Iodine and pregnancy - a UK cross-sectional survey of dietary intake, knowledge, and awareness

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ABSTRACT

Iodine is a key component of the thyroid hormones, which are critical for healthy growth, development and metabolism. The UK population is now classified as mildly iodine insufficient. Adequate levels of iodine during pregnancy are essential for fetal neurodevelopment, with mild iodine deficiency linked to developmental impairments. In the absence of prophylaxis in the UK, awareness of nutritional recommendations during pregnancy would empower mothers to make the right dietary choices leading to adequate iodine intake. This study aimed to estimate mothers' dietary iodine intake in pregnancy (using a food frequency questionnaire) and to assess awareness of the importance of iodine in pregnancy, understanding of existing pregnancy dietary and lifestyle recommendations with relevance for iodine, and confidence in meeting adequate iodine intake. A cross-sectional survey was conducted. Questionnaires were distributed between August 2011 and February 2012 on a local (Glasgow) and national level (online electronic questionnaire); 1026 women, UK resident, pregnant or mother to a child aged up to 36 months participated in the study. While self-reported awareness about general nutritional recommendations during pregnancy was high (96%), awareness of iodine-specific recommendations was very low (12%), as well as confidence of how to achieve adequate iodine intake (28%). Median pregnancy iodine intake, without supplements, calculated from the FFQ, was 190 μg/day (interquartile range (IQR) 144-256), lower than the World Health Organisation (WHO) recommended intake for pregnant women (250 μg/day). Current dietary recommendations in pregnancy, and their dissemination, do not equip women to meet the requirements for iodine intake.

INTRODUCTION

Iodine is essential for the production of thyroid hormones, which are crucial for neurodevelopment *in utero*, in infancy and beyond. Iodine deficiency (ID) is a major public health problem affecting 1.9 billion globally, and the most preventable cause of intellectual disability [(1)]. This issue is not limited to developing countries, with mild maternal iodine insufficiency (classified based on median urinary iodine concentration being 50-99 µg/L, according to the WHO criteria [(1)]) recently shown to affect the cognitive function of the offspring, in the Avon Longitudinal Study of Parents and Children (ALSPAC) study [(2)] and in the Gestational Iodine Cohort study[(3)].

In the UK, the Reference Nutrient Intake (RNI) for adults is 140 µg/day, without any proposed increment for pregnant and lactating women. Meanwhile, the WHO / United Nations Children's Fund (UNICEF) / International Council for the Control of Iodine Deficiency Disorders (ICCIDD) recommended daily intake for adults is 150 µg/day, increasing to 250 µg/day for pregnant women [(1)]. The European Food Safety Authority (EFSA) recently proposed a new reference value of adequate intake for pregnant women of 200 µg/day [(4)]. This increase is necessary to ensure that mothers have sufficient iodine to allow for increased thyroid hormone production, fetal needs and increased maternal renal clearance during this time [(5; 6; 7)]. Principal dietary sources of iodine include seafood and dairy products (mainly due to the iodine fortification of cattle feeds and the use of iodophores for sanitation during milking), and, in some countries, iodine fortified salt or bread [(8; 9; 10)]. The unborn and breastfed infant is entirely reliant on their mother for iodine supply, making young infants and pregnant or lactating mothers the most vulnerable groups of the population because of their special requirements during these critical periods[(11; 12)]. At present, there is no recommendation for routine iodine supplementation in the UK, unlike folic acid and vitamin D, or routine testing in pregnancy that would reflect iodine levels, unlike iron. Instead, women rely on recommendations for a nutritionally balanced diet in pregnancy, such as those disseminated by the National Health Service (NHS, Ready Steady Baby book) and the Food Standard Agency (Eating while you are pregnant)[(13)].

While mild iodine insufficiency has been shown in UK females of childbearing age [(14)], as well as pregnant women [(15)], there is no iodine prophylaxis in place, and no pregnancy-specific recommended iodine intake. According to international guidelines, mothers need to meet the recommended iodine intake, an increase of 100 µg/day over this of an adult, via dietary choices alone. However, general nutritional knowledge of Western populations has been shown to be poor [(16)], especially when it comes to iodine-specific needs: this was true in Australia before mandatory iodine fortification of salt and bread [(17)] and remained after introduction of the measure despite a slight improvement of knowledge and intake of iodine [(18)]. A notable exception is New Zealand, where iodine fortification and awareness measures are more common than in the UK, the US or

Australia [19] as the problem there has been noticed earlier and has been the centre of attention for research.

In the absence of prophylaxis for iodine in the UK and the need of mothers' empowerment, the aims of this study are to i) define the dietary iodine intake of this population using a validated iodine-specific questionnaire[10] and ii) to examine the levels of knowledge and awareness of mothers, either pregnant or with a child aged up to 36 months, regarding pregnancy-specific dietary recommendations, as well as iodine-specific requirements.

