



The Impact of Mandatory Fortification of Bread with Iodine

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Final Report

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The Impact of Mandatory Fortification of Bread with Iodine

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Executive Summary

Iodine is an essential micronutrient needed for the synthesis of thyroid hormones required for normal growth and development particularly of the brain. New Zealand has low levels of iodine in the soil, which predisposes the population to iodine deficiency. Due to changes in food habits and industry practices over the last 30 years, there has been a re-emergence of iodine deficiency in New Zealand. In order to address this nutritional problem the New Zealand government introduced the mandatory fortification of bread with iodised salt in September 2009. The purpose of this study was to determine if the mandatory fortification of bread had improved iodine status in a representative sample of 300 adults aged 18-74 years living in Dunedin and Wellington in 2012. A secondary purpose was to obtain information on the sodium status of New Zealanders. Because it is difficult to quantify the amount of salt used at the table and in cooking, accurately assessing iodine and sodium intakes is problematic. Approximately 90% of dietary iodine and sodium is excreted in the urine, thus participants were asked to collect 24 hour (24hr) urine samples.

The median (25th, 75th percentile) Urinary Iodine Concentration (UIC) of these adults was 73 (46,107) µg/L, which falls between 50-99 µg/L indicative of mild iodine deficiency. This is significantly higher than the median UIC of 53 µg/L reported in the 2008/09 Adult Nutrition Survey, and shows that there has been an increase in iodine intakes in New Zealand adults between 2008/09 (i.e. pre-fortification) and 2012 (i.e. post-fortification). A better estimate of iodine intake is the 24hr iodine excretion. The (geometric) mean 24hr iodine excretion was 124 µg/day; males 45-64 yr had the highest 24hr iodine excretion of 147 µg/day and females 18-24 yr the lowest 24hr iodine excretion at 104 µg/day. These values all fall above the Estimated Average Requirement for iodine of 100 µg/day.

The mean 24hr sodium excretion was 3373 mg/day. Almost all (93 %) adults had a 24hr sodium excretion that exceeded the Suggested Dietary Target for sodium of 1600mg/day. The majority (76%) of participants had a 24hr sodium excretion that exceeded the Upper Tolerable Limit for sodium of 2300 mg/day. These estimates are consistent with previous population surveys in New Zealand indicating the ongoing need for intervention to lower population sodium intake.

Background

Iodine

The thyroid hormones, thyroxine (T_4), and tri-iodothyronine (T_3), are produced by the thyroid gland located at the base of the neck. Iodine is an integral part of the thyroid hormones which are required for normal growth and development^{1, 2}, particularly of the brain and central nervous system. The brain continues to develop until the fifth decade of life, thus an adequate intake of iodine is particularly important during pregnancy, childhood, adolescence, and the first half of adulthood. Iodine deficiency is still one of the most common micronutrient deficiencies, affecting hundreds of millions of people worldwide³. The consequences of severe iodine deficiency are well known with the most serious iodine deficiency disorder being cretinism, characterised by physical abnormalities and profound mental impairment^{4, 5}. There is growing recognition that less severe iodine deficiency is also of concern; mild iodine deficiency adversely affects cognition^{6, 7} and increases the risk of thyroid cancer⁸.

The measurement of the urinary iodine concentration (UIC) in a single or spot urine sample is the most commonly used and recommended index to assess iodine status in the population. Approximately 90% of dietary iodine is excreted in the urine. A median UIC 100-299 $\mu\text{g/L}$ indicates adequate iodine status, while a median UIC 50-99 $\mu\text{g/L}$ is indicative of mild iodine deficiency and a median UIC $>300 \mu\text{g/L}$ of excessive iodine intakes. However, 24hr urine samples can also be collected and have the advantage of providing an estimate of daily iodine intake [3]. Dietary assessment methods, such as the diet recall or diet record, typically underestimate iodine intakes because it is difficult to quantify the contribution to total iodine intakes from discretionary salt use (i.e. at the table and in cooking).

New Zealand has low levels of iodine in the soil, which predisposes the population to iodine deficiency. Studies conducted in the 1920s and 1930s found that up to 30% of New Zealand schoolchildren had goitre. The introduction of iodised table salt in the first half of last century was viewed as a simple but practical solution to improve iodine intakes. In many countries where iodised salt was regularly used, including New Zealand, iodine deficiency and consequently goitre all but disappeared by the mid 1950s⁹. However, a change in food habits led to a re-emergence of iodine deficiency in many parts of the world including the United

Kingdom¹⁰, Australia¹¹ and NZ¹². In the 1990s there were reports of iodine deficiency in volunteer samples of New Zealand adults¹³⁻¹⁵ and in children aged 8-10 years (yr) living in Dunedin and Wellington¹⁶. Mild iodine deficiency was subsequently confirmed in a representative sample of schoolchildren (n=1153) as part of the Children's Nutrition Survey conducted in 2002 (median UIC of 68 µg/L)¹⁷ and in a representative sample of adults (n=3033) in the 2008/09 Adult Nutrition Survey (median UIC of 53 µg/L)¹⁸.

