

Short Communication

Poor iodine status and knowledge related to iodine on the eve of mandatory iodine fortification in Australia

Karen E Charlton PhD^{1,2}, Heather R Yeatman DPH², Fiona Houweling MSc^{1,2}

¹Smart Foods Centre, Faculty of Health and Behavioural Sciences, University of Wollongong, NSW, Australia

²School of Health Sciences, Faculty of Health and Behavioural Sciences, University of Wollongong, NSW, Australia

Background: Mandatory fortification of bread with iodised salt is proposed to address the re-emergence of iodine deficiency in Australia and New Zealand. The impacts of fortification require baseline data of iodine status among vulnerable sectors of the population. **Objective:** To assess the iodine status of healthy women and to investigate consumer understanding and attitudes related to the proposed mandatory iodine fortification programme. **Design:** Cross-sectional sample of 78 non-pregnant women aged 20-55 y was conveniently sampled in Wollongong, NSW. A single 24-hr urine sample was collected for urinary iodine concentration (UIC). A self-administered questionnaire assessed consumer understanding, perceptions and attitudes related to iodine fortification. **Outcomes:** Median UIC = 56 µg/L (IQR = 41-68), indicating mild iodine deficiency. Knowledge about iodine was poor with less than half associating low iodine status with adverse pregnancy outcomes. Health education and supplementation, particularly at the medical practitioner interface, was considered the best strategy for improving low iodine levels. **Conclusions:** The iodine status of women in one region of New South Wales was low. These data add support to the need for a national approach to address iodine intake which includes an accompanying consumer education campaign.

Key Words: iodine, salt, fortification, consumer perceptions, women

INTRODUCTION

Approximately 70% of the world's population is estimated to use iodized salt in a total of 130 countries,¹ and it has been estimated that close to 79 million infants are born with some degree of protection from the adverse consequences of iodine deficiency. While the rest of the world is celebrating the success of Universal Salt Iodisation (USI), Australia is grappling with the re-emergence of mild-to-moderate iodine deficiency in all groups tested, including schoolchildren, adult volunteers, and pregnant and post-partum women.²⁻⁷ The recent 22nd Total Diet Survey demonstrated that Australians, particularly women of child-bearing age, do not consume sufficient dietary iodine to meet their requirements.⁸

Food Standards Australia and New Zealand (FSANZ) has approved the mandatory iodine fortification of all salt used in bread-making, with the exception of organic bread, to be implemented in Australia from October 2009.⁹ Concurrently, mandatory folate fortification of bread flour will come into effect, in mid September 2009.¹⁰

FSANZ plans to disseminate consumer education materials related to mandatory fortification of bread with folic acid,¹¹ and iodine¹² as part of their wider communication strategy to key agencies and organizations, industry and other stakeholders at the commencement of the Standard.¹³ Prior testing of consumer awareness of the health issue at hand and acceptability of the proposed strategy, foods to be targeted and consumers' understanding of why food is to be fortified with the selected nutri-

ent, together with associated benefits, is recommended before fortification commences.¹⁴ However, little research has been undertaken with regard to consumers' attitudes and understanding of mandatory fortification of foodstuffs in Australia.

This study aimed to assess the iodine status of healthy Australian women within the context of consumer understanding, perceptions and attitudes related to the proposed mandatory iodine fortification of salt used in bread.

MATERIALS AND METHODS

A convenient sample of 78 women, aged 19-56 years, was recruited from workplaces in Wollongong, NSW, Australia, through advertisements and email correspondence. Exclusion criteria included major illnesses, use of antihypertensive medication and/or diuretics, pregnancy or lactation, and formal training in nutrition. Approval to conduct the study was granted by the Human Ethics Research Committee of the University of Wollongong and the Wollongong and Shellharbour City Council management committees.