EXPERIMENTAL METHODS

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the University of Glasgow ethics committee. Consent was informed, confirmed by ticking both on the questionnaire and implied by submitting a completed questionnaire. A sample size calculation based on an estimated 33% prevalence of provision of iodine-related information during pregnancy[20], a 95% confidence interval (CI), a design effect of 2 and an absolute precision of 5% resulted in a sample size of at least 680 women. To allow for subgroup comparisons, a sample size of at least n=823 is required (α=0.05, 1-β=0.8), based on the prevalence of iodine-related information cited above, to detect a difference in prevalence of low iodine intake of 15% between groups[21].

Study design and participants

The study was cross-sectional, with participants recruited i) using convenient sampling in Greater Glasgow, and ii) via distribution of an online version of the questionnaire in the UK, between July 2011 and February 2012. In greater Glasgow, both public and private locations were used for recruitment, including mothers and toddler groups, pregnancy classes, shops, libraries, community playgroups, public parks, playgrounds and indoor soft play areas. Recruitment posters were displayed with the study team contact detail as well as a link to the electronic form of the survey. In parallel, women were approached as they entered or exited the facility/shop. The online version of the questionnaire was posted on parenting websites and forums (mumsnet.com, netmums.com, bounty.com, pregnancyforum.org.uk, Gurgle.com) as well as regional Gumtree groups throughout the UK, parenting Facebook groups (Single Mums UK, West of Scotland Birth Support Group, Teenage Mums, Young Mums, British Mum and Toddler Group, North London Mums) and via Twitter. To be eligible, participants had to be women residing in the UK (England, Scotland, Northern Ireland or Wales) who were either pregnant or mother to a child aged from 0 to 36 months.

Questionnaire design and data collection

Data were collected anonymously through questionnaires employing qualitative and semi-quantitative measures. The questionnaire was validated prior to use for face value and content (content validation was carried out independently by three subject experts, assessing the representativeness of the items, while face validation was carried out by 5 lay contributors, assessing presentation, phrasing and clarity of instructions). The same questionnaire was used locally and online. It consisted of four sections.

The first section focused on participants' socio-demographic characteristics (age, ethnicity, education), details of specific dietary habits (veganism, vegetarianism, lactose intolerance, other specific requirements), existence of thyroid condition and lifestyle habits during pregnancy (alcohol and tobacco consumption). It also included questions regarding the participant's current/most recent pregnancy (due date, parity, age of last child, whether the pregnancy was planned) and breastfeeding intentions.

The second part of the questionnaire assessed participants' awareness of pregnancy-specific dietary recommendations, their usual source of information and level of understanding for these recommendations. A 7-point Likert scale assessed how closely participants followed dietary recommendations in pregnancy and the likelihood of ceasing the consumption of dairy and seafood in any doubt regarding the safety of consuming the item.

The third section of the questionnaire included a validated iodine-specific food frequency questionnaire (FFQ) [10]. A question focused on pregnancy vitamins and supplements, evaluating frequency of intake (every day or some days) and pregnancy period when supplements were taken (first trimester only, or throughout pregnancy), along with brand name.

The reasons motivating any dietary changes during pregnancy were investigated with multiple choice and open questions, as well as awareness about micronutrient requirements and confidence about the level of information received to achieve requirements.

The final section of the questionnaire assessed knowledge about iodine (food sources, and consequences of maternal deficiency on the offspring via closed and multi-choice questions) and confidence in how to achieve the recommended iodine intake (7-point Likert scale).

Data analysis

Data were entered manually in a database, or downloaded from the University of Glasgow server hosting the electronic survey data. The overall database was cleaned, and descriptive statistics were calculated for all outcome variables. Open text questions were reviewed for key themes. Results were expressed as mean and standard deviation for parametric continuous data, median and inter quartile range for non-parametric continuous data and mode and frequencies for categorical data. The FFQ was analysed as described by Combet and Lean [10] and dietary iodine intake was reported as a single value for the whole pregnancy. Supplemental iodine intake was defined according to the brand name, the frequency ("every day", or "some days" estimated as every other day). Since supplemental iodine intake was reported either throughout the pregnancy or in the first trimester only, total iodine intake was calculated for the first trimester (T1) and the second and third trimester (T2 & T3) separately.

The chosen cut-off for adequate iodine intake was the WHO recommendation for pregnant women (250μg/day)[1] rather than the UK RNI [22]; this choice was motivated by the fact that the UK RNI has not been revised since 1991, despite evidence that iodine requirement increases during pregnancy[1]. Comparison between groups was carried out using the χ^2 test for categorical data, the student's t-test for parametric continuous data, or the Mann-Witney U test for continuous non-parametric data.