A decrease in the use of iodised salt at the table and in cooking in response to public health messages to decrease sodium intakes, the rising popularity of rock or sea salt with negligible amounts of iodine, Western diets that contain relatively small amounts of fish and other seafood, and an increase in the intake of processed foods that usually contains non-iodised salt, explain the decline in iodine intakes observed over the last 20 years. In response to the re-emergence of iodine deficiency, the New Zealand government introduced the mandatory fortification of bread (i.e. non-organic) with iodised salt in September 2009. Fortification of bread with iodised salt has improved the iodine status of New Zealand schoolchildren, with a median UIC of 113 µg/L reported in children 8-10 yr studied in 2010/11¹⁹. However, the impact of mandatory fortification on the iodine status of adults is not known.

Sodium

Sodium intakes in excess of those recommended by current guidelines are associated with elevated blood pressure in adults and children, increased risk of stroke and ischaemic heart disease, and gastric cancer^{20, 21}. Dietary sodium reduction strategies have been identified as one of the most effective and cost-effective public health strategies available to reduce chronic disease. Sodium reduction has the potential to substantially reduce mortality and morbidity from cardiovascular disease and reduce health care costs^{22, 23}.

New Zealand and Australia have jointly determined nutrient reference values for sodium intake with the recommended Upper Level of intake (UL) for adults set at 2,300 mg/day sodium. For children and adolescents the UL has been extrapolated at a lower level based on proportional energy intake²⁴. The adult UL has been set at this level based on observational data from the INTERSALT study²⁵. INTERSALT was a large population-based observational study of populations in 32 countries which showed relatively low levels of hypertension with intakes

of 2,300 mg/day sodium, but also no evidence of adverse effects of sodium deficiency below this level. New Zealand and Australian guidelines also state that for some people (older or overweight people and those with existing hypertension) a lower Suggested Dietary Target (SDT) of 1,600 mg/day sodium would be beneficial ²⁴. This recommendation is based on evidence from the Dietary Approaches to Stop Hypertension (DASH) trial, which showed that participants randomised to a sodium intake of 65mmol/day (1,495mg/day) benefited by a significantly lowered SBP and DBP with no adverse effects ²⁶. The WHO recommends a population average salt consumption should be less than 5g/day salt (2,000mg/day sodium) except where lower recommended maximum levels have been set ²⁷. WHO also strongly recommends a daily intake of sodium for individual adults of less than 2000mg (5 grams salt), with recommended levels for children adjusted downwards based on relative energy intake ²⁸.

Despite this, many populations around the world have sodium intakes that exceed this level. New Zealand's mean population intake is likely to be around 3500mg sodium/day (equivalent to around nine grams salt per day) according to 24hr urine samples in 1998, and spot urine samples in 2008/09. Analysis of data from the Adult Nutrition Survey 2008/09 suggests that around 65% of adults 15 years and over have an intake higher than the recommended upper level of intake of 2300mg/day ^{29, 30}. These estimates are consistent with data from similar countries, such as Australia and the United States ^{31, 32}. In the UK monitoring shows a reduction in sodium intake from an average of 3800mg/day in 2000-01 to 3,240mg sodium/day in 2011 following the implementation a national sodium reduction strategy ³³.

The most accurate method of estimating total daily sodium intake is to measure excretion via collection of a 24hr urine sample, as around 90% of dietary sodium is excreted in the urine, with only small amounts being lost in faeces and in sweat ³⁴. Estimates based on 24hr diet recall are also used, but generally intakes underestimate total intake by 10-20% ^{35, 36}. Spot urine, overnight urine and 12hr urine samples have also been used to estimate 24hr sodium excretion and may be more suitable for large population samples. However, this method is less accurate than 24hr urine sampling due to the diurnal variation of sodium excretion ³⁷.

Purpose of Study

The purpose of this study was to complement existing monitoring activities being undertaken by the Ministry of Primary Industries and help to answer whether the mandatory fortification of bread has been successfully implemented and is having a measurable effect on the iodine status of New Zealanders. A secondary purpose was to obtain information on the sodium status of New Zealanders.