Corresponding Author: Dr Karen E Charlton, School of Health Sciences, Faculty of Health and Behavioural Sciences, University of Wollongong, Wollongong, NSW 2522, Australia. Tel: +61 2 4221 4754; Fax: +61 2 4221 3486
Email: karenc@uow.edu.au
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A single 24-hour collection of urinary excretion was obtained; from this an aliquot was taken for a spot urinary iodine assessment. Twenty-four hour urine volumes were used to estimate daily dietary iodine intake from the median UIC values. Samples that had volumes of 500 ml/24 hours or less were considered to be incomplete collections and not used for the dietary intake assessments ($n = 2$). Dietary estimates were also performed using the reference of Zimmerman et al 2008,¹⁵ which is based on estimates of mean 24-h urine volume and an assumption of an average iodine bioavailability of 92%: urinary iodine ($\mu\text{g/L}$) $\times 0.0235 \times \text{bodyweight (kg)} = \text{daily iodine intake } (\mu\text{g})$. Using this formula, a median urinary iodine concentration of 100 $\mu\text{g/L}$ corresponds roughly to an average daily iodine intake of 150 μg . Urine samples were stored at -80°C and batch-analysed by the accredited laboratory of the Institute of Clinical Pathology and Medical Research (ICPMR), Westmead Hospital, Sydney. Urinary iodine was analysed using an adaptation of the Sandell-Kolthoff method,¹⁶ with ammonium persulphate digestion and microplate reading. Sensitivity of the urinary iodine assay is 5 $\mu\text{g/L}$. At 46 $\mu\text{g/L}$ (± 7.72 (i.e. 2SD)) the coefficient of variation (CV) is 16.7%, at 153 (± 8.9) $\mu\text{g/L}$ the CV is 5.8%, while at 347 (± 30) the CV is 8.65%. Urinary sodium was assessed using the indirect ion specific electrode method (Roche Modular).

Body weight and percentage body fat were measured in an upright position in minimal clothing and without shoes, using scales with a bioelectrical impedance component (Tanita TBF-622). Blood pressure (BP) was measured using an automatic blood pressure monitor (DINAMAP™ XL Vital Signs Monitor) on three occasions, according to standard protocol recommended by the American Heart Association.¹⁷ The average of the second two measurements was used.

The questionnaire was adapted from a New Zealand study on public opinion of proposed iodine fortification strategies,¹⁸ as well as a survey of iodine nutrition knowledge conducted in South African households.¹⁹ Knowledge questions included identification of good dietary sources of iodine, the health implications of inadequate iodine in the diet, sources of dietary iodine information, personal use of iodised salt and awareness of iodine as a public health problem. Views were sought on acceptable strategies to address iodine deficiency in Australia.

Statistical analysis

Urinary iodine status data are presented as median urinary iodine concentrations (UIC) and iodine deficiency or sufficiency assessed according to the reference values of the World Health Organization and the International Committee on the Control of Iodine Deficiency Disorders (ICCIDD)²⁰ [Urinary Iodine Excretion (UIE) ≥ 100 $\mu\text{g/L}$ represents iodine replete status]. To estimate daily dietary intake of iodine, in the absence of 24 hr urinary collections, an average urinary volume of 1.5 L/24 hr is often assumed, together with an average iodine bioavailability of 90%.²¹ Dietary iodine intake was estimated in two ways and expressed as percentiles: (i) $\text{UIC } (\mu\text{g/L}) \times \text{Urinary volume (L/24hr)}/0.90$ and (ii) $\text{UIC } (\mu\text{g/L}) \times (1.5 \text{ L}/24 \text{ hr})/0.90$. Urinary iodine concentration percentiles were compared using all three values to enable extrapolation

from spot urine samples to more complete collections. Mann-Whitney U tests were performed to assess differences in UIC according to urinary sodium excretion values of ≥ 2300 mg Na/24 hr and < 2300 mg Na/24 hr, and reported iodised salt use (categorical variable). Spearman's correlation coefficients assessed the association between age and UIC. Descriptive statistics present knowledge and practices of dietary iodine. All data were analysed using the SPSS statistical package (version 15: SPSS Inc, Chicago IL) with a significance level of 0.05.