A multinomial logistic regression analysis was performed for the prediction of dietary iodine intake, total iodine intake (dietary intake plus supplements) during T1 and during T2 & T3. The categories for iodine intake were defined as: less than 140 μg/day; which is the cut-off for adequacy in adults; 140-250 μg/day which is between the cut-off of adequacy for adults and the recommended intake pregnant women; and >250 μg/day [1]. Because iodine intake might be affected by a range of factors (socioeconomic and existing knowledge of the iodine importance), relevant independent variables were included in the model. These were age, education level (school, college or university), ethnicity (British, other white groups, other ethnic groups), smoking status, having received any information on iodine or calcium, and being aware of the importance of iodine for healthy development of the unborn baby. The statistical software SPSS Version 21.0 (IBM Corp., Armonk, NY) was used.

RESULTS

Participants' characteristics

A total of 1026 women took part in the survey, 30% of which were pregnant at the time of the study. The median age of participants was 32 years (IQR 29-36) with their youngest child a median age of 14 weeks (IQR 6-25). Most had one child (51%), 37% had two or more children while 12% were pregnant with their first child. Most pregnant women were in the third trimester of pregnancy (51%). Most pregnancies (80%) were planned and discovered at 4 weeks (IQR 4-6). The majority of participants were White British (87%), and educated at degree level or more (62%) (Table 1).

General nutritional awareness during pregnancy

The majority of women (96%) reported awareness of dietary and lifestyle recommendations specific for pregnancy, such as those currently provided in the Ready Steady Baby NHS book or websites on pregnancy diet (such as the Food Standard Agency "Eating while you are Pregnant")[(13)]. The main sources of information were the internet (65%) and books and magazines (62%), followed by written and oral advice from their doctor (59% and 52% respectively) and family and friends (43%). Only 16% received information during antenatal classes. The majority (90%) were aware of recommendations about smoking, alcohol, caffeine. However a third (34%) of smokers continued smoking during pregnancy and 14% of the total population did not stop or limit alcohol consumption.

Most of the respondents found the dietary recommendations easy to understand (92%) and easy to follow (83%). There was a high level of awareness for most dietary recommendations for pregnancy with the exception of the recommendation for vitamin A intake (Table 2). Confusion over the recommendations were reported by 47% (n=482) of the overall population, with 41% (n=419) seeking clarification or further information. The internet was the main source of complementary information (82%), followed by Health Care Professionals (18%), books (15%) and family and friends (8%).

Information provision about specific nutrients (folic acid, iron, iodine, calcium and vitamins A and D) varied. All (100%) had heard about folic acid and most had heard about iron (96%) in pregnancy. However, 64% of the mothers had never received information about iodine, and only 11% had heard about iodine from a health care professional (Table 3). Only 12% reported that information received was sufficient for iodine, followed by 50% and 49% for vitamin D and vitamin A (Table 4).

Changes in dietary habits during pregnancy

Only a minority of the participants were vegetarian (9%), vegan (1%) or lactose intolerant (1%) and 6% reported an existing thyroid condition. Salt was added to food by 48% of women (at the table or during cooking).

Most reported an increased fruit consumption during pregnancy (49%). The majority reported similar levels of intake for milk, cheese, yoghurts, eggs, oily fish, white fish, meat, brassicas, other vegetables, soy products and grains, cereals and pasta during pregnancy compared to before (Table 6). Increased intakes for milk, cheese and yoghurt were reported by 43%, 19% and 25%, respectively (Table 5).

Nearly half (44%) of changes in dietary patterns were motivated by recommendations and advice specific for food and diet during pregnancy. Foods most often mentioned were fruit (8%), fish (9%), cheese (6%) and milk (6%). Morning sickness was the reason motivating 30% of the dietary changes reported, mostly meat, fish and milk. Other reasons were heartburn (21%) and change in taste (7%).

High adherence to dietary recommendation was reported (mode 6, frequency 33%, on a 7-point Likert scale), which was reflected in choices to withdraw from consuming a particular type of food if the safety of consuming the item could not be confirmed (cheese: mode 7, frequency 25%; fish: mode 7, frequency 31%).

Iodine intake during pregnancy

Without taking supplements in consideration, median dietary iodine intake in pregnancy was estimated at 190 μg/day (IQR 144-256), with 74% consuming below the recommended 250 μg iodine per day and 55% below the proposed 200 μg/day threshold (Figure 1). The highest contributors to iodine intake were milk (40%, contributing toward 75μg/day, IQR 42-113), followed by other dairy products (31%) and fish (24%).