Methods

This was a cross-sectional survey of New Zealand adults aged 18-64 yr conducted between February and November 2012. A sample size of 300 adults was a sufficient number of participants to determine the median UIC with a precision of $\pm 8 \mu\text{g/L}$ and sodium concentration with a precision of $\pm 176 \text{ mg/day}$. A copy of the New Zealand Electoral Roll was obtained from Statistics New Zealand for adults residing in Dunedin city and Wellington city. Adults between the ages of 18-64 years living within a 25 km radius of central Dunedin city and 25 km radius of central Wellington were stratified into six different sex and age groups (18-24 yr, 25-44 yr, and 45-64 yr) and assigned a random number, then ordered. Adults from each sex and age category were sequentially selected from the electoral roll in each city and sent a letter of invitation; a further three contacts (2 postcards, and another letter) were made for each participant, if required. In addition, a snowballing technique (i.e. word of mouth through research assistants and friends (but not family members) of previous participants) was used to recruit further participants in order to meet the required sample size of 300 participants from Dunedin and Wellington.

Participants indicated their interest in taking part in the study by returning a consent form in a prepaid envelope, or by email. Interested participants were phoned to determine if they met the following inclusion criteria: no history of thyroid, heart, or kidney disease; not taking any thyroid medication or had not started diuretics in the previous 2 weeks; and not taking an iodine or kelp containing supplement. Eligible participants were then asked to attend a 15 minute interview where they had their height, weight, and blood pressure measured. At the end of the interview, participants were instructed on the completion of a 24-hour urine sample,

which took place on a day convenient to them. Completed urine samples were collected from the homes of each participant by courier. The total volume of urine was then recorded, noting if any samples were missed. Participants who missed more than two samples over the 24hr period were deemed to have incomplete urine collections and excluded. An aliquot of urine was stored at -20°C until analysis. Participants were also asked to complete a questionnaire online on SurveyMonkey. The questionnaire asked about date of birth, sociodemographic information such as ethnicity, level of education, and personal income, and included questions about the frequency of consumption of bread and bread products and use of iodised salt. Data entered into SurveyMonkey by participants was checked to ensure that the participant identification code matched the sociodemographic variables collected during the interview (i.e. date of birth and sex) and that responses were appropriate. If a discrepancy or anomaly existed, participants were contacted by phone to confirm the correct response. Ethical approval was obtained from the University of Otago Ethics Committee (Ref 11/244).

UIC was determined using a modification of the method of Pino et al.³⁸ at the Department of Human Nutrition, University of Otago. An external reference standard (Serorm Trace Elements Urine, Sero As, Norway) was analysed with each batch of samples giving a mean iodine concentration of 93 µg/L (expected: 97 µg/L) with a coefficient of variation (CV) of 3.7%. Urinary iodine excretion (UIE) µg/day was determined for each participant by multiplying UIC (µg/L) by the total urine volume (L/day). Urinary sodium was determined on a Roche Hitachi Cobas C311 ISE unit biochemical analyser using an ion-selective electrode in the Department of Human Nutrition, University of Otago. An external reference standard (PreciPath U, Roche) was analysed with each batch of samples giving a mean sodium concentration of 143 mmol/L (expected range: 132-156 mmol/L) with an intra-assay CV of 2.1%. These data illustrate that both the iodine and sodium analyses were accurate and precise. For each individual's urine, volume was multiplied by the urinary concentration of iodine or sodium, giving the 24hr iodine (µg/day) and 24hr sodium (mg/day) excretion, respectively.

All statistical analyses were carried out using the statistical package STATA 11.1 (StataCorp LP. College Station, TX, USA). Socioeconomic status was determined by identifying the meshblock for the participant's residential address and using the New Zealand Index of

Deprivation scale (NZDep2006)³⁹. The scale is divided into deciles with NZDep1 representing the least deprived area and NZDep10 the most deprived area. Log transformation was carried out for data that was not normally distributed (i.e. UIC, 24 hr iodine, 24hr sodium). Regression analysis was used to determine the effect of age (18-24yr, 25-44 yr, 45-64 yr), sex (male, female), use of iodised salt (i.e. yes or no), and frequency of consumption of bread (i.e. number of serves of bread per week) on UIC, 24hr iodine and 24hr sodium excretion. Both 24hr iodine excretion and 24hr sodium excretion were used as estimates of daily iodine and sodium intakes, respectively. For iodine, the proportion of the study population that fell below the Estimated Average Requirement of 100 µg/day was determined⁴⁰. For sodium, the proportion of the study population that fell above the Suggested Dietary Target of 1600 mg/day and Tolerable Upper Limit of 2300 mg/day was determined⁴⁰. All tests were two-sided and the level of significance set at $p < 0.05$.

