Suboptimal iodine status of Australian pregnant women reflects poor knowledge and practices related to iodine nutrition


\(^a\)Smart Foods Centre, School of Health Sciences, University of Wollongong, Wollongong, New South Wales, Australia
\(^b\)Institute of Clinical Pathology and Medical Research, Westmead Hospital, Sydney, New South Wales, Australia

**Objective:** To assess the iodine status and knowledge and practices related to iodine nutrition of Australian women during pregnancy.

**Methods:** A cross-sectional study was conducted at a public antenatal clinic in the Illawarra region of New South Wales. One hundred thirty-nine pregnant women across all trimesters provided a spot urine sample \((n = 110)\) and completed a short questionnaire \((n = 139)\) in English. Iodine status was based on World Health Organization/International Committee for the Control of Iodine Deficiency Disorders urine iodine concentration (UIC) categories.

**Results:** Median UIC was 87.5 mg/L (interquartile range 62); only 14.5% of participants had an adequate UIC value \(>150\) mg/L. Fifteen percent of women had very low UIC values \(<50\) mg/L), whereas 45.5% had values in the 50- to 99- mg/L range. Knowledge of the adverse health effects of an inadequate iodine intake was poor. Approximately half the participants were able to indicate good dietary sources of iodine, such as fish (58%) and iodized salt (51%). However, a high level of confusion regarding other foods was evident. Only a small number of participants (11%) reported that they had intentionally changed their diet to increase iodine intake during pregnancy, but 59% indicated supplement use, of which 35% contained iodine. Those who were taking supplements that contained iodine had significantly higher UIC levels (139.1 mg/L) than those who were not (90.8 mg/L, \(P < 0.05\)).

**Conclusion:** Public health strategies, including nutritional education and supplementation, are urgently required to improve the iodine status of pregnant women. Currently, no readily accessible information on iodine is available to women attending antenatal clinics in Australia.
child-bearing age, do not consume sufficient dietary iodine to meet their requirements [14].

It has been suggested that reasons for the iodine-depleted status of the Australian population relates to a cessation in the use of iodophors as sanitizers in the dairy industry, the lack of a mandatory salt iodization program, and a low uptake of commercially available iodized salt, accompanied by an increase in the consumption of processed foods that contain non-iodized salt [8, 15–16]. Further, the global strategy of the World Action on Salt and Health, to which Australia subscribes, aims to influence consumer behavior to reduce salt intake through social marketing campaigns and co-operation from food manufacturers and governmental agencies to reduce sodium in the food supply. Such activities may have led to a decreased intake of salt overall, including iodized salt; however, reliable data on salt consumption patterns are sparse.

In Australia, health education materials are available for pregnant women that address topics related to nutrition and food safety, including folate [17], calcium, iron, *Listeria*, and food poisoning [18–20]. However, there are no strategies to improve the knowledge and awareness of iodine for pregnant women, despite a World Health Organization (WHO) recommendation for countries such as Australia to promote public education programs [21]. The main aim of this study, therefore, was to assess pregnant Australian women’s iodine status and their knowledge and practices related to iodine nutrition.

Materials and methods

Participants and setting

A cross-sectional survey was conducted at a public antenatal clinic in the Illawarra region of New South Wales, Australia. During the months of August to September 2008, pregnant women across all three trimesters were invited by clinic staff to participate in the study as they attended routine antenatal appointments. Non–English-speaking women were excluded. Consenting women completed a self-administered questionnaire on iodine knowledge and practices (n = 139) and provided a spot urine sample (n = 130).

Urine samples were stored at −80°C until batch-analyzed by the accredited laboratory of the Institute of Clinical Pathology and Medical Research, Westmead Hospital, Sydney, which serves as a reference center for iodine deficiency disorders in the region. Urinary iodine was analyzed using an adaptation of the Sandell-Kolthoff method [22] with ammonium persulfate digestion and microplate reading. Sensitivity of the urinary iodine assay is 5 μg/L. At 46 ± 7.72 μg/L (i.e., two standard deviations), the coefficient of variation is 16.7%; at 153 ± 8.9 μg/L, the coefficient of variation is 5.8%; and at 347 ± 30 μg/L, the coefficient of variation is 8.65%.

