI) per serve for Australian pregnant women (10µg/serve). Serving sizes were based on standard serves using the Australian Guide to Healthy Eating or food labels and were expressed as measurements (in grams) or convenient household units (cup/tsp /tbsp). There were some foods that fell just below the 5% RDI criteria per serve, however were included in the I-FFQ as these foods were considered common in the Australian diet, including noodles and pasta, rice, cheese, ice cream, cooked broccoli, spinach and bok choy, chocolate, cashews, cheese flavoured snacks and pizza. For those food items with more than one variety, such as different types of fish and cheese, the average iodine content was used. The final questionnaire consisted of 44 food items (See *appendix 1)*. The food items were classified into seven main food groups based on those listed in the NUTTAB database [20] including seafood, cereal products, dairy, egg, vegetables, snacks and sweets and ready made foods. For each food item, the frequency of intake was recorded as the number of serves per day, per week or per month. If the food was not consumed on a monthly basis the frequency of intake was marked as rarely/<1 per month. An additional three questions were included which related to salt use, including whether salt was added in cooking or at the table, if the salt added was iodised salt and the individual daily portion used.

Validation of the I-FFQ

The validity of the I-FFQ was assessed in the following ways:

1. The comparison of iodine intake estimated from the I-FFQ with the four day weighed food record at 28 weeks gestation.
2. The reproducibility of the I-FFQ during pregnancy (<20 weeks and 28 weeks gestation).
3. The correlation between iodine intake from the I-FFQ and urinary iodine from a 24 hour urine sample and spot urine sample at 28 weeks gestation.
4. The correlation between iodine intake and thyroid function (TSH, Tg, fT3 and fT4) at 28 weeks gestation.

Assessment of iodine intake

The women completed the I-FFQ at enrolment (<20 weeks gestation) and at 28 weeks gestation. The questionnaire was checked for completeness by a dietitian. To calculate the mean daily iodine intake, all frequencies of consumption (per week and per month) were converted to per day assuming that there were sever days in a week and 30 days in a month. The frequency of consumption per day was multiplied by the average iodine content of the specific food. This calculation was completed for each individual food item and was added together to give the total mean daily iodine intake. The use of iodised salt was not quantified and therefore not included in the total iodine intake.

Women were asked to keep a weighed food record for four consecutive days including one weekend day between 26-28 weeks gestation. They were given oral and written instructions and were provided with digital kitchen scales and measuring cups. The women were asked to weigh and record details of the food consumed as well as weigh and record any left overs of each food item. If eating out the women were asked to record details about their meal. A separate space was provided to record any home cooked recipes including the amount (in grams or units) of raw ingredients used, the number of serves the recipe yields and the number of serves consumed. Foodworks with the NUTTAB 2010 and AUSNUT 2007 (Version 7, 2012) was used to assess dietary intake from the weighed food records. Food items not listed in the database were entered as the closest resembling food item or the nutritional information derived from the food label or company website was added to the database. These food items were kept in a log for consistency of data entry.

Information regarding supplement usage, including brand name, dose and frequency was gathered from women at 28 weeks gestation. Iodine intake from these supplements was calculated based on the manufacturer's information and this was added to the iodine amount estimated from the I-FFQs and weighed food records as the total iodine intake.

Assessment of urinary iodine

Urinary iodine excretion from 24 hour urine collections were used to validate the I-FFQ as urinary iodine is determined from a pooled 24 hour sample and therefore is seen to better reflect an individual's iodine excretion when compared to a spot urine sample [22]. The women were asked to collect the 24 hour urine sample after completing the weighed food

record and within two days of their 28 week gestation appointment. The first urine passed on the day of collection was not saved and was recorded as the start time and date of the 24 hour collection. All urine passed for the next 24 hours was collected. The last sample was collected 24 hours later from the start time and was recorded as the end time and date. Women were provided with written instructions and with the necessary equipment, including a 4L container to store the total urine collected and a 1L measuring jug to assist with collecting each sample, both of which had been tested and cleared for iodine contamination.