Results

Recruitment and Participants

Letters of invitation were sent to 1525 randomly selected adults from the electoral roll living in Dunedin and Wellington; 149 letters were returned indicating that these people no longer lived at the address and 3 people were deceased, resulting in a possible sample size of 1373 from the electoral roll. More than half of adults ($n=778$; 56.7%) did not respond to any of the four postal contacts (Table 1). Of the 598 who responded, 305 people declined, while 293 people agreed to take part, giving an overall response rate from the electoral roll of 23.0% (Dunedin 29.3% and Wellington 18.5%). Of those who agreed to take part, 251 met the inclusion criteria and provided a complete set of data. In order to increase the sample size, a further 54 people were recruited utilising a snowballing technique of whom 50 subjects provided a complete set of data. This resulted in a final sample size of 301 participants (see Figure 1 for flow of participants through study).

Table 1. Recruitment of subjects and response rates

	Dunedin		Wellington		All Subjects	
	n	%	n	%	n	%
Consent, complete data ¹	159 (34)	25.0	142 (16)	15.0	301 (50)	19.1
Consent, incomplete data ¹	14 (2)	2.2	13 (2)	1.4	27 (4)	1.7
Declined	107	16.9	198	21.0	305	19.3
Deceased	0	0	3	0.3	3	0.2
Not eligible	7	1.1	9	1.0	16	1.0
Not at address	46	7.2	103	10.9	149	9.4
No response	302	47.6	476	50.4	778	49.3
Total	635	100.0	944	100.0	1579	100.0

¹ Figures in brackets include the number of total from each city that were recruited by snowballing.

The sociodemographic characteristics of the participants in the study are presented in Table 2. In comparison to the 2006 New Zealand Census data for Dunedin and Wellington citizens⁴¹, in this study there were a higher percentage of participants of New Zealand European and Other (NZEO) ethnicity and with incomes greater than \$50,000. Twenty percent of participants lived in the least deprived areas (i.e. NZDep1), while less than 10% of participants were in each of the most deprived areas (i.e. NZDep8, NZDep9, and NZDep10).

The mean volume of urine excreted was 1.988 L; no participant missed more than two samples in the 24hr period. The mean intake of fortified bread products was significantly higher at 19.6 serves/week (i.e. 2.8 serves/day) in males than the 14.1 serves/week (i.e. 2.0 serves/day) consumed by females ($p<0.001$). Based on an average iodine content of 46 $\mu\text{g}/100\text{g}$ ⁴² and a typical serving size of 38 g, fortified bread products were estimated to provide 17.5 μg of iodine per serve. The majority of participants (71 %) stated that they used iodised salt (either at the table or in cooking), while 29 % used non-iodised salt including rock or sea salt.