RESULTS

The mean age of participants was 38 (SD = 11) y, ranging from 18-55 y; 64% were aged 18-44y and the remainder aged 45+ y. Most (88%) participants had completed post school qualifications. Mean BMI was 24.0 (SD = 3.5); most women had a BMI in the desirable weight range (68%); 29% were overweight and 5% obese. Mean percentage body fat was 30.4 (6.4) % and mean systolic and diastolic blood pressure were 109 (12) and 65 (9) mmHg, respectively.

Urinary Iodine Concentrations

Median UIC was 56.0 $\mu\text{g/L}$ (Interquartile range = 43-69 $\mu\text{g/L}$). Only 8% of participants had a UIC value in the adequate range of 100-199 $\mu\text{g/L}$ (Table 1).²⁰ Median UIC calculated using 24 hr urinary volumes (mean volume = 1.975 (SD = 0.796) L/24 hr) was 95.9 $\mu\text{g/L}$, (IQR = 73.4 $\mu\text{g/L}$ - 135.0 $\mu\text{g/L}$). No association was found between 24hr UIC and age (Spearman $\rho = 0.041$; $p = 0.728$). There was a non-significant trend in 24 hr median urinary iodine excretion between those with a high (≥ 2300 mg Na/day; $n = 43$) and low (< 2300 mg Na/day; $n = 32$) urinary sodium excretion (101.4 $\mu\text{g}/24$ hr and 84.1 $\mu\text{g}/24$ hr, respectively; Mann-Whitney U test; $p = 0.179$). Similarly, no difference was found in median 24 hr UIC between reported consumers ($n = 43$) and non-consumers ($n = 30$) of iodised salt (Mann-Whitney U test; $p = 0.191$).

Knowledge, attitudes and practices relating to iodine fortification

Knowledge was low - 24% were aware that lack of iodine is a common health problem in Australia; 18% considered it to be an issue but only in some groups; 62% associated iodine deficiency with goitre, or impaired physical development during growth in childhood (53%); 44% with fetal malformations and 43% with mental retardation. Incorrect responses included weak bones/teeth (25%) and arthritis (12%). The population group identified to be most at risk for iodine deficiency was young children (71%). Only 49% identified pregnant women as high risk.

Knowledge of food sources of iodine, apart from the correct identification of fish and seafood (74%) also was low (Table 2), or incorrect (fruit and vegetables were considered rich sources, 32% and 45%, respectively). Only 35% of participants considered their own diet to provide enough iodine for their body's needs, while most did not know (59%).

Regarding strategies to address iodine deficiency, all participants supported nutrition education activities (by health professionals, 100%; or mass media, 97%); supplementation was recommended by 61%; and less than

Table 1. Urinary iodine concentrations of non-pregnant women in Illawarra, NSW

	Reference range (UIC, $\mu\text{g/L}$) ¹⁵	n [†]	% sample
Iodine replete	($\geq 100 \mu\text{g/L}$)	6	8.0
Iodine deficiency	$< 100 \mu\text{g/L}$	69	92.0
Mild deficiency	50 – 99 $\mu\text{g/L}$	31	41.3
Moderate deficiency	20 – 49 $\mu\text{g/L}$	38	50.7

Estimated daily dietary intake of iodine (Percentile distribution)	UIC ($\mu\text{g/L}$) [‡]	Estimated from 24hr urine collec- tions [§]	Estimated assum- ing 1.5L urine volume/day [¶]	Estimated using refer- ence of Zimmerman et al., 2008 ^{15††}
5 th percentile	27.0	49.5	44.5	64.6
10 th percentile	30.6	51.9	46.7	71.5
25 th percentile	43.0	81.5	73.4	104.8
50 th percentile	56.0	106.6	95.9	165.3
75 th percentile	69.0	150.0	135.0	219.9
90 th percentile	96.4	230.0	207.0	343.7
95 th percentile	115.2	243.9	219.5	365.2