Daily iodine intake from foods was not different between women taking supplements or not ($p=0.36$). However, taking supplements significantly increased total iodine intake, both during T1 (237 μg/day (IQR 163-320) vs 190 μg/day (IQR 144-256), non-supplemented) and during trimesters 2 & 3 (223 μg/day (IQR 157-309) vs 190 μg/day (IQR 144-256), non-supplemented) ($p<0.001$).

Knowledge of iodine-rich foods and awareness of its role during pregnancy

Knowledge of iodine-rich foods was low, with 56% unable to identify any iodine-rich food and a majority wrongfully believing that dark green vegetables (54%) and table salt (21%) (which is not fortified in the UK) are iodine-rich foods. Milk and yoghurt were only recognised as iodine-rich sources by 9% and 6% of the population, respectively, with fish faring slightly better (33% for oily fish and 14% for white fish).

While 84% were unaware that, during pregnancy, iodine from the diet is important for healthy development of the unborn baby, most (85%) agreed or strongly agreed they would attempt to increase their iodine intake if made aware of the impact of iodine deficiency (7-point Likert scale). Mothers (72%) however disagreed or strongly disagreed that they were confident on how to achieve an adequate iodine intake in pregnancy (7-point Likert scale).

Impact of dietary advice and awareness on iodine intake

Receiving any advice on iodine (n=371, 36%) had no impact on iodine intake from food only (p=0.218), or intake from food and supplements in the first trimester of pregnancy (p=0.106). However, intakes were marginally higher in trimesters 2 & 3 (T2 & T3) for those who had received information (p=0.049) (Table 6). Those who perceived the advice to be sufficient (n=112, 12%) had no higher iodine intake from either food only during the whole pregnancy (p=0.974), or from food and supplements during T1 (p=0.402) or during T2 & T3 (p=0.530).

Receiving any advice on calcium (n=911, 89%) increased iodine intake from food only (p=0.009), intake from food and supplement in the first trimester of pregnancy (p=0.001) and intake in T2 & T3 (p=0.001) (Table 6). Participants who perceived the calcium advice to be sufficient (n=610, 64%), had a higher intake of iodine from food only (p=0.014), and food and supplement in T1 ($p<0.001$), as well as T2 & T3 ($p<0.001$).

Awareness of the impact of low iodine during pregnancy on healthy development of the unborn baby (n=165, 16%) did not lead to significantly higher iodine intake, with or without supplementation (food only p=0.782, from food and supplement in T1 p=0.905, or T2 & T3 p=0.660).

Other factors affecting iodine intake in pregnancy

Planned pregnancies, salt usage and smoking did not impact on iodine intake (with or without supplement). However, education level had an impact on dietary iodine intake (p=0.009) and total iodine intake in T2 & T3 (p=0.010), with higher intake generally associated with higher education levels. Total iodine intakes in T2 & T3 were also higher in older women compared to younger (p=0.036).

The multinomial logistic regression models (Table 7) for iodine intake from the diet alone, total iodine intake in T1 and T2&3 had an improved fit compared to the empty models (models with no predictor variables) (p=0.05, 0.02 and 0.01, respectively), with low pseudo R-square values (below

0.05). Receiving information about calcium significantly lowered the odds of having a low iodine intake (<140µg compared to >250µg/day) at any stage of pregnancy, from diet alone, or taking supplement in consideration. It also decreased the odd of having a total iodine intake between 140-250µg compared to >250µg, in T1 and T2&3. Those who had ever been informed about iodine had surprisingly higher odds of having a low total iodine intake (<140µg compared to >250µg/day) in T1, T2&3. Being aware of the importance of iodine had no predictive value in the models. Education did not consistently predict iodine intake, with achieving school education predicting higher odds of lower total iodine intake (<140µg compared to >250µg/day) in T2&3.