Once completed, the samples were refrigerated and delivered to the laboratory at the Women's and Children's Hospital within two days of collection. The total volume was measured and aliquots of 10ml were taken and stored at -20^{0}C for analysis. The method for the analysis of UIC was modified from the WHO 'Method A' procedure [2, 23], using ammonium persulfate digestion and microplate reading. The analytical value for the external iodine standard was 284.5 ± 12.2µg/L compared with the certified value of 304 ± 44µg/L. The percent relative standard deviation of the assay was 4.3%.

As part of the PINK study participants also provided a spot urine sample at 28 weeks. Similar to the 24 hour urine sample, UIC from the spot urine sample was analysed and used as an additional reference measure.

Blood Biomarkers

At 28 weeks gestation a blood sample was taken via venepuncture for analysis of thyroid stimulating hormone (TSH), thyroglobulin (Tg), free T3 (fT3) and free T4 (fT4). The analysis was conducted by SA Pathology, a National Association of Testing Authorities (NATA) accredited diagnostic laboratory in Adelaide. TSH, fT3) and fT4 were determined using an ADVIA Centaur automatic chemiluminescence immunoassay (Siemens Healthcare Diagnostics, US). Tg was determined using the Immulite 2000 chemiluminescent immunometric assay (Siemens Healthcare Diagnostics, UK). The coefficients of variability for TSH, fT3, fT4 and Tg were 5%, 7%, 4.5% and 8%, respectively.

Sample size and Statistics

184 At the time that the study was conducted there was limited data on total dietary iodine intake
185 in pregnant women. Therefore, sample size calculations were based on iodine intake data
186 from a previous iodine FFQ validation study in females of child bearing age [17]. Assuming a
187 median iodine intake of 115µg [17], we estimated that 84 women would be required to detect a
188 minimum difference of 20µg (10% of the RDI) in reported iodine intake between the two
189 dietary assessment methods with 90% power and a correlation of 0.5 ($p<0.05$). A difference
190 of < 10% RDI was considered clinically insignificant.
191
192 Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS)
193 V16.0.0 (SPSS Inc. Chicago IL, USA). Results were reported as the mean ± SD for
194 continuous variables and number and percentage for categorical variables. Paired *t* tests were
195 conducted to compare mean iodine intakes between the I-FFQ and weighed food records as
196 well as iodine intake from the I-FFQ between the two time points (<20 weeks vs 28 weeks
197 gestation). Pearson's correlation coefficient was used to determine the corelation between
198 iodine intake from the I-FFQ and weighed food record (food only and food plus supplements)
199 as well as the correlation in iodine intake estimated from the I-FFQ (food only) at the two
200 time points. Agreement between the two dietary methods was assessed using the Bland–
201 Altman method. Limits of Agreement (LOA), defined as the mean difference ± 2 standard
202 deviations between the methods were calculated [24].
203
204 Iodine intake from the I-FFQ and weighed food record was also categorised into adequate
205 (≥220µg/day) and inadequate (<220µg/day) based on the Australian RDI. Weighted kappa
206 coefficient k was used to assess the agreement in the categorisation between both dietary
207 assessment methods. The following guide was used to describe the strength of agreement: k
208 <0.20 = poor agreement; k: 0.21-0.40 = fair agreement; k: 0.41-0.60 = moderate agreement;
209 k: 0.61-0.80=good agreement; k: 0.81-1.0 = very good/strong agreement [25].
210
211 Linear regression analysis was used to assess the relationship between the I-FFQ (food +
212 supplements) and biomarkers including urinary iodine excretion (UIE), UIC and thyroid
213 function as well as the relationship between UIE from the 24 hour urine sample and UIC
214 from the spot urine sample, adjusted for potential confounding factors including BMI, age,
215 gestational age, parity, smoking status and education. Subgroup analyses were conducted to
216 compare iodine supplement vs. non-iodine supplement users and iodised salt vs. non-iodised
217 salt users. Statistical significance was set at $P < 0.05$.

Results

One hundred and twenty-two women were recruited for the validation study and 96 women completed the study. Characteristics of the participants are shown in Table 1. These women were aged between 18-41 years with a gestational age at study entry between 11-19.5 weeks. Seventy five percent of women were taking iodine supplements and 44% were using iodised salt. Demographic characteristics of non-completers (n=26) compared to completers (n=96) did not differ (data not shown). Reasons for women not completing the study included lack of time (n=17), withdrawal from the PINK study (n=7), miscarriage (n=1) and illness (n=1).

