Improved iodine status in Tasmanian schoolchildren after fortification of bread: a recipe for national success

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Abstract

Objectives: To examine population iodine status in Tasmania after mandatory iodine fortification of bread and assess the magnitude of difference compared with results from a period of voluntary iodine fortification.

Design and setting: A cross-sectional urinary iodine survey of schoolchildren from classes that included fourth-grade students was conducted in Tasmania in 2011. Results were compared with surveys conducted before fortification and during a period of voluntary fortification.

Participants: Three hundred and twenty students aged 8–13 years from 37 participating school classes.

Main outcome measures: Median urinary iodine concentration (UIC) and proportion of UIC results < 50 μg/L.

Results: Median UIC in 2011 was 129 μg/L, and 3.4% of samples had a UIC under 50 μg/L. This was significantly higher than during the period of voluntary fortification (129 μg/L v 108 μg/L) (P < 0.001), which was significantly higher than before fortification (108 μg/L v 73 μg/L) (P < 0.001). There was a reduction in the proportion of samples with UIC under 50 μg/L after mandatory fortification (3.4%) compared with results from the period of voluntary fortification (9.6%) (P = 0.01), which was a further reduction compared with results from the prefortification period (17.7%) (P < 0.001).

Conclusions: Iodine status in Tasmania can now be considered optimal. Mandatory iodine fortification has achieved significantly greater improvements in population iodine status compared with voluntary fortification. However, surveys of schoolchildren cannot be generalised to pregnant and breastfeeding women, who have higher iodine requirements. Measurement of iodine status in population surveys is warranted for ongoing monitoring and to justify the appropriate level of fortification of the food supply into the future.

Iodine is an essential micronutrient required for thyroid hormone synthesis. Inadequate dietary iodine intake is associated with a spectrum of diseases termed iodine deficiency disorders. The most serious and overt consequences are neurocognitive disorders and endemic goitre.[1] Urinary iodine excretion is a marker of recent dietary iodine intake and is typically used to monitor population iodine sufficiency. Population iodine status is considered optimal when median urinary iodine concentration (UIC) is between 100 μg/L and 199 μg/L, with no more than 20% of samples having UIC under 50 μg/L.[1]

Concern about the emergence of widespread mild iodine deficiency in Australia and New Zealand led to mandatory iodine fortification of yeast-leavened bread in 2009.[2] Tasmania has a well documented history of endemic iodine deficiency, with iodine supplementation strategies implemented since the 1950s.[3] The use of iodophors as sanitising agents in the dairy industry was thought to have provided protection; however, urinary iodine surveys of Tasmanian school children in 1998 and 2000 showed a recurrence of iodine deficiency.[4]

In October 2001, the Tasmanian Government introduced a state-based voluntary iodine fortification program as an interim measure to reduce the recurrence of iodine deficiency. This program resulted in a modest but significant improvement in population iodine status.[5] The Tasmanian voluntary fortification experience provided valuable information for the development of the Australia and New Zealand mandatory iodine fortification program.

In this article, we describe the results of the 2011 urinary iodine survey of Tasmanian schoolchildren and compare these results to surveys conducted before fortification and during a period of voluntary fortification.

Methods

A cross-sectional urinary iodine survey of Tasmanian schoolchildren was conducted in 2011. Survey methods were comparable to those used during the period of voluntary fortification, as described elsewhere.[5]

A one-stage cluster sampling method was used to randomly select school classes that included fourth-grade students from all government, Catholic and independent schools in Tasmania (such classes may include children in third, fourth, fifth and sixth grade, as composite class structures are popular in Tasmania). A total of 52 classes (from 49 schools) were invited to participate. This included 42 classes that had been randomly selected for the final survey conducted during the period of voluntary fortification and an additional 10 classes randomly selected in 2011 to boost sample size. In total, 37 classes (from 35 schools) agreed to take part, representing a class participation rate of 71%. Of the 880 children in participating classes, 356 (40%) returned positive consent and 320 (36%) provided a urine sample for analysis. These participation rates are comparable with the rates reported from previous surveys.[5]

Spot urine samples were collected at home, returned to school and transported by a private pathology provider to a laboratory where they were frozen and stored. Batch analyses were completed by the Institute of Clinical Pathology and Medical Research, Westmead Hospital. UIC was measured using the ammonium persulfate digestion method based on the Sandell–Kolthoff reaction.[6]

UIC data from children of comparable age from prefortification surveys and from participants in the surveys from the voluntary fortification period were used for comparison with the data from this survey.