[†]n = 3 did not provide urine samples

[‡]Spot urine sample ($\mu\text{g/L}$)

[§](Urinary iodine concentration ($\mu\text{g/L}$) x 24hr urine volume (L))/0.90²⁰

[¶](Urinary iodine concentration ($\mu\text{g/L}$) x 1.5 L)/0.90²⁰

^{††}Urinary iodine ($\mu\text{g/L}$) $\times 0.0235 \times$ bodyweight (kg) =daily iodine intake (μg)¹⁵

Table 2. Knowledge of food sources of iodine (N=76)[†]

Food	Good	Not a Good Source	Don't Know
Meat	29% [‡]	11% [‡]	60%
Milk	16% [‡]	19% [‡]	66%
Bread	16% [‡]	18% [‡]	65%
Fish and seafood from the sea	74% [‡]	1%	24%
Fruit	32% [‡]	16% [‡]	52%
Vegetables	45% [‡]	11% [‡]	45%
Eggs	24% [‡]	11%	65%

[†]n = 2 did not complete questionnaires; [‡]Indicates correct answer. Food considered good source if that food contributed $> 5\%$ of total iodine intake in the Food Standards Australia New Zealand Total Diet Survey (2008).⁸

half supported either mandatory or voluntary fortification of foods or salt (39-43%).

Potential vehicles considered appropriate for iodine fortification include iodisation of table salt (81%); fortification of bread (73%); breakfast cereals (61%); other products containing flour, such as biscuits, baked products and pasta (40%); and milk (37%). Iodine added to salt licks for cows was considered to be a more acceptable strategy (57%) than being added directly to milk itself. There was little support for iodine to be added to the water supply (36%).

DISCUSSION

This sample did not meet the World Health Organisation (WHO) definition of an iodine-replete population (i.e. $> 50\%$ subjects with UIC = 100-199 $\mu\text{g/L}$ and $\leq 20\%$ with UIC $< 50 \mu\text{g/L}$), highlighting the urgency for increasing iodine in the Australian diet.

Most salt in Australian diets is now consumed in processed foods, however the food industry does not generally use iodised salt.²² Our finding that urinary iodine concen-

trations did not differ between individuals with high and low urinary sodium excretion values (equivalent to greater or lower than 6g salt per day, respectively) supports the low reported use of discretionary iodised salt use.^{8,22}

Women's knowledge of the health impacts of iodine deficiency was poor. Less than half of the women identified iodine deficiency as a cause of mental and physical impairment in fetal development, and pregnancy and lactation were not considered to be high risk periods for iodine deficiency. The mandatory iodine fortification programme is expected to increase dietary iodine intake by 46 μg per day, if three slices (100 g) of bread are consumed,²³ but this will not meet the increased iodine requirements of pregnancy and lactation.^{24,25} As the women's knowledge of dietary sources of iodine was also found to be poor, achieving an optimal iodine status prior to becoming pregnant may be very difficult and use of iodine-containing supplements during pregnancy will be important.

Women identified nutrition education activities provided by either health practitioners or through public education (mass media) as preferred strategies to address iodine deficiency. However, health professionals, particularly doctors, are not widely consulted for this purpose.²⁶⁻²⁸ The media are more frequently accessed as sources of information on nutrition,^{27,29} but whether or not FSANZ plans to use the media are unclear. The low support for fortification (39%-43%), either mandatory or voluntary, may reflect a low level of public debate of such issues in Australia.