Iodine intake from the I-FFQ and four day weighed food record

Mean iodine intakes from the I-FFQ and four day weighed food record were 144 ± 52 µg/d and 160 ± 54 µg/d, p< 0.001 (food only) and 281 ± 124 µg/d and 297 ± 124 µg/d, p< 0.001 (food + supplement). As shown in Figure 1**,** a significant correlation was found between the estimated iodine intake from the I-FFQ and weighed food record (r=0.349, p<0.001) that was strengthened once supplements were added (r=0.876, p<0.001). The limits of agreement (LOA) for the Bland-Altman plot was between -102 and 134 µg across the range of iodine intake reported from food (Figure 2). There was a strong agreement (k=0.799, p<0.001) between the two dietary measures in the ability to classify the women as adequate or inadequate intake based on RDI with 92% of women classified into a same category.

Reproducibility of the I-FFQ in pregnancy

There was no difference in the mean iodine intake estimated from the I-FFQ completed at enrolment (<20 weeks gestation) and at 28 weeks gestation (153 ± 70 µg/d vs. 144 ± 52 µg/day respectively, p=0.338). A significant positive correlation (r=0.622, p<0.001) was shown in the estimated iodine intake from the I-FFQ completed at the two time points (Figure 3).

Correlation between iodine intake estimated from the I-FFQ and UIC

Median UIC (interquartile range) from the 24 hour urine sample and spot urine sample was 178 (38-586) µg/L and 212 (7-881) µg/L, respectively. Urinary iodine excretion (UIE) from the 24 hour urine sample was 332 (49-799) µg/day, calculated using UIC from the 24 hour urine multiply by the total volume of 24 hour urine. The percent of women with UIC <150 µg/L was 39%from the 24 hour urine sample and 37% from the spot urine sample. Iodine intake from the I-FFQ was positively correlated with iodine concentration from the 24 hour urine sample expressed either as UIC (µg/L) or UIE (µg/day), with adjustment for BMI, age, gestational age, parity, smoking status and education ($r=0.321$ and $r=0.448$, $p<0.001$, respectively) or without adjustment ($r=0.299$ and $r=0.477$, $p<0.001$). There was no correlation between iodine intake from the I-FFQ and the spot urine sample (Table 2) or between UIE (µg/day) from the 24 hour urine sample and UIC (µg/day) from the spot urine sample ($r=0.112$, $p=0.281$).

Correlation between iodine intake from the I-FFQ and thyroid function

No correlation was found between total iodine intake (food + supplement) from the I-FFQ and any markers of thyroid function including TSH, fT3, fT4 and Tg with or without adjustment for BMI, age, gestational age, parity, smoking status and education (Table 2).

Subgroup analysis

There were no differences in iodine intake (food only) estimated from the I- FFQ and weighed food record between subgroups (iodine supplement vs. non-supplement users or iodised salt vs. non-iodised salt users).

Iodine-supplement users showed a correlation between iodine intake from the I-FFQ and the weighed food record (food only) ($r=0.721$, $p<0.001$), and between iodine intake from I-FFQ and UIC (µg/L) ($r=0.362$, $p=0.004$) or UIE (µg/day) ($r=0.313$, $p=0.008$) from the 24 hour urine sample, while no correlation was shown in non-iodine supplement users.

Non-iodised salt users also showed a positive correlation between the I-FFQ and weighed food record ($r=0.576$, $p<0.001$) and between iodine intake from I-FFQ and UIC (µg/L) from the 24 hour urine sample ($r=0.491$, $p<0.001$) while no correlation was observed in iodised salt

users. UIE (µg/day) from the 24 hour urine sample was positively correlated with the I-FFQ in both iodised salt (r=0.331, p=0.028) and non-salt users (r=0.605, p<0.001).

With the exception of fT4 in non-iodine supplement users, no correlation was shown between the I-FFQ and UIC (µg/L) from spot urine samples or thyroid function in all subgroups (data not shown).

Discussion

To the best of our knowledge this is the first study to develop and validate an iodine specific FFQ for assessing iodine intake in pregnant women, using both dietary assessment and functional biomarkers. Our results suggest that the I-FFQ can be used as a valid tool in estimating iodine intake in pregnant women as the I-FFQ had a good correlation with the four day weighed food record and UIE from the 24 hour urine sample, and showed strong reproducibility. Additionally, our results suggest that the I-FFQ can be useful in screening women that may be at risk of inadequate dietary intake.

