Assessment of pre-fortification iodine status by ICPMS in the West Australian population

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Re-emergence of iodine deficiency in Australia

- Published evidence shows that the consumption of iodine is declining in Australia (similar in US)
  - *Eastman et al; Asia Pac J Clin Nutr (2001)*
- UIE from schoolchildren, healthy adults, pregnant women, diabetics in the Sydney area
- Results showed that all 4 study groups had median UIE below 100 ug/L
- Reduced Iodine levels in milk, <10% of the population use iodised salt.
The Network for Sustained Elimination of Iodine Deficiency pledges full collaboration to accelerate the progress in every country toward universal salt iodization where needed, and to ensure that adequate iodine nutrition will be sustained.
Mandatory Iodine Fortification

- Food Standards Australia New Zealand (FSANZ) regulation – July 2009
- To help address the re-emergence of iodine deficiency across most of the population
- Replacement of non-iodised salt with iodised salt in all bread, except organic bread, from October 2009
- Studied pre-fortification iodine levels in three West Australian populations
Iodine

- Iodine is an essential trace element found in soil and water.
- Primary function of iodine in the human body is the synthesis of thyroid hormones.
- Thyroid hormones are required for:
  - Growth
  - Organ development, especially brain
  - Metabolism (utilization of nutrients by body)
Iodine in thyroid Hormones

- Approximately 80µg of Iodine intake needed daily
- Only partially taken up by thyroid
- Rapidly excreted in the urine
How much iodine do we need?

- Most adults require 150 ug per day
- Pregnant (220 ug/day) and Breastfeeding (270 ug/day) women need more because they provide all of the baby’s iodine
- 90 ug for pre-school children (0-5 yrs)
- 120 ug for school children (5-12 yrs)

From WHO/UNICEF/ICCIDD (2001)
## Iodine content of various foods

<table>
<thead>
<tr>
<th>Food</th>
<th>μg of iodine per 100 grams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bread (with added iodised salt)</td>
<td>3 (46)</td>
</tr>
<tr>
<td>Apple, Oranges, Grapes, Bananas</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>Beef, Pork, Lamb</td>
<td>&lt;1.5</td>
</tr>
<tr>
<td>Sushi (containing seaweed)</td>
<td>92</td>
</tr>
<tr>
<td>Oysters</td>
<td>160</td>
</tr>
</tbody>
</table>
Iodine Status

- Random spot UI concentration (µg/L) is the International accepted criteria for assessing and monitoring the iodine status of a population (not individuals).
- WHO uses the following criteria for characterising populations:
  - Median values (skewed distribution)
  - UI < 25 µg/L is severely deficient
  - UI 25-50 µg/L is moderately deficient
  - UI 51-100 µg/L is mildly deficient
  - UI > 100 µg/L is adequate
  - Levels greater than 300 have increased risks of adverse health consequences such as iodine induced hyperthyroidism, autoimmune thyroid disease.
WHO Recommendations

- Populations as a whole should have median levels >100ug/L and less than 20% with values below 50ug/L
- Pregnancy should have median levels >150ug/L
- UI/creatinine ratio may be more reliable because it takes into account state of hydration, however:
  - No WHO recommendations
  - Cumbersome, expensive, unnecessary
  - Unreliable in populations with low protein intake
    i.e. dietary dependant
Adequate Iodine Intake

Daily Intake 150µg

35% uptake
55 µg

Requirement 80µg

Body Iodine Stores Normal

Recycling 65µg

55 + 25 = 80 µg
80µg required/provided

95 µg

40 µg

Urine Excretion 135µg
Inadequate Iodine Intake

Daily Intake 70µg

50% uptake
35 µg

Requirement 80µg

Body Iodine Stores low

Recycling 65µg

33µg

Upgrade iodide trapping mechanisms

35 + 33 = 68 µg
12<<missing>>µg

Iodine stores progressively depleted

Adaption of lowering urinary loss

Urine Excretion 67µg
Inadequate Iodine Intake – In Pregnancy

Daily Intake 70µg

60% uptake
42µg

Requirement 120µg

Body Iodine
Stores very low

28 µg

62 µg

Recycling 104µg

42 µg

42 + 62 = 104 µg
16 ⇠<sup>missing</sup> µg

Urine Excretion 70µg
Adaptation to inadequate iodine in pregnancy

Depletion of thyroid iodine stores
Excessive thyroid stimulation
Goitre - Increase in thyroid size in both mother and newborn

Foetal Iodine Deficiency
Higher incidence of abortions, still births and congenital anomalies
Neonate has retarded mental and physical development
Spectrum of Iodine Deficiency Disorders (IDD)

Foetus
- Abortions
- Stillbirths
- Congenital anomalies
- Neurological cretinism:
  - mental deficiency
  - deaf mutism, spastic diplegia, squint
- Hypothyroid cretinism:
  - mental deficiency, dwarfism, hypothyroidism
- Psychomotor defects

Neonate
- Increased perinatal mortality
- Neonatal hypothyroidism
- Retarded mental and physical development

Child and Adolescent
- Increased infant mortality
- Retarded mental and physical development

Adult
- Goitre with its complications
- Iodine induced hyperthyroidism (IIH)

All Ages
- Goitre
- Hypothyroidism
- Impaired mental function
- Increased susceptibility to nuclear radiation