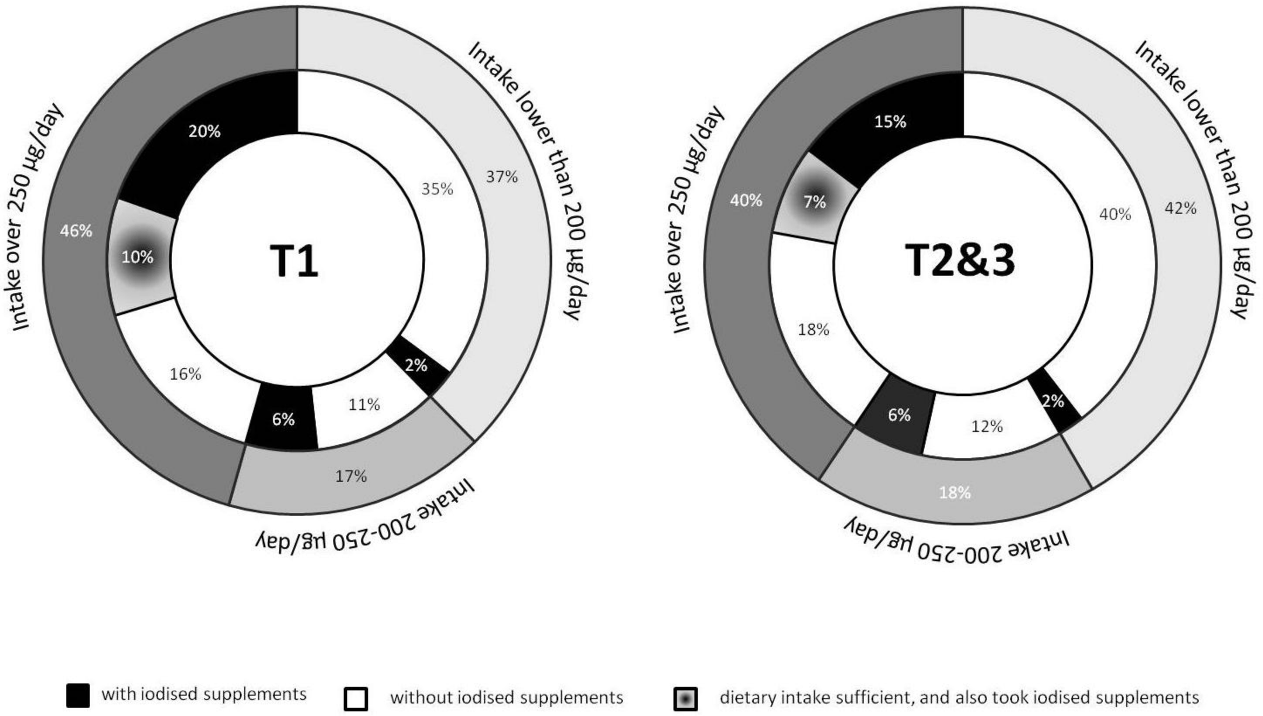

Figure 1 | Iodine intake in pregnancy in n=1026 women, recruited in the UK August 2011 – February 2012, according to set levels of adequacy from WHO/UNICEF/ICCIDD [2] (>250 µg/day)and EFSA NDA Panel [5] (>200 µg/day). Supplement use for each sector of iodine intake is depicted on the inside circle. Only 26% during T1 and 25% during T2&3 reached the 250µg threshold through diet only (regardless whether they consumed iodised supplements). The new proposed level of adequate intake (200µg/day) was reached by 63% during T1 (26% thank to supplements) and 58% during T2 & T3 (21% thank to supplements).

DISCUSSION

Principal study findings

Dietary iodine intake in pregnancy was lower than the WHO recommendation of 250 µg per day, even when supplemental iodine was taken inconsideration. This is consistent with recent findings in pregnant women in the South East of the UK[15]. Despite generally high self-reported awareness of existing dietary and lifestyle recommendations for pregnancy, iodine awareness and knowledge were low among UK mothers (pregnant or with children aged 0-36 months). This is in agreement with other countries, where a large gap still exists for iodine awareness and knowledge[16; 17; 23].

Iodine is crucial during pregnancy and the first months of life, to ensure adequate brain development, driven by the thyroid hormones. Mild insufficiency has been linked to measurable cognitive decline in school performance and cognition[2; 24]. A recent meta-analysis of 24 studies on iodine and intellectual disability in young children concluded that iodine impacts on mental impairment, and this is apparent when comparing the IQ score of children from deficient mothers, which is 7.4 points lower compared to children from iodine replete mothers [24]. Although many of the studies included in the review suffered from poor design, with only a few randomised controlled trials, there is some evidence that iodine deficiency impacts on cognitive function. In particular, supplementation with 300 µg iodine during the first trimester of pregnancy led to improved cognitive development in the offspring[25]. It is therefore a major concern that the majority of (recently) pregnant women in the UK are unaware of the importance of iodine when the evidence points toward inadequate iodine status in women[14; 26; 27] in a country with no iodine prophylaxis.

Awareness is a mean of empowerment in any case of choice. While the messages around folic acid and iron were heard (from various sources) and perceived to be sufficient, mothers were not confident about their iodine intake, in term of dietary sources or how to meet the adequate level for pregnancy, in accordance with recent Australian findings[17].

The UK has been listed as the top 8th iodine deficient country in the world[28]. Participants in this study had an average daily iodine intake of 190 µg/day, based on iodine from food only, lower than the recommended 250µg/day during pregnancy [1] and newly proposed 200µg/day EFSA threshold [4]. In fact, through their diet, only 26% of women were meeting the 250µg/day recommendation and 45% the 200µg/day. Milk and other dairy products remain the main contributors to iodine intake, in agreement with data from 1997-1998 [29].