Figure 1: Flow diagram of participation

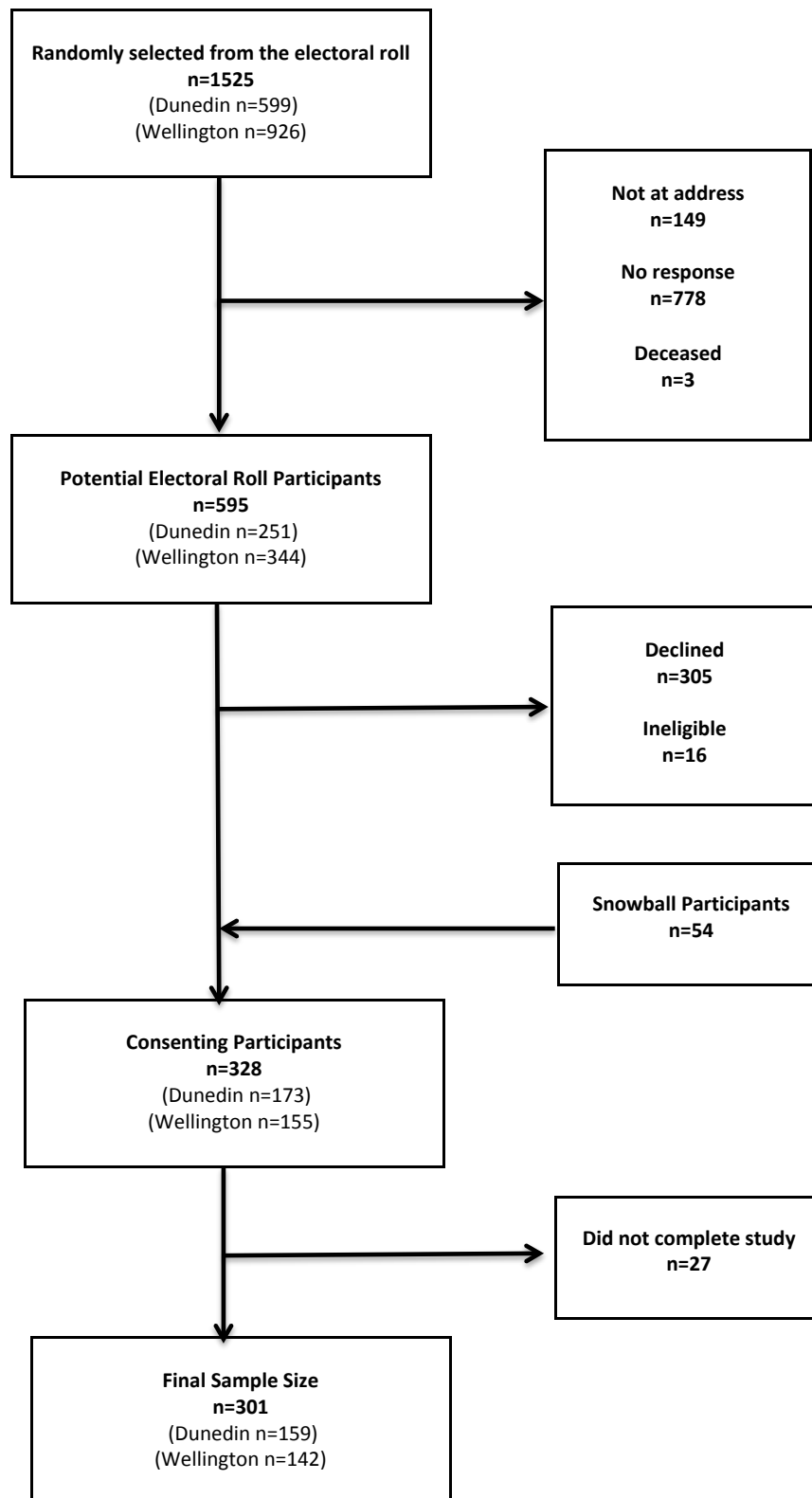


Table 2. Comparison of sociodemographic characteristics of participants with 2006 New Zealand census data for adults aged 15-64 yrs

Variable	Dunedin		Wellington	
	% Participants (n)	% of Adults ¹	% Participants (n)	% of Adults ¹
Ethnicity				
NZEO	97.5 (155)	91.3	89.4 (127)	79.4
Māori	2.5 (4)	6.4	5.6 (8)	12.8
Pacific	0	2.3	4.9 (7)	7.8
NZDep Category ²				
% NZDep1-3	39.6 (57)	NA	40.2 (55)	NA
% NZDep4-7	39.6 (57)	NA	39.4 (54)	NA
% NZDep8-10	20.8 (30)	NA	20.4 (28)	NA
Body Mass Index				
Overweight ³	53.5 (85)	67.8	60.6 (86)	67.8
Income				
% > \$50,000	30.2 (47)	13.4	36.0 (51)	23.6
Education				
% School Qualification	38.4 (61)	37.5	30.3 (43)	46.3

NZEO; NZ European and Other Ethnicities NA; Not Applicable

¹ Compared with 2006 New Zealand Census Data [42] unless stated otherwise for that city.

² Scale ranges from 1-10 with NZDep1 being the least deprived and NZDep10 being the most deprived. NZDep not available for all addresses.

³ Overweight defined as BMI >25 kg/m². Compared with data from 2008/2009 Adult Nutrition Survey.

Iodine Status

The median (25th, 75th percentile) UIC of this sample of New Zealand adults was 73 (46,107) µg/L (Table 3), which falls within the range 50-99 µg/L indicative of mild iodine deficiency³. The cut-offs for UIC used to categorise populations as iodine deficient (i.e. median UIC <100 µg/L) and iodine sufficient (i.e. median UIC >100 µg/L) have been validated in casual or spot urine samples obtained from schoolchildren with an average urine volume of 1.0 L. As there are no validated cut-offs for UIC to assess iodine deficiency in adults, the cut-offs for schoolchildren are often used in older age groups, however, the results should be interpreted with caution.

Males 18-24 yr had the highest median UIC of 92 µg/L and females 25-44 yr had the lowest median UIC of 60 µg/L, however, all sex and age groups had a median UIC that fell between 50-99 µg/L. Furthermore, 31% of adults had a UIC <50 µg/L and 70% had a UIC <100 µg/L, above the 20% and 50%, respectively, recommended by ICCIDD/UNICEF/WHO ³. A median UIC >300 µg/L in a population is indicative of excessive iodine intakes. In this sample of adults, only 2% of participants had a UIC >300 µg/L. The median UIC of 73 µg/L in this study was significantly higher (p<0.001) than the median UIC of 53 µg/L reported in the 2008/09 Adult Nutrition Survey, and suggests that there has been an increase in iodine intakes in New Zealand adults between 2008/09 (i.e. pre-fortification) and 2012 (i.e. post-fortification). There was no association between UIC and age (p=0.241), use of iodised salt (p=0.113), or serves of bread per week (p=0.366). Males had a higher UIC than females (75 vs 65 µg/L; p=0.054). There was no difference in UIC between participants recruited from the electoral roll or by snowball (p=0.211).