The questionnaire was a 15-item instrument that was adapted from a New Zealand study [23] and modified for use in pregnancy. Questions related to knowledge of iodine nutrition included identification of good dietary sources of iodine, the health implications associated with inadequate iodine in the diet, and sources of dietary information. Questions related to practices included changes made to the diet during pregnancy to intentionally increase iodine intake, nutritional supplement use, and the use of iodized salt. Participants were asked about their current level of awareness of iodine as a public health problem and whether they felt confident that they had received enough information to make informed choices on various nutritional concerns during pregnancy. Information on the number of previous pregnancies and/or miscarriages was also obtained.

Approval for the study was granted by the University of Wollongong human research ethics committee and site-specific approval was granted by the South Eastern Sydney Illawarra Area Health Service.

Statistical analyses

Urinary iodine status was assessed according to the most recent WHO-endorsedd reference median UIC categories for pregnancy (<150 μg/L indicating insufficiency) [21]. Mann-Whitney tests were performed to assess differences in UIC according to consumption of iodine supplements, reported intentional changes to dietary intake, education level, and iodized salt use. Descriptive statistics (means ± standard deviations, proportions) are presented regarding knowledge and practices of iodine. Chi-square tests were performed to assess differences in the practice of supplementation according to number of previous pregnancies and level of education. All data were analyzed using SPSS 15 (SPSS Inc., Chicago, IL, USA) with a significance level of α < 0.05.

Results

Participant characteristics are listed in Table 1. Most women were in their third trimester, with a mean gestational age of 33 ± 7.01 wk. This was the first (successful) pregnancy for 41% of women. The mean age of participants was 28.4 ± 5.7 y (age range 16–45 y).

Urinary iodine concentration

Median UIC was 87.5 μg/L (interquartile range 62); only 14.5% of participants had an adequate UIC value ≥150 μg/L [20] (Table 2). Fifteen percent of women had very low UIC values (<50 μg/L), whereas 45.5% had values in the 50- to 99-μg/L range. Participants who were taking supplements that contained iodine had significantly higher UIC levels (139.1 μg/L) than those who were not (90.8 μg/L, P < 0.05). No difference was found between those who had intentionally increased their iodine intake (100 μg/L) compared with those who had not (109.8 μg/L, P = 0.73).

Level of education had no association (UIC 107.9 μg/L in women with tertiary education versus 98.9 μg/L in women with no tertiary education, P = 0.185), and there was no significant difference between users of iodized salt (117.8 μg/L) and non-users (90.1 μg/L, P = 0.06).

Knowledge, attitudes, and practices

Knowledge

No significant differences were found in iodine knowledge according to age, education, and number of pregnancies; therefore, data are presented for the total sample.

Participants demonstrated a limited knowledge of the health effects of a low iodine intake when presented with a list of the following conditions: malformations in pregnancy (27.3%), goiter (23.7%), impaired physical development (18%), blindness (14.4%), and mental retardation (12.2%). Health issues not associated with iodine inadequacy that were incorrectly rated affirmatively include weak bones/teeth (21.6%), neural tube defects (20.1%), and arthritis (12.2%). One-tenth of women perceived iodine to be a common health problem, whereas most participants did not know whether it was a health problem or not (73%).

Knowledge of good dietary iodine sources was poor (Table 3). Approximately half the participants were unable to name any good sources of iodine. Some good sources of iodine that were identified included fish (58%) and salt (51%), but many participants also incorrectly indicated meat (50%), fruit (37%), and vegetables (59%) to be high in iodine. Only 26% indicated milk as a good source of iodine. Little variation was
observed in women of different ages, education, and number of pregnancies.