Taking supplements containing iodine in consideration (consumed by 38% of the participants), the daily iodine intake was 237 μg/day in T1 and 223 μg/day in T2&3. Use of iodised supplements helped women to achieve an adequate iodine intake. It has been shown that nutritional knowledge is strongly associated with the use of supplements during pregnancy [30]. Iodine supplementation given to pregnant women with mild deficiencies appeared to benefit future child development [31]. However, in our study less than half of the participants were taking iodine containing supplements, in accordance with previous findings [26; 32; 33; 34; 35]. This is despite the leading prenatal multivitamin brands contain iodine, since many women will take single folic acid supplement or a formulation not labelled for pregnancy or not containing iodine [26].

While healthcare professionals are well placed to impart advice and help effect dietary change, studies indicate women's dietary patterns change little during pregnancy[36; 37; 38]. Our results are in agreement with this, and consumption levels of milk, dairy and fish were mostly unchanged during pregnancy, despite the increased daily requirement for iodine. Similarly, another UK cohort study examining dietary patterns before and at two points during pregnancy showed that the median weekly consumption of iodine-rich foods did not change significantly[39].

Strengths and weaknesses of the study

Deprivation, defined by income or education, has been shown to be associated with increased risks of insufficient micronutrient intake[40] and poorer quality diet [41]. In this study, levels of deprivation based on postcodes could not be used, due to differences between the English, Scottish, Northern Irish and Welsh deprivation scoring. Women of higher socioeconomic status (defined by education, income, and/or occupation) are also more likely to consume iodine-rich foods, such as fish and dairy [42]. In light of this, it appears that women of lower socioeconomic status may be less likely to achieve sufficient iodine intake during pregnancy.

This study used a food frequency questionnaire[10] involving an element of recall, which may have led to a loss of accuracy and overestimation of the nutrient[43]. The convenient sampling method used locally, and the electronic recruitment used nationally have yielded a large sample size. A majority (68%) of the participants were recruited online. While this was considered to be a limitation in the past[44], the wide access to the internet in the UK renders online recruitment a successful method in health research[45; 46]. The study participants were generally quite knowledgeable about health, had a high rate of planned pregnancies (80%, versus 55% in the UK population [47]) and were well educated. This appears to be common in survey-based studies but importantly the results show how poor is the knowledge about iodine even amongst educated women.

Possible mechanisms and implications for clinicians and policy makers

Achieving an intake of 250 μg/day (or 1750 μg/week) is challenging and requires consumption of high amount of dairy and seafood. For illustrative purpose, 250 μg/day[1] (or 1750 μg/week) would be covered by consuming all of the following: milk in cereals once a day, milk in drinks (such as tea, coffee) three times a day, two yogurts per day, one dairy-based dish or pudding per day, cheese, twice a day, white sea fish, twice a week, oily fish, once a week (based on the average iodine content of these foods[48]). Since receiving information about calcium and iodine during pregnancy predicted, along with a higher education level, sufficient iodine intake, there is scope for improved dietary recommendations to address the current iodine insufficiency in this vulnerable group.

Directing pregnant women towards resources which present causal links between iodine and fetal development may increase the motivation for behavioural change [49], as the present study also observed. The Health Belief Model encompasses this idea. Perceived threats to health can alter behaviour if the individual is confident they are able to carry out the change, there is an understanding that changed actions will reduce the susceptibility or severity of a health condition and that motivating factors outweigh the barriers that stand in the way of implementing the behavioural change [50].

There is no guideline in the UK for iodine supplementation of mothers during pregnancy or lactation, in contrast to the United States and Canada [51]. Supplementation during pregnancy and lactation is endorsed by the WHO, the UNICEF and the ICCIDD in iodine deficient countries without universal salt iodisation, such as the UK [52]. There is a sustained debate on the ethical implication of a randomised controlled trial of iodine supplementation in pregnancy[53; 54], in parallel with concerns over the conflicted message that salt iodisation would convey[55]. The Scientific Advisory Committee on Nutrition review recently published their position statement on iodine and health [56], highlighting existing gaps in the evidence base. This study goes toward providing evidence on dietary and supplemental intakes of iodine in pregnancy, and an increased understanding of mothers' knowledge and awareness of recommendation relevant to iodine in pregnancy.

Unanswered questions and future research

Most pregnancies remain unplanned in the UK (approximately 55% planned) and in other high income countries (France, Spain, Japan, United States)[47] and iodine prophylaxis in the peri-conception time requires further considerations. A stronger evidence-base is required in order to set thresholds for adequacy of iodine intake during and before pregnancy, with careful consideration of iodine uptake and homeostasis as a function of iodine stores.