Table 3 Median (25th, 75th percentile) urinary iodine concentration (UIC), and proportion (95% CI) of population with UIC <50, <100 and >300 µg/L in 18-64 year old New Zealand adults

	n	UIC µg/L ¹	% UIC <50 µg/L ²	% UIC <100 µg/L	% UIC >300 µg/L
All	301	73 (46,107)	31 (25, 36)	70 (64, 75)	2 (1, 4)
18-24 yr					
Males	48	92 (50, 119)	25 (14, 40)	58 (43, 72)	0 (0, 1)
Females	41	71 (47, 91)	27 (14, 43)	80 (65, 91)	5 (1, 18)
25-44 yr					
Males	49	73 (43,120)	35 (22,50)	65 (50, 78)	2 (1,11)
Females	55	60 (42, 86)	35 (22, 49)	82 (69, 75)	2 (0,10)
18-44 yr					
Females	96	68 (43, 105)	31 (22, 42)	81 (72, 88)	3 (1, 9)
45-64 yr					
Males	50	79 (49, 115)	28 (16,42)	62 (47, 75)	0 (0, 7)
Females	58	69 (43, 105)	33 (21,46)	71 (57, 82)	3 (0, 12)

¹ As determined in 24hr urine sample. A median UIC >100 µg/L indicates adequate iodine status in school children based on a urine volume of 1.0 L. In this study mean urine volume of adults was 2.0 L.

² Cut-offs as suggested by ICCIDD/UNICEF/WHO for school children as follows: % UIC <50 µg/L should be <20%, % UIC <100 µg/L should be <50%; no recommendation for >300 µg/L.

The advantage of a 24hr urine collection is the ability to determine the total daily amount of iodine excreted. The mean (95th Confidence Interval (CI)) 24hr iodine excretion of this sample of New Zealand adults was 124 (117, 132) µg/day (Table 4). As approximately 90% of dietary iodine is excreted in the urine, UIE is an estimation of dietary iodine intake. When UIE was compared to the EAR, the proportion of participants with inadequate iodine intakes (i.e. below the EAR) was 32%. Males in each age category had a lower proportion of inadequate iodine intakes than females. The proportion of inadequate iodine intakes in females 18-24 yr was 49% and in women of childbearing age the proportion of inadequate intakes was 39%.

Table 4. Mean (95% CI) 24hr urinary iodine excretion and proportion (95% CI) below Estimated Average Requirement (EAR)

	n	Iodine excretion µg/day ¹	% < EAR ²
All	301	124 (117,132)	32 (27, 37)
18-24 yr			
Males	48	129 (111, 149)	25 (14, 40)
Females	41	104 (86, 127)	49 (33, 65)
25-44 yr			
Males	49	135 (116, 157)	29 (17, 43)
Females	55	112 (97, 131)	31 (19, 45)
18-44 yr			
Females	96	108 (97, 123)	39 (29, 49)
45-64 yr			
Males	50	147 (128, 169)	22 (12, 36)
Females	58	118 (98, 142)	38 (26, 52)

¹ As determined by multiplying UIC (µg/L) by urine volume (L/day.)
Geometric mean is presented

² The EAR for iodine in adults is 100 µg/day.

There was no association between 24hr iodine excretion and age (p=0.543), but males had higher 24hr iodine excretion than females (137 vs 112 µg/day; p=0.003). There was no

association between 24hr iodine excretion and use of iodised salt ($p=0.0633$). There was a significant association between the number of serves of bread consumed each week and 24hr iodine excretion ($p=0.022$); the number of serves of bread consumed each week was positively associated with UIE in males ($p=0.008$) but not in females ($p=0.907$). There was no difference in 24hr iodine excretion between participants recruited from the electoral roll or by snowball ($p=0.062$).

Sodium Status

Mean 24hr sodium excretion was 3373 mg/day. Ninety-three % of participants had a 24hr sodium excretion that exceeded the recommended SDT of 1600mg/day (97% of men and 90% of women). The majority (76%) of participants had a 24hr sodium excretion that exceeded the recommended UL of 2300 mg/day (84% of men and 76% of women). There were no differences in 24hr sodium excretion by age ($p=0.184$). There was a significant difference in 24hr sodium excretion between males (3833 mg/day) and females (2934 mg/day) ($p<0.001$). Sodium excretion did not differ significantly by geographic location (Dunedin or Wellington) ($p=0.215$) or education ($p=0.145$) when controlling for age and sex. Sodium excretion did not differ significantly between those recruited from the electoral roll and those recruited by snowball sampling ($p=0.703$) when controlling for age and sex. The number of serves of bread consumed each week was positively associated with 24hr sodium excretion ($p<0.001$), and after controlling for sex, this relationship was attenuated but still significant ($p=0.021$). There was a significant association between 24hr sodium excretion and UIC ($p=0.021$) and 24hr iodine excretion ($p<0.001$).