Data were analysed using Stata version 11 (StataCorp). Median UIC, interquartile range and the proportion of samples with UIC under 50 µg/L were calculated for each survey. To facilitate comparisons between medians and the proportion of UIC results under 50 µg/L across intervention periods (prefortification, voluntary fortification and mandatory fortification), data were combined from the two prefortification surveys (1998 and 2000) and from the four surveys conducted during the period of voluntary fortification (2003, 2004, 2005 and 2007). Differences in median UIC across intervention periods were compared using Kruskal–Wallis χ^2 (corrected for ties) with post-hoc Wilcoxon rank-sum test.

Ethics approval was obtained from the Tasmanian Health and Medical Human Research Ethics Committee and the Department of Education Tasmania. Parent or carer consent was obtained for all participating children.

1 Urinary iodine concentration (UIC) of Tasmanian schoolchildren by year and intervention period

Intervention period	Year (*n*)	Median UIC (95% CI)	IQR	Proportion of samples with UIC < 50 µg/L (95% CI)
Prefortification*	1998 (124)	75 µg/L (72–80 µg/L)	60–96 µg/L	16.9% (10.3%–23.6%)
	2000 (91)	72 µg/L (67–84 µg/L)	54–103 µg/L	18.7% (10.6%–26.7%)
Voluntary fortification*	2003 (347)	105 µg/L (98–111 µg/L)	72–147 µg/L	10.1% (6.9%–13.3%)
	2004 (430)	109 µg/L (103–115 µg/L)	74–159 µg/L	10.0% (7.2%–12.8%)
	2005 (401)	105 µg/L (98–118 µg/L)	72–155 µg/L	10.5% (7.5%–13.5%)
	2007 (304)	111 µg/L (99–125 µg/L)	75–167 µg/L	7.2% (4.3%–10.1%)
Mandatory fortification	2011 (320)	129 µg/L (118–139 µg/L)	95–179 µg/L	3.4% (1.4%–5.4%)

IQR = interquartile range. * Based on 1998–2005 surveys.[5] ◆

Results

Of the 320 students participating in the 2011 survey, 158 (49%) were boys, 153 (48%) were girls and nine (3%) were of unknown sex. Participants were aged 8–13 years, with 83% aged 9–10 years. The median UIC in 2011 was 129 µg/L, and 3.4% of samples had a UIC under 50 µg/L.

The median UIC in 2011 was significantly higher than during the period of voluntary fortification (129 µg/L v 108 µg/L; $P < 0.001$), which in turn was significantly higher than the median UIC from the prefortification period (73 µg/L; $P < 0.001$) (Box 1). There was a reduction in the proportion of UIC results under 50 µg/L after voluntary fortification compared with prefortification, from 17.7% to 9.6% ($P < 0.001$), and a further reduction to 3.4% after mandatory fortification ($P = 0.001$) (Box 2). Box 3 shows the progressive improvement in median UIC results from Tasmanian urinary iodine surveys of schoolchildren over the iodine fortification intervention periods (prefortification, voluntary fortification and mandatory fortification).

Discussion

Our findings show a progressive improvement in the iodine status of Tasmanian schoolchildren over the iodine fortification intervention periods (from prefortification to voluntary fortification and mandatory fortification). This study also shows the specific benefit of a mandatory versus a voluntary approach to iodine supplementation.

Population iodine status is routinely assessed by measuring UIC, whereas determining the appropriate level of fortification in food relies on estimates of dietary intakes. The relationship between dietary iodine intake and UIC is usually linear — an increase in dietary intake results in a comparable increase in urinary excretion.[7] The 56 µg/L increase in median UIC from prefortification to mandatory fortification is consistent with the predicted 52 µg/d increase in the mean dietary iodine intake for children aged 9–13 years, estimated by dietary modelling before the introduction of mandatory iodine fortification.[8]

This is the first study to specifically evaluate the adequacy of iodine nutrition in an Australian population after the introduction of mandatory iodine fortification of bread in 2009. The results are of significance to the Australian population more broadly, as the magnitude of effect of mandatory supplementation on the national population is likely to be similar to that observed in Tasmania.

In the 2004 National Iodine Nutrition Study, a survey of schoolchildren found that Western Australia had the highest median UIC of all Australian jurisdictions, at 142.5 µg/L.[9] Extrapolating the magnitude of increase in UIC from our surveys to that observed in WA would result in a UIC just under 200 µg/L (56 µg/L + 142 µg/L), which is at the upper level of the optimal range.[1]

To facilitate comparisons, the sampling method used in our 2011 survey was modelled on the method used in the surveys conducted during the period of voluntary fortification.[5] Classes that included fourth-grade children were originally chosen as the sampling frame to be consistent with World Health Organization guidelines for assessing population iodine status.[1] Staff from the Department of Education Tasmania advised that this age group would be sufficiently independent to provide a urine sample, while minimising self-consciousness likely in older children. It is yet to be seen whether the observed impact of mandatory fortification is representative of other population groups, such as adults. Published surveys of prefortification UIC of Melbourne adults offer a useful baseline for this purpose.[10] The Australian Health Survey 2011–2013 is measuring UIC in adults and children across Australia, and we anticipate this will provide further evidence of the iodine status in the Australian population.