Practices

Few participants (11%) reported that they had intentionally changed their diet during pregnancy to increase iodine intake. Fifty-nine percent of women indicated supplement use during their pregnancy, of which 35% contained iodine (Table 4). Supplement use was higher among women in their first pregnancy (72% versus 49%, \( P < 0.005 \)) and women who had a tertiary education (73.5% versus 54%, \( P = 0.049 \)). Most supplement users had been taking them for over 3 mo (3–6 mo, 36.5%; ≥6 mo, 41%). Less than half the sample (41%) reported the use of iodized salt in cooking (41%) and 84% planned to breast-feed their babies.

Beliefs

Only 20% of participants were confident that their diet provided enough iodine, 6% knew their diet did not provide enough iodine, and most (74%) did not know. Most participants indicated that they had received sufficient information to make informed decisions regarding iron (80%), calcium (72%), folate (78.5%), and food poisoning, including Listeria (64%), but only 17% for iodine.

Most participants indicated that they had received their information on nutritional concerns during pregnancy from health care professionals by written material such as pamphlets, but only 16% indicated they had received information on iodine (Table 5). Approximately 20–35% of participants indicated they had received dietary information directly by verbal communication for the same nutrient concerns during pregnancy but only 6.5% for iodine. Other major contributing sources of information were magazines (15–23%) and the Internet (14–18%); however, the contributions regarding iodine from these media sources were 5% and 7%, respectively.

Discussion

Given the potentially detrimental effects of a suboptimal iodine status on fetal development [1,2,4], the finding that UIC values indicate inadequacy in pregnant Australian women is of major public health concern.

Our data confirm those of previous studies in Australia. In New South Wales, Central Coast pregnant women were found to be mildly iodine deficient (median UIC 85 μg/L; of which 17% had UIC <50 μg/L indicating moderate deficiency) [11]. A study of 802 pregnant women in Melbourne found median UIC levels in Caucasian, Vietnamese, and Indian/Sri Lankan women of 52, 58, and 61 μg/L, respectively [10], with the UIC of Caucasian women being significantly lower than their Vietnamese and Indian/Sri Lankan counterparts, suggesting ethnic differences in dietary intake. The increasing body of evidence indicates that an inadequate iodine status in pregnancy is a common public health problem in Australia and is found across ethnic groups and geographic locations in the country.

The Food Standards Australia and New Zealand recently approved the mandatory fortification of all bread with iodine in these two countries, excluding organic bread, through utilization of iodized salt in the bread-making process [24]. However, the concentration at which the salt is to be iodized (25–65 mg/kg of salt) may only reduce the problem rather than eliminate it, as has been demonstrated in a pilot project of bread iodization in Tasmania [25,26]. Supplementation would still be required, in the absence of a universal salt iodization program in the country.

The WHO convened a technical consultation on the prevention and control of iodine deficiency in pregnant and lactating women and in children younger than 2 y in Geneva, January 24–26, 2005. The daily recommended nutrient intake for iodine proposed for pregnant and lactating women was increased to 250 μg/d, with an upper level of intake of 500 μg/d [21]. Recommended public health approaches were provided, according to three country categories of risk of iodine deficiency, which is dependent on the presence of a functioning universal salt iodization program. Australia falls into category 2 (i.e., 20–90% of households using iodized salt, median UIC levels >20 and <100

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**Table 2**

<table>
<thead>
<tr>
<th>Urinary iodine concentrations of pregnant women attending public antenatal services (n = 110)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (interquartile range) (μg/L)</td>
</tr>
<tr>
<td>Minimum–maximum (μg/L)</td>
</tr>
<tr>
<td>Urine iodine concentration category</td>
</tr>
<tr>
<td>Inadequate (&lt;150 μg/L)</td>
</tr>
<tr>
<td>Adequate (150–249 μg/L)</td>
</tr>
<tr>
<td>More than adequate (≥250 μg/L)</td>
</tr>
<tr>
<td>Excessive (≥500 μg/L)</td>
</tr>
</tbody>
</table>