Table 5 Mean (95% CI) sodium excretion, and proportion (95% CI) above Suggested Dietary Target (SDT) and Upper Limit (UL)

	n	Na mg/day ¹	% > SDT ²	% > UL ²
All	301	3373 (3208, 3539)	93 (91, 96)	76 (71, 81)
18-24 yr				
Males	48	3843 (3345, 4341)	96 (90, 100)	83 (70, 93)
Females	41	3017 (2724, 3310)	95 (88, 100)	73 (57, 80)
25-44 yr				
Males	49	3795 (3372, 4217)	94 (87, 100)	84 (70, 93)
Females	55	3035 (2706, 3365)	95 (87, 100)	80 (67, 90)
45-64 yr				
Males	50	3861 (3486, 4236)	100	84 (71, 93)
Females	58	2780 (2418, 3142)	83 (73, 98)	55 (42, 68)

¹ As determined by 24 hr urine sample.

² Suggested Dietary Target is 1600 mg/day.

³ Tolerable Upper Limit is 2300 mg/day.

Discussion

The median UIC of this sample of New Zealand adults was 73 µg/L, which falls within the range 50-99 µg/L indicative of mild iodine deficiency³. The median UIC in the current study was significantly higher than the median UIC of 53 µg/L reported in the 2008/09 Adult Nutrition Survey, and demonstrates that there has been an increase in iodine intakes in New Zealand adults between 2008/09 (i.e. pre-fortification) and 2012 (i.e. post-fortification). It is important to note that the cutoffs for UIC used to categorise populations as iodine deficient (i.e. median UIC <100 µg/L) and iodine sufficient (i.e. median UIC >100 µg/L) have been validated in casual or spot urine samples obtained from schoolchildren with an average urine volume of 1.0 L. As there are no validated cut-offs for UIC to assess iodine deficiency in adults, the cut-offs for schoolchildren are often used in older age groups. However, in adolescents and adults the mean urine volume is assumed to be 1.5 L and in this study, the mean urine volume was 2.0 L. The higher urine volume in adults is important because this will dilute the absolute concentration of

iodine in urine and decrease UIC. This issue was addressed in a recent paper by Zimmermann and Andersson, who suggest that a median UIC of 60-70 µg/L would indicate adequate iodine status in adults ⁴³. Based on this value, the median UIC of all groups assessed in this study indicates adequate iodine status. Currently there are studies being conducted in Switzerland to validate cutoffs for median UIC in adults ⁴³.

An advantage of this study was the collection of 24hr urine samples which allows the determination of both iodine and sodium excretion. Approximately 90% of dietary iodine is excreted in the urine, thus 24hr iodine excretion, sometimes referred to as Urinary Iodine Excretion or UIE, is a good estimate of daily iodine intake. Indeed, the difficulty in quantifying the contribution of iodised salt used in cooking and at the table to total dietary iodine intakes means that 24hr iodine excretion is likely to be a more accurate estimate of iodine intake than dietary methods such as diet records and diet recalls. The (geometric) mean 24hr iodine excretion was 124 µg/day. The EAR is typically used as a "yardstick to determine the adequacy of nutrient intakes" ⁴⁴. In this study the proportion of adults who had a 24hr iodine excretion less than the EAR was 32%. Approximately a fifth (i.e. 22%) of males 45-64 yr had an iodine intake below the EAR while almost half (i.e. 49%) of females 18-24yr had an iodine intake below the EAR. These figures are likely to overestimate the proportion as there was no adjustment for intra-individual variation as only one 24hr urine sample was collected from each participant and only 90% of dietary iodine is excreted in the urine.

The primary change in the New Zealand diet that has occurred between 2008/09 and 2012 with regard to iodine is the mandatory fortification of bread with iodised salt, therefore, the increase in the median UIC between 2008/09 and 2012 indicates that this government initiative has increased iodine intakes in New Zealand adults. However, the voluntary use of iodised salt in other processed foods is still permitted and there are anecdotal reports that other processed foods now have iodised salt added to them, which may have also contributed to the increase in iodine intakes observed here. Furthermore, changes in dietary patterns, for instance an increase in the consumption of seafood such as sushi, could also be a contributing factor. Males did have a higher UIC and 24hr iodine excretion than females, which is not surprising as men are likely to eat more foods containing iodine due to their higher energy intakes (11.4 vs 10.6 MJ) ⁴⁴.