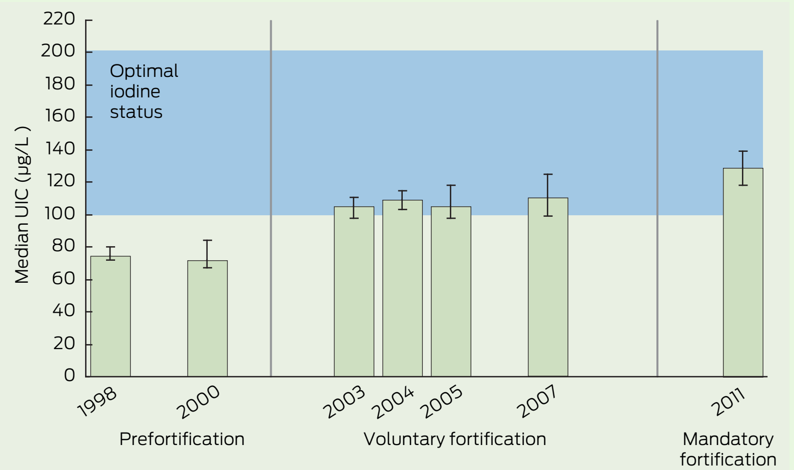
Comparisons with prefortification surveys should be interpreted with the knowledge that there were subtle differences in sampling methods. A two-stage stratified sampling procedure was adopted in the prefortification period (1998–2000), where schools and then students from within schools were randomly selected. Subsequent surveys used a one-stage cluster sampling method with classes that included fourth-grade students as the sampling frame. These sampling differences are not considered significant and have been discussed elsewhere.[5] Any sample bias associated with factors

2 Comparison of urinary iodine concentration (UIC) of Tasmanian schoolchildren across intervention periods

Fortification intervention period (*n*)	Median UIC (95% CI)	Difference from prefortification period	*P** compared with results from prefortification period	*P** compared with results from voluntary fortification period	Proportion of samples with UIC < 50 µg/L (95% CI)	Odds ratio (*P*)† compared with results from prefortification period	Odds ratio (*P*)† compared with results from voluntary fortification period
Prefortification (215)	73 µg/L (70–79 µg/L)	—	—	—	17.7% (12.6%–23.8%)	1	—
Voluntary fortification (1482)	108 µg/L (102–111 µg/L)	+ 35 µg/L	< 0.001	—	9.6% (8.1%–11.1%)	0.49 (< 0.001)	1
Mandatory fortification (320)	129 µg/L (118–139 µg/L)	+ 56 µg/L	< 0.001	< 0.001	3.4% (1.4%–5.4%)	0.17 (< 0.001)	0.34 (0.001)

* Difference in medians compared using Kruskal–Wallis χ^2 (corrected for ties) with post-hoc Wilcoxon rank-sum test. † Difference in proportion of samples with UIC < 50 µg/L estimated by logistic regression. ◆

3 Median urinary iodine concentration (UIC) of Tasmanian schoolchildren from 1998 to 2011



such as socioeconomic status or geographic location is unlikely to affect the results, as an association between UIC and these factors has not been found previously.[4]

Although the 2011 results are consistent with iodine repletion in the general population, they cannot be generalised to high-risk subgroups such as pregnant and breastfeeding women, whose daily iodine requirements increase by about 40%.[11] Prior research in Tasmania has shown persistent iodine deficiency in pregnancy despite the introduction of voluntary iodine fortification.[12] Recent evidence suggests that while mandatory iodine fortification may have benefited breastfeeding women, only those consuming iodine-containing supplements had a median UIC in the adequate range.[13] Future studies of iodine nutrition should specifically assess the adequacy in these groups. Similarly, ongoing awareness of the recommendation that pregnant and lactating women take 150 µg of supplemental iodine per day should not be overlooked, particularly in those parts of Australia where marginal iodine deficiency has been previously reported.[14,15]

Changes to the iodine content of food supply (such as the level of iodine in milk or the level of salt in bread) or shifts in dietary choice (such as a preference for staples other than bread) could jeopardise iodine status in the future.[3,16] The value of ongoing vigilance in monitoring population iodine status has been highlighted by previous authors.[12,17,18] In addition, monitoring iodine levels in the food supply will be required to inform future adjustments to the mandatory iodine fortification program.

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