A recent systematic review concluded that women in developed countries are not nutritionally well educated, specifically about nutrition during pregnancy[57]. The iodine awareness, knowledge and perception of mothers in the UK were high for general recommendations during pregnancy but low for iodine. As a result health campaigns, fortification, supplementation and nutrition education should be considered. It is unclear whether any of these strategies will be successful, with the UK food landscape and dietary habits in mind. We have previously shown that the terminology used to define concepts of nutritional balance are commonly misunderstood by the public[58]. In addition to providing causal links, dietary recommendations should be accurate, simple to understand and give practical advice which is easy to follow. Consistency in the advice provided (by healthcare professionals, websites, books) is essential, to avoid misinterpretations and misleading messages. The current debate on the required next step for iodine prophylaxis in the UK should not ignore that the impact of any intervention will be blunted if the current lack of awareness and knowledge is not tackled. As there is a difference between awareness of exact requirements at population level, awareness of the need to take supplements (which currently only applies to folic acid in the UK) and awareness of the importance of a nutrient during a key time in the lifecourse, this should be further investigated using a more qualitative approach in future studies.

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CONFLICT OF INTEREST

None

AUTHORSHIP

EC designed and supervised the study, with input from CW and MEJL. CW, MB and BP collected the data and contributed to its analysis. EC and MB prepared the manuscript, with input from all co-authors. All authors approved the final version of the manuscript.

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Table 1: Basic characteristics of participants

Demographic data	Median	IQR
Maternal Age (years)	32	29-36
Babies Age (weeks)	14.0	6-25
Ethnicity	**n**	**%**
White British	887	87
Other White	83	8
Other ethnic groups	56	6
Education		
School level	186	18
College level	206	20
BSc/MSc/PhD	625	62
Use of supplements (iodised/non-iodised)		
Throughout pregnancy	305/209	30/20
1st trimester only	87/199	8/19
Never	101	10
Pregnancy	305	30
1st trimester	67	22
2nd trimester	79	26
3rd trimester	154	51
Planned pregnancies	807	80
Number of children		
0 (Expecting first)	123	12
1	520	51
2 or more	383	37
Smokers	100	10

Table 2: Pregnancy dietary recommendations[ǂ] – self-reported awareness and confusion

	Number of participants	% of total sample
Self-reported awareness		
Stop Smoking	1012	99
Stop/limit alcohol	1012	99
Limit caffeine	961	94
Avoid certain foods due to bacterial infection risk	940	92
Avoid raw meat, fish or poultry	912	89
Avoid certain fish due to heavy metals / toxins	864	84
Wash all fruit and vegetables	848	83
Limit oily fish to two portions per week	748	73
Limit vitamin A intake	592	58
Any other recommendations*	134	13
Self-reported confusion in recommendations		
Avoid certain foods due to bacterial infection risk	192	19
Limit vitamin A intake	167	16
Avoid certain fish due to heavy metals / toxins	99	10
Limit oily fish to two portions per week	99	10
Limit caffeine	71	7
Stop/limit alcohol	65	6
Avoid raw meat, fish or poultry	49	5
Any other recommendation*	37	4
Wash all fruit and vegetables	26	3
Stop Smoking	7	1
Was extra information sought in case of confusion?		
Yes	419	41
No	140	14
N/A	334	33
Did the extra information provide clarification?		
Yes	260	25
No	73	7
Not sure	157	15

[ǂ] recommendations available in the NHS Ready Steady Baby book, and the Food Standard Agency "Eating while you are Pregnant"[(13)]

* folic acid, cheese, eggs, nuts, vitamin D

Table 3: Sources of information obtained for specific nutrients

	Source of information (% of total population)				
	Never heard of	*Doctor, midwife or health visitor*	*Family and friends*	*Books and magazines*	*Internet*
Folic acid	0	88	39	47	40
Iron	4	71	24	32	27
Iodine	64	11	4	8	8
Calcium	11	49	25	33	25
Vitamin D	19	44	14	29	24
Vitamin A	24	42	12	29	25

Table 4: Perceived sufficiency of the information received regarding specific nutrients in order to make decisions on dietary modification to achieve an adequate intake/levels in pregnancy

	Was information sufficient? (% of total population)		
	No	Yes	Not sure
Folic acid	5	92	4
Iron	13	76	11
Iodine	54	12	34
Calcium	21	64	16
Vitamin D	30	49	22
Vitamin A	28	50	22

Table 5: Reported changes in the amount of food items during pregnancy

	Not consumed during or before pregnancy		Decreased or stopped consumption		As before		Increased	
	n	%	n	%	n	%	n	%
Milk	51	5	53	5	465	47	429	43
Cheese	25	3	171	17	609	61	193	19
Yoghurts	54	5	65	7	627	63	246	25
Eggs	46	6	255	26	609	61	89	9
Oily Fish	137	14	268	27	494	50	96	10
White fish	121	12	114	12	674	68	79	8
Meat	67	7	103	10	739	72	106	11
Brassicas	48	5	65	6	651	64	205	20
Other vegetables	8	1	38	4	633	63	324	32
Fruits	7	1	36	4	467	47	491	49
Soy products	376	40	98	10	457	48	22	2
Bread, rice, cereals, pasta	3	0	33	3	703	70	261	26

Table 6: Iodine intake with and without supplements in the whole group, in women having received advice on iodine, advice on calcium and in women who were aware of iodine importance during pregnancy. Advice received could be from any source (doctors, midwives or health visitors, family and friends, books and magazines or from the internet).