Furthermore, as a proportion of total energy intake, men also have a higher intake of bread than women (17.8% vs 16.5%), and most of this bread would be fortified with iodised salt. In this study, males consumed on average 2.8 serves of iodine-fortified bread per day, while females consumed 2 serves per day. There was no correlation between those participants who used iodised salt or non-iodised salt, however, as stated previously, it is difficult to quantify the contribution of iodised salt, particularly that used in cooking, to iodine intakes. Overall, the proportion of the participants with a high UIC (i.e. >300 µg/L) was low, demonstrating that the increase in iodine intakes in the population has not been excessive.

The sodium excretion data indicate that the majority (76%) of New Zealand adults consume sodium that is in excess of current dietary guidelines. Since 90% of sodium consumed is excreted in the urine, this is likely to be an underestimate of actual intake. These estimates are consistent with previous population surveys in New Zealand indicating the ongoing need for intervention to lower population sodium intake^{45, 46}. It was of interest to note that sodium and iodine excretion was highly correlated. This suggests that sodium intake is a strong predictor of iodine intake, hence any measures that are taken to decrease sodium intake in the population must consider the impact on dietary iodine intakes.

Strengths and Limitations

A strength of this study was the collection of 24hr urine samples that enabled an objective and more accurate estimate of iodine and sodium intakes. By comparison, the determination of the iodine and sodium content of the diet using dietary assessment methods is problematic for a number of reasons. Firstly, the interpretation of a “sprinkle” or “pinch” of salt varies from person to person. Secondly, salt can be added to food in many ways (e.g. using one’s hand, salt grinders or shakers that dispense salt in different amounts. Thirdly, if food intake is being weighed such as with a weighed diet record, the amount of salt used at the table may be less than a gram, and the weighing scales may not be sensitive enough to measure this quantity, hence it might be recorded as nil (i.e. 0) grams. Finally, when salt is added to cooking, particularly to water used for cooking vegetables or pasta, the amount that becomes incorporated into the cooked food is unknown⁴⁷.

Another strength of this study was the use of the electoral roll to collect a representative sample of the New Zealand adult population. Oversampling of Māori and Pacific people was not undertaken due to limited resources, consequently ethnic-specific comparisons cannot be reported. The use of the electoral roll does not capture those not registered on the roll and highly mobile New Zealanders who are less likely to update their entry on a regular basis. This is reflected in the relatively high number of invitations returned (i.e. not at address), and probably many of those who did not respond to our letters and postcards. In order to reach our sample size of 300 participants, particularly in the younger age groups, 50 (17%) subjects were recruited using a snowballing or "word of mouth" technique. The use of snowball sampling did not introduce selection bias, as there was not a significant difference in iodine and sodium excretion between those recruited by snowball sampling compared to those recruited from the electoral roll.

The biggest limitation of this study is the lack of validated cut-offs to assess iodine status in adults, for either spot or 24hr urine samples. The cut-offs for UIC currently used to categorise populations as iodine deficient have been validated in spot urine samples obtained from schoolchildren with an average urine volume of 1L. Care must be taken when interpreting the iodine status of adults using UIC determined from a 24hr urine sample with a urine volume >1L, because dilution will lower UIC. The use of 24hr iodine excretion may be a better index of the true iodine status in adults. Cut-offs to assess iodine status in adults are currently being established by ICCIDD and should be available within the next 12 months.

Another limitation of the study was the low response rate of 23%, which may introduce bias. Response rates in population surveys of 24hr urine collection in other countries are variable with relatively low rates reported in Switzerland (10%) and Spain (25%), while a representative survey in the United Kingdom in 2005/06 reported a response rate of 43%⁴⁸. In this study, both iodine and sodium excretion was not significantly associated with age or education. Previous estimates of sodium excretion based on spot urine samples indicate that sodium excretion was not significantly associated with socioeconomic status or ethnicity²⁹. Similarly, UIC was not significantly associated with socioeconomic status in the 2008/09 Adult

Nutrition Survey but there were ethnic differences, with Pacific people having a higher UIC than NZEO⁴⁴.

Conclusions

In conclusion, this study found that the median UIC of New Zealand adults had increased since the introduction of the mandatory fortification of bread with iodised salt in 2009. The current study is supported by the recent finding that iodine intakes of New Zealand schoolchildren have also increased, with these children now categorised as having adequate iodine status¹⁹. It is also important to note that New Zealanders who do not eat commercial bread and bread products or who eat organic breads will not benefit from mandatory fortification. Given current initiatives aimed at decreasing the sodium content (and consequently iodised salt) of bread, it is important that continuing surveillance be undertaken to assess both the sodium and iodine status of the New Zealand population.

List of Abbreviations

CI: Confidence Interval; CV: coefficient of variation; ICCIDD: International Committee for the Control of Iodine Deficiency Disorders; NZEO: New Zealand European and Other Ethnicities; UIC: urinary iodine concentration; UNICEF: United Nations Children's Fund; WHO: World Health Organization; yr: year.

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