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**Table 3**

<table>
<thead>
<tr>
<th>Food sources of iodine indicated by participants (n = 139)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
</tr>
<tr>
<td>Meat</td>
</tr>
<tr>
<td>Milk</td>
</tr>
<tr>
<td>Bread</td>
</tr>
<tr>
<td>Fish and seafood from the sea</td>
</tr>
<tr>
<td>Fruit</td>
</tr>
<tr>
<td>Vegetables</td>
</tr>
<tr>
<td>Eggs</td>
</tr>
<tr>
<td>Salt</td>
</tr>
</tbody>
</table>

* Correct answer. Considered a good source if the food contributed >5% of total iodine intake in the Food Standards Australia New Zealand 22nd Australian Total Diet Survey, 2008 [14].

† Good source only if iodized.
which only 27% were multivitamins [27]. Another survey of 588 natal clinic in Adelaide indicated supplement use in 62%, of Australia. A survey of 211 pregnant women attending an ante- was comparable to other recent investigations conducted in mendation of the WHO[20].

ments marketed to pregnant women, in line with the recom- mendation that does not contain iodine but is targeted to pregnant women. The most commonly used supplement, taken by 21% of participants, was a popular brand UIC compared with non-users. The most commonly used sources of information identified by participants who are responsible for antenatal care because many pregnant women present late in their first trimester and only after referral from their general practitioner. This may be too late. Action by governments is required to meet the responsibilities outlined in the UN declaration.

The main limitation of the present study is the use of a single casual urine sample to assess iodine status. Despite being the method accepted by the International Committee for the Control of Iodine Deficiency Disorders/UN Children's Fund/WHO (2001) [35] for the assessment of the iodine status of groups of people, intraindividual day-to-day variation in iodine intake could not be investigated using this approach. The validity of multiple spot urinary collections compared with a single sample for the assessment of iodine status in pregnancy warrants further consideration. In non-pregnant populations, daily urinary iodine excretion closely reflects recent iodine intake because over 90% of iodine intake is excreted in the urine [36]. During pregnancy, urinary iodine excretion increases due to an increased glomerular filtration rate that peaks by the end of the first trimester to a glomerular filtration rate of 40–50% above prepregnant levels [37]. The increased ioduria in early pregnancy and subsequent decline with advancing gestation [38] necessitates the use of pregnancy-specific urinary iodine reference ranges [26] for the assessment of iodine status, as was used in the present study. Caution needs to be exercised when comparing urinary iodine excretion values of pregnant women with values for other groups within populations to avoid underestimation of iodine deficiency in pregnancy. In countries

μg/L, which has a recommendation of iodine supplementation to ensure a total daily intake of 250 μg/d or as a single annual oral dose of 400 mg of iodine as iodized oil [21].

In the present study, more than half of participants were using nutritional supplements for their pregnancy (59%), but only 35% of these supplements contained iodine. Users of supplements that contained iodine had a significantly higher UIC compared with non-users. The most commonly used sources of information taken by 21% of participants, was a popular brand that does not contain iodine but is targeted to pregnant women. Only recently in Australia iodine begun to be added to commercially available pregnancy supplements, presumably in response to the recent research findings and media releases from the Food Standards Australia New Zealand highlighting this public health problem. To assist Australian women to meet their nutrient requirements during pregnancy, there is a need to regulate for specified levels of iodine (equivalent to 150 μg/d) in multivitamin and mineral supplements marketed to pregnant women, in line with the recommendation of the WHO [20].

The prevalence of the use of nutritional supplements (59%) was comparable to other recent investigations conducted in Australia. A survey of 211 pregnant women attending an ante-natal clinic in Adelaide indicated supplement use in 62%, of which only 27% were multivitamins [27]. Another survey of 588 pregnant women in Melbourne showed 82% supplemented in some form [28]. No details of iodine were included in that study, but 35% of women were taking pregnancy-specific multivita- mins, which suggests a similarly low level of iodine supple- mentation as that identified in this study.