	All women (n=1026)		**Women who received iodine advice (n=371)**		**Women who received calcium advice (n=911)**		**Women aware of iodine importance during pregnancy (n=165)**	
Iodine intake *(μg/day)*	Median	IQR	Median	IQR	Median	IQR	Median	IQR
Dietary iodine only	190	144-256	185	136-261	193*	146-259	193	138-267
Total (T1) §	237	163-320	240	170-320	242*	167-324	241	152-339
Total (T2&T3)	223	157-163	228*	165-309	228*	160-312	220	149-317

*Statistically significant difference of iodine intake from the rest of the group. Mann Whitney U test, $p<0.05$

§ Total indicates iodine from food and supplement sources. T1, 2, 3 = trimester 1, 2, 3

Table 7: Logistic regression analysis for predictors of dietary iodine intake (throughout pregnancy), total iodine intake in the first trimester and total iodine intake in trimesters 2 & 3

		Dietary iodine intake throughout pregnancy		**Total iodine intake during T1**		**Total iodine intake during T2&T3**	
		<140µg/day versus >250µg/day	140-200µg/day versus >250µg/day	<140µg/day versus >250µg/day	140-200µg/day versus >250µg/day	<140µg/day versus >250µg/day	140-200µg/day versus >250µg/day
		OR (95% CI)[ǂ]	OR (95% CI)[ǂ]	OR (95% CI)[ǂ]	OR (95% CI)[ǂ]	OR (95% CI)[ǂ]	OR (95% CI)[ǂ]
Age	>30 years old (reference)						
	20-30 years old	0.99 (0.66-1.49)	1.08 (0.76-1.52)	1.35 (0.89-2.04)	0.94 (0.69-1.29)	1.25 (0.83-1.86)	0.92 (0.67-1.26)
	<20 years old	1.64 (0.28-9.65)	0.62 (0.08-4.56)	2.56 (0.52-12.63)	0.39 (0.04-3.85)	1.84 (0.37-9.04)	0.29 (0.03-2.85)
Ethnicity	White British (reference)						
	Other white groups	0.85 (0.42-1.71)	1.08 (0.62-1.88)	0.67 (0.3-1.5)	1.14 (0.69-1.87)	0.71 (0.34-1.49)	1 (0.61-1.66)
	Other groups	1.23 (0.57-2.69)	0.7 (0.34-1.42)	1.57 (0.68-3.6)	1.17 (0.61-2.25)	1.65 (0.73-3.77)	1.27 (0.65-2.47)
Education	University (reference)						
	Secondary education	0.85 (0.53-1.35)	0.6 (0.41-0.89)**	1.14 (0.7-1.86)	0.89 (0.62-1.28)	1.24 (0.78-1.98)	0.86 (0.6-1.25)
	School	1.62 (0.97-2.7)	0.98 (0.62-1.54)	1.59 (0.96-2.63)	1.09 (0.73-1.63)	1.85 (1.12-3.07)*	1.35 (0.9-2.03)
Smoking status	*(reference is "non-smoker")*	1.02 (0.5-1.49)	0.94 (0.53-1.35)	1.61 (0.62-1.84)	1.05 (0.54-1.3)	1.39 (0.59-1.73)	0.98 (0.58-1.41)
Informed about iodine	*(reference is "not informed")*	1.39 (0.89-2.17)	0.93 (0.64-1.36)	1.77 (1.12-2.81)**	1.1 (0.78-1.54)	1.83 (1.17-2.85)**	1.04 (0.74-1.47)
Informed about calcium	*(reference is "not informed")*	0.44 (0.24-0.8)**	0.77 (0.45-1.34)	0.33 (0.18-0.6)**	0.5 (0.31-0.81)**	0.32 (0.18-0.58)**	0.52 (0.32-0.86)**
Aware of iodine importance	*(reference is "not aware")*	0.86 (0.5-1.49)	0.84 (0.53-1.35)	1.06 (0.62-1.84)	0.84 (0.54-1.3)	1.01 (0.59-1.73)	0.9 (0.58-1.41)

ǂ OR= Odds Ratio; CI= Confidence Interval; * $p<0.05$; ** $p<0.01$. § Total indicates iodine from food and supplement sources.