"Iodine deficiency is the leading cause of preventable mental retardation"

Methods for Urine Iodine

- Colorimetric (Sandell/Koltkoff method - urine is first acid digested under mild conditions and iodide determined from its catalytic reduction of cerium in the presence of arsenic acid)
  - Well established but prone to interferences (thiocyanate)
- ICP-MS is the reference method, more precise, lower detection limits
- Iodine is mono-isotopic at m/z 126.9
The measurement of Urine Iodine

Use of ICPMS to measure Urinary Iodine in NHANES 2000: Comparison with previous method, *Clin Chem*, 49, No.6, 2003, pg 1019-1021

\[ n = 96 \]
\[ \text{Intercept} = -19 \text{ ug/L} \]
\[ \text{Slope} = 1.0655 \]
\[ r^2 = 0.980 \]

Values <250ug/L, SK method was 3-16ug/L higher
ICP-MS

- **Iodine** normally exists as **iodide** in nature, however other common forms include **iodate** and **molecular iodine**.
  - Iodide, in the presence of acid, will form molecular iodine. Molecular iodine will cause memory effects and background problems due to its adsorption onto glass.
- Consequently, total iodine by ICPMS is best performed in dilute base such as tetramethylammonium hydroxide (TMAOH).
ICP-MS

- Sample diluent – 0.1% TMAOH, 0.01% triton X, I.S.
- $I^+$, $In^+$, $Tb^+$ ions measured at 127, 115 and 159 respectively
- Standards – AR reagents, 1000 mg/L
- UTAK Iodine Controls – blank (20ug) and Spiked (200ug)
- Varian 820MS
- RF power – 1.4 kW
- Dwell time – 20 ms, 25 scans/replicate, 5 replicates/sample
- Nebuliser gas flow – 1.0 L/min
In 2001 the CDC established the EQUIP program (Ensuring the Quality of Iodine Procedures) – no cost

- Standardization program to help labs worldwide with iodine analysis, technical support
- More than 77 labs in 47 countries
- 3-5 urine samples three times a year
## EQUIP

**Round 23 : August 2009**

<table>
<thead>
<tr>
<th>Mean</th>
<th>Sandell-Kolthoff Reaction</th>
<th>ICP-MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>53.9%</td>
<td>6.2%</td>
</tr>
<tr>
<td>75</td>
<td>18.8%</td>
<td>2.3%</td>
</tr>
<tr>
<td>200</td>
<td>14.8%</td>
<td>2.8%</td>
</tr>
<tr>
<td>440</td>
<td>3.5%</td>
<td>3.1%</td>
</tr>
</tbody>
</table>
Iodine Study

- **AIM:**
  - To assess the iodine status in Western Australian population including pregnant women and the impact of iodine fortification.

- **METHOD:**
  - Urine samples from three different populations in July/August 2009: pregnant women attending for urine microscopy and culture, patients who had Fasting Metabolic Bone Study and diabetic patients who had urine albumin/creatinine.

- **FOLLOW-UP:**
  - Urine from March/April 2010 after universal salt iodisation will be collected and analysed for post fortification urine iodine.
Iodine in Pregnancy (WA)

- Maternal iodine status in 327 pregnant women
- Skewed distribution
- Median = 181ug/L
- [WHO rec >150]
Pregnant 1\textsuperscript{st} trimester

327 women

<table>
<thead>
<tr>
<th></th>
<th>Perth</th>
<th>WHO Recommend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median urine iodine</td>
<td>181 µg/L</td>
<td>&gt;150 µg/L</td>
</tr>
<tr>
<td>Insufficient &lt;150 µg/L</td>
<td>42%</td>
<td></td>
</tr>
<tr>
<td>Deficient &lt;50 µg/L</td>
<td>11%</td>
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</tbody>
</table>

11% are iodine deficient
## Bone Metabolism Studies

**105 men and women**

<table>
<thead>
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<th>Perth</th>
<th>WHO Recommend</th>
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<tr>
<td><strong>Median urine iodine</strong></td>
<td>105 µg/L</td>
<td>&gt;100 µg/L</td>
</tr>
<tr>
<td>Insufficient</td>
<td>48%</td>
<td></td>
</tr>
<tr>
<td>&lt;100 µg/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deficient</td>
<td>19%</td>
<td>&lt;20%</td>
</tr>
<tr>
<td>&lt;50 µg/L</td>
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</tbody>
</table>

**Borderline iodine sufficient**
## Diabetics Type 2

**132 men and women**

<table>
<thead>
<tr>
<th></th>
<th>Perth</th>
<th>WHO Recommend</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Median urine iodine</strong></td>
<td>142 µg/L</td>
<td>&gt;100 µg/L</td>
</tr>
<tr>
<td><strong>Insufficient</strong></td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>&lt;100 µg/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Deficient</strong></td>
<td>8%</td>
<td>&lt;20%</td>
</tr>
<tr>
<td>&lt;50 µg/L</td>
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**Iodine sufficient**
Conclusions

- Speed and accuracy of ICP-MS ideal for iodine population studies
- Pre-fortification study of pregnant women shows 11% are iodine deficient – offspring at risk of a spectrum of Iodine Deficiency Disorders
- Study to be repeated 6 months post iodine fortification