Consumers and manufacturers have to navigate various public health messages, which sometimes may be contradictory. Folate and iodine fortification of bread are being implemented simultaneously, potentially causing confusion for consumers. The iodisation of salt used in bread may undermine programs to reduce the salt content of bread. The fortificant levels of bread were set at 25-65 mg of iodine per kg salt. However, Grimes et al found that

many Australian breads already fall below 450 mg of salt per 100 g, a recommended target,^{30,31} and revision of fortificant levels may be required if Australian bread manufacturers aim for the more ambitious 400 mg of salt per 100 g recommendations.³² Iodised salt will have to be listed as an ingredient and food manufacturers may choose to make nutrition claims, as currently permitted under the Code.^{33,34} However, the costs associated with changes to labelling on bread packaging may be considered prohibitive. Importantly, ongoing monitoring and evaluation of the fortification programme and associated activities will be required.¹⁹

There are a number of considerations when interpreting the study findings. A single 24-hr urinary collection was obtained, whereas casual (spot) urine samples in groups of individuals is the method accepted by the International Committee for the Control of Iodine Deficiency Disorders (ICCIDD)/UNICEF/WHO for use in epidemiological studies.²⁰ Daily urinary excretion of iodine closely reflects iodine intake in non-pregnant populations³⁵ and a recent meta-analysis³⁶ confirmed urinary iodine is an effective biomarker. However, a single urinary iodine excretion value is associated with large variation, both between and within individuals,³⁷⁻³⁹ and large numbers (n = 125) of repeat samples are required for precision.⁴⁰ In the present study, estimated dietary iodine intake using measured 24-hr urinary volumes and assuming an average iodine bioavailability of 90% were compared with estimates using an average 24-hr urinary volume of 1.5 L.²¹ Similar median iodine intake values were found using both estimated and actual urine volumes, also reported by other authors.²¹ The data reported in this study caution against the rule of thumb of assuming a urinary excretion of 1.5 L/day, as this sample population, living in the temperate climate of a coastal region of New South Wales, Australia, had much higher urinary outputs than this value. The much higher estimation of dietary iodine intake, using the reference of Zimmerman et al,¹⁵ also highlights the need for more validation studies in this area. At present, the use of spot urine median UIC concentrations is the method of choice for iodine status estimation in groups.

Other limitations of this study relate to the generalisability of the findings. This study sample size was small, from only one geographical area of NSW, comprising women of relatively high educational level, mostly of desirable weight and generally healthy, and thus may be more informed about health issues than the general public.

CONCLUSION

Mild iodine deficiency was identified in a sample of non-pregnant Australian women. This group are not sufficiently informed about the health implications of an inadequate iodine intake, nor were they aware of dietary sources of iodine, or the potential benefits of fortification. The data support the need for a consumer education campaign to accompany the recently implemented iodine fortification programme in Australia.

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AUTHOR DISCLOSURES

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Karen E Charlton PhD^{1,2}, Heather R Yeatman MPH², Fiona Houweling MSc^{1,2}

¹Smart Foods Centre, Faculty of Health and Behavioural Sciences, University of Wollongong, NSW, Australia

²School of Health Sciences, Faculty of Health and Behavioural Sciences, University of Wollongong, NSW, Australia

澳洲強制加碘政策前不良的碘營養狀況及碘相關知識

背景：在澳洲及紐西蘭，建議在麵包中強制添加碘鹽，以解決重新浮現的碘缺乏情況。欲瞭解強化政策的影響，首先需要那些易缺乏族群的碘狀況之基本資料。目的：評估健康婦女的碘營養狀況以及調查消費者對強制加碘計畫的認知及態度。研究設計：在新南威爾士州的臥龍岡市，藉由便利性取樣，共取得 78 位 20-55 歲的非懷孕婦女為橫斷性的樣本。搜集一次 24 小時尿液樣本以檢測尿液中碘的濃度。利用自填式問卷來評估消費者對加碘強化的認知、觀念及態度。結果：尿液中碘濃度的中位數為 56 µg/L (四分位數間距為 41-68)，表示有輕微的碘缺乏。少於一半的人明瞭碘營養缺乏與不良懷孕有關，顯示對碘的知識不足。健康教育及補充碘，特別是經由醫療工作者的介入，被認為是改善低碘濃度的最佳策略。結論：新南威爾士州的一個地區，婦女的碘營養狀況是不良的。這些資料更佳支持需要全國性的政策，以解決碘的攝取問題，這其中也包括消費者教育活動。

關鍵字：碘、鹽、強化、消費觀念、婦女