Our results show that the correlation between the I-FFQ and weighed food record was strengthened once supplements were added which is likely a result of the increased range of iodine intake. The correlation coefficient in our study compared well with other iodine FFQ validity studies in adults with four day weighed food records (r ranging from 0.45 to 0.52) [17, 18] and repeated 24 hour dietary recalls (r=0.377) [19]. Other validation studies in pregnancy have assessed multiple nutrients including iodine, and not surprisingly the findings were inconsistent with energy adjusted correlation coefficients ranging from 0.4 to 0.66 between FFQ and four day weighed food records [15, 26] to -0.03 between FFQ and a 24 hour diet recall [14], which may be a reflection of the reference method and FFQ used, including the length and food items included. Other single nutrient validation studies reported similar correlations to our study including an iron specific checklist with diet history interview (r=0.69, iron from food and supplement) during pregnancy [27] and a calcium specific FFQ with six day weighed food record in women of child bearing age (r=0.42) [28].

Although correlation analysis is commonly used, this does not indicate the agreement between two methods. The Bland-Altman method is often viewed as the preferred technique to assess agreement and hence to determine validity of a new method [24]. The results of this

316 study showed large Limits of Agreement, indicating low agreement between the I-FFQ and
317 the four day weighed food record. Many dietary validation studies have found similar results
318 [14, 17-19, 27, 29, 30]. This is likely to be a reflection of the differences between the dietary
319 measures, as FFQs are commonly used to estimate longer term, habitual intake while diet
320 records or 24 hour recalls estimate recent intake. It should therefore be questionned whether
321 assessing agreement using the Bland-Altman method is appropriate for dietary validation
322 studies as this technique was originally designed to compare similar methods [24].
323
324 Our study is the only validation study which used both 24 hour urine and spot urine samples
325 as reference markers to validate I-FFQ. The correlation between iodine intake from the I-
326 FFQ and 24 hour UIE in our study is comparable to one [17] of the two validation studies that
327 examined this relationship in non-pregnant women but in contrast to the other study [18],
328 which showed no correlation between iodine intake from I-FFQ and 24 hour UIE. This is
329 perhaps not surprising because although a 24 hour sample is less variation when compared to
330 a spot urine sample [22, 31], it is still subjected to day-to-day variation in iodine intake and
331 therefore it is not a reliable marker of iodine status for individuals Furthermore, there was no
332 correction between the 24 hour UIE (µ/day) and the spot UIC, demonstrating that UIC from a
333 spot urine sample is a poor indication of iodine intake and status. UIC based on spot urine
334 adjusted for creatinine (expressed as iodine to creatinine ratio) has been suggested as a more
335 accurate measure of iodine excretion and better reflection of iodine intake than spot UIC
336 alone [12, 19, 22, 31, 32]. However, it has been shown that 10 repeated spot urine samples are
337 needed to assess individual iodine status[12], which is cumbersome and impractical similar to
338 the 24 hour urine collection. Due to these limitations of UIC as a marker of individuals'
339 iodine status, a simple I-FFQ like the one developed in our study would be a better and
340 practical tool to assess iodine intake and status in pregnant women.
341
342 No relation between iodine intake from the I-FFQ and any of the blood biomarkers was
343 shown. It is known that thyroid function is tightly regulated and adaptive mechanisms are in
344 place to ensure that the functional needs are met, even in times of mild iodine deficiency [33].
345 Therefore, it may be that changes in blood biomarkers as a result of inadequate iodine intake
346 will only occur in severely deficient populations, which is not the case for this population,
347 explaining the lack of correlation shown here. This may also be similar to other biomarkers of
348 nutrient intake as single nutrient validation studies in pregnancy that have used blood
349 biomarkers as reference measures also found no or very weak correlations with FFQs [27, 34].

Additionally, there are a number of modifications in the regulation of thyroid function that occur during normal pregnancy, with not all of these entirely well understood. These normal changes may also contribute to the lack of correlation with dietary iodine intake.