The suboptimal iodine status was accompanied by poor knowledge and practices related to iodine nutrition. Overall, the knowledge of iodine nutrition was very poor regardless of age, level of education, or number of previous pregnancies. The vast majority of participants did not know the associated health effects of low iodine in the diet or what constituted good food sources of iodine. Few (20%) were confident that they consumed enough iodine in their diet, but only a small number of women (11%) reported they had intentionally changed their diet to increase iodine intake during their pregnancy. However, these women did not have higher UIC values than other women in the study, which highlights the difficulty in meeting increased needs in pregnancy without fortification and/or supplementation.

### Table 5

<table>
<thead>
<tr>
<th>Health professionals</th>
<th>Iron</th>
<th>Iodine</th>
<th>Calcium</th>
<th>Healthy eating</th>
<th>Folate</th>
<th>Listeria</th>
<th>and/or food poisoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Written information (e.g., pamphlet)</td>
<td>58.3%</td>
<td>15.8%</td>
<td>48.2%</td>
<td>63.3%</td>
<td>54.0%</td>
<td>48.2%</td>
<td></td>
</tr>
<tr>
<td>Verbal (counseling)</td>
<td>28.8%</td>
<td>6.5%</td>
<td>23.7%</td>
<td>36.0%</td>
<td>32.4%</td>
<td>18.0%</td>
<td></td>
</tr>
<tr>
<td>Media</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Newspaper</td>
<td>3.6%</td>
<td>1.4%</td>
<td>2.9%</td>
<td>7.9%</td>
<td>3.6%</td>
<td>5.8%</td>
<td></td>
</tr>
<tr>
<td>Magazine</td>
<td>17.3%</td>
<td>5.0%</td>
<td>17.3%</td>
<td>23.0%</td>
<td>15.1%</td>
<td>15.8%</td>
<td></td>
</tr>
<tr>
<td>Television</td>
<td>10.1%</td>
<td>2.9%</td>
<td>7.2%</td>
<td>12.9%</td>
<td>8.6%</td>
<td>5.8%</td>
<td></td>
</tr>
<tr>
<td>Radio</td>
<td>3.6%</td>
<td>1.4%</td>
<td>2.2%</td>
<td>5.0%</td>
<td>2.2%</td>
<td>4.3%</td>
<td></td>
</tr>
<tr>
<td>Internet</td>
<td>11.5%</td>
<td>7.2%</td>
<td>13.7%</td>
<td>18.0%</td>
<td>15.1%</td>
<td>15.1%</td>
<td></td>
</tr>
<tr>
<td>Did not receive any information</td>
<td>13.7%</td>
<td>41.7%</td>
<td>12.9%</td>
<td>12.9%</td>
<td>12.2%</td>
<td>18.7%</td>
<td></td>
</tr>
<tr>
<td>Do not know</td>
<td>1.4%</td>
<td>7.9%</td>
<td>2.2%</td>
<td>2.2%</td>
<td>2.2%</td>
<td>3.6%</td>
<td></td>
</tr>
</tbody>
</table>

The responses from participants regarding iodine compared with other nutritional concerns were substantially lower for all questions, revealing a poor awareness of the importance of this nutrient in pregnancy. Participants were better informed regarding iron, folate, calcium, Listeria, and food poisoning and were more confident that they could make informed decisions regarding these issues. Currently, no information on iodine is provided to pregnant women in Australia, but information regarding other nutritional concerns during pregnancy (e.g., healthy eating, food safety, mercury in fish, and folic acid) is available in pamphlets and on various government and non-governmental Web sites [29–32]. This could explain the finding, to some degree, because most participants received their information from pamphlets (48–63%) and the Internet (11.5–18%) combined.