Within this population there were a similar number of women who used iodised salt compared to those that did not. Interestingly, non-salt users showed a stronger correlation between the I-FFQ and both the weighed food record and UIE (µg/day), while iodised salt users showed no correlation. Although not statistically significant, the non-iodised salt users had a higher iodine intake of approximately 20µg (10% RDI). It may be a possibility that those women who add no salt to cooking or at the table are more health conscious and therefore include foods that are higher sources of iodine, resulting in stronger correlations between the I-FFQ and weighed food record. Furtermore, iodised salt was not quanitified from the I-FFQ which may explain the poor correlation between the I-FFQ and UIE in iodised salt users compared to non-iodised salt users. However these results should be interpreted with caution as this is a secondary analysis and the sample size within the subgroups may be inadequate.

This study has a number of strengths. The most updated food composition data was used when estimating iodine intake from the two dietary measures, and the time allocated for the collection of the reference methods was well controlled and the sample size was adequate. Additionally, both subjective (the gold standard for dietary assessment) as well as objective measures were used to assess the validity of the I-FFQ. However, we did not include iodine intake from iodised salt due to the issues associated with quantifying this. As half of the women reported the use of iodised salt, this is likely to have increased the mean iodine intake and therefore effect the relationship between the iodine intake from the I-FFQ and reference measures.

Conclusion

The validity of the I-FFQ to estimate habitual iodine intake in Australian pregnant women has been demonstrated by strong correlations with four day weighed food records and moderate correlation with UIE from 24 hour urine samples as well as strong reproducibility. Furthermore, the results of our validation study indicate that the I-FFQ can be used as a simple clinical tool to screen pregnant women at risk of inadequate iodine intake. However

the I-FFQ has limited ability to predict thyroid function. This I-FFQ could be modified to assess iodine intake in other populations.

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Conflict of interest

None

Authorship

The authors contributions are as follows: D.C, M.M, S.S and S.J. Z designed the study; D.C collected the data and performed statistical analysis; D.C drafted the manuscript with contributions from all authors. All authors reviewed and approved the manuscript submitted.

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Table 1: Demographic characteristics of the study population

	Participants (n=96)	
	Mean	**SD**
Age[a] (year)	31.5	5.1
Gestational Age[a] (week)	15.3	2.3
Weight[a] (kg)	70.1	16.1
BMI[a] (kg /m^2)	26.2	5.8
Primiparous[b]	55% (53)	
Completed secondary education[b]	85% (82)	
Currently smoking[b]	7% (7)	
Smoking 3 months prior to pregnancy[b]	13% (12)	
Taking iodine containing supplements[b]	75% (72)	
Using iodised salt[b]	45% (43)	

BMI: Body mass index

[a]Data are Mean ± SD

[b]Data are % (number)

Table 2: Association between I-FFQ (Food plus Supplement) and biomarkers

	Unadjusted (n=96)			Adjusted[a] (n=96)		
	B	**SE**	**P**	**B**	**SE**	**P**
Spot urine UIC	0.213	0.128	0.095	0.239	0.143	0.098
FT3	-0.001	0.000	0.052	0.000	0.000	0.318
FT4	-0.001	0.001	0.529	0.000	0.001	0.097
TSH	0.000	0.001	0.900	0.000	0.001	0.798
TG	-0.005	0.011	0.691	-0.009	0.012	0.488

I-FFQ: Iodine specific food frequency questionnaire
B: coefficient
SE: standard error of the coefficient
UIC: urine iodine concentration
FT3: Free Triiodothyronine
FT4: Free thyroxin
TSH: Thyroid stimulating hormone
TG: thyroglobulin
[a]Adjusted for BMI, age, gestational age, parity, smoking status and education

Figure Legends

Figure 1: Iodine intakes (µg/day) measured from the I-FFQ at baseline (<20 weeks) and 28 weeks gestation (r=0.622, p<0.001).

Figure 2: Iodine intakes (µg/day) measured from the I-FFQ and weighed food diary with a) no added supplements (r=0.349, p<0.001) and b) added supplements (r=0.876, p<0.001).

Figure 3: Agreement between the I-FFQ and weighed food diary (µg/day) in estimates of iodine intake assessed by the Bland-Altman technique- mean difference *(±2SDs)*