Another major source of dietary information identified by participants was health care professionals. Participants received substantially less dietary information on iodine (16%) compared with other nutrients (48–63%). The lack of information that is available in the antenatal setting was illustrated by the fact that, to receive ethical approval for the study, an iodine information sheet had to be developed for the participants because none of the educational materials for pregnant women in New South Wales included information on iodine [33]. This brings into question the results, as to how health care professionals could provide information on iodine in the form of written materials when such materials are not actually available. This highlights the urgent need for educational strategies specifically targeting health care providers to encourage supplementation, as recommended by the WHO [21].

The declaration for the Survival, Protection, and Development of Children made after the World Summit for Children convened by the United Nations (UN) in New York in 1989 stated that “every mother has the right to an adequate iodine nutrition to ensure that her newborn child experiences normal brain develop-ment” [34]. Responsibility cannot be left to medical practi- tioners who are responsible for antenatal care because many pregnant women present late in their first trimester and only after referral from their general practitioner. This may be too late. Action by governments is required to meet the responsibilities outlined in the UN declaration.

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that have mild iodine deficiency, as in Australia, the increased ioduria in early pregnancy and the fetoplacental drain on available maternal iodine could deplete total body iodine reserves without the capacity for replacement if dietary iodine intake is inadequate [38]. Even in countries such as Italy that have a functioning salt iodination program, most pregnant women appear to be at risk of iodine deficiency, at least in early pregnancy. Similarly low median UIC values (74 µg/L, range 17–243 µg/L) to those found in the present study were reported in a sample of Italian women in Rome [39].

Regarding the use of other biomarkers to assess iodine status, a recent meta-analysis that included 21 intervention studies [40] confirmed that urinary iodine is an effective biomarker reflecting changes in iodine status in response to iodine administration in certain circumstances, including pregnancy. Serum thyroglobulin and serum thyroxine were not found to be valid biomarkers in pregnant and lactating women, although there was no evidence that triiodothyronine is a useful biomarker for iodine status. Thyroid-stimulating hormone concentrations may be used to detect changes in iodine status over time in pregnant, lactating, and non-pregnant adult women (but not in children and adolescents or those with moderate baseline thyroid-stimulating hormone status), but its use in cross-sectional surveys of current iodine status has not been demonstrated.

Future studies with larger samples and including recruitment of pregnant women from a range of sites are required to enable broader generalizations of our preliminary findings. Such studies should consider including additional questions regarding good food sources of other key nutrients and related health issues during pregnancy to enable comparisons to be made regarding pregnant women’s knowledge of the different nutritional concerns during pregnancy. Because most women in this study intended to breast-feed, optimization of their iodine status during pregnancy is of even greater concern. In this regard, studies from New Zealand [41,42] have identified a low iodine status of lactating mothers and their infants. It is recommended that more studies be conducted in Australia and other countries that are classified as being mild to moderately iodine deficient to determine specific iodine requirements during the different gestational stages of pregnancy and the implications of breast-feeding on the iodine status of mothers and their infants.

Conclusion

The median UIC is consistent with other recent findings revealing a suboptimal iodine status of pregnant women in Australia. Compared with previous studies, the results indicate that low iodine status may be the result of poor knowledge and practices of iodine nutrition. Most participants did not know the adverse health effect of low iodine in the diet and did not have an adequate knowledge of good dietary sources. This, combined with the large proportion of women who indicated that they had not received enough information regarding iodine compared with other nutritional concerns, highlights the urgent need for public health action. Strategies should include supplementation and nutritional education for women of child-bearing age to improve their iodine status before and during pregnancy. Fortification may assist non-pregnant women but may not be sufficient to meet new WHO guidelines for iodine during pregnancy. Women need to be informed regarding the importance of iodine before they become pregnant so that they are empowered to request supplementation or seek it out themselves. A range of actions is required by governments, not just supplementation, to ensure that the basic human rights of women and children do not continue to be violated.

Acknowledgments

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References


