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Iodine nutrition in Europe & iodine bioavailability

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1993

110 countries iodine deficient
12% of the global population with goiter

WHO, Global prevalence of IDD, 1993
Iodine an essential component for thyroid hormone production

Iodine deficiency (ID) has multiple adverse effects on health: ‘iodine-deficiency disorders’
Daily iodine intakes

Adults

<table>
<thead>
<tr>
<th>Average daily iodine intake (µg/d)</th>
<th>Risk of inadequacy</th>
<th>Risk of excess</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.0</td>
<td>0.0</td>
</tr>
<tr>
<td>95</td>
<td>0.5</td>
<td>0.0</td>
</tr>
<tr>
<td>150</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>450</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>600-1100</td>
<td>0.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

- **EAR**: Estimated Average Requirement
- **RDA**: Recommended Dietary Allowance
Adequate iodine intake

Iodine sufficiency

Positive iodine balance

↑ thyroidal iodine clearance

Thyroid dysfunction

↑ thyroid volume, ↑ Tg

↑ TSH

↓ thyroid hormone

Inadequate iodine intake

Iodine deficiency

Decreasing habitual daily iodine intake

Increasing thyroidal iodine stores
Daily iodine intakes

Adults

Average daily iodine intake (µg/d)

Risk of inadequacy

Risk of excess

0  95  150  450  600-1100

0.0  0.2  0.5  1.0

EAR  RDA  Excess intake  Upper level

Risk of inadequacy

Risk of excess

0  95  150  450  600-1100

0.0  0.2  0.5  1.0
Dietary sources

- Native iodine content of most foods & beverages is low:
  3-80 µg per serving

- Major sources:
  - Bread
  - Milk & dairy products
# Dietary sources

<table>
<thead>
<tr>
<th>Food Type</th>
<th>µg/100 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dried kelp</td>
<td>27000</td>
</tr>
<tr>
<td>Seaweed/grass</td>
<td>3900</td>
</tr>
<tr>
<td>Fish, marine</td>
<td>49</td>
</tr>
<tr>
<td>Fish, freshwater</td>
<td>10</td>
</tr>
<tr>
<td>Meat</td>
<td>2</td>
</tr>
<tr>
<td><strong>Milk</strong></td>
<td><strong>12</strong></td>
</tr>
<tr>
<td><strong>Bread</strong></td>
<td><strong>31</strong></td>
</tr>
<tr>
<td>Vegetables</td>
<td>0.5</td>
</tr>
<tr>
<td>Fruits</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Iodine contents in foods are largely dependent on:
- Iodine content of the soil
- Distance to the sea
- Animal husbandry practices
Daily iodine intakes

Adults

Average daily iodine intake (µg/d)

Risk of inadequacy

Risk of excess

0 95 150 450 600-1100

EAR

RDI

Excess intake

Upper level

Risk of inadequacy:

- 1.0 (Risk of inadequacy)
- 0.5 (Risk of inadequacy)
- 0.0 (Risk of inadequacy)

Risk of excess:

- 1.0 (Risk of excess)
- 0.5 (Risk of excess)
- 0.0 (Risk of excess)
Universal salt iodization

KI or KIO$_3$
20-40 mg I/kg salt
Household coverage of iodized salt
128 countries

UNICEF, Child Info Database, 2012
Household coverage of iodized salt
128 countries

Iodized salt is available in households of 71% of the global population, up from 20% in 1990

UNICEF, Child Info Database, 2012
Monitoring of iodine status

Urinary iodine concentration (UIC)

Spot sample
3 ml

1. Reflect iodine intake

2. Sensitive indicator of recent changes in iodine intake  
   WHO, 2007

3. Easy to collect and more objective

4. Spectrophotometric method:
   - Sandell-Kolthoff reaction
   - Sample volume: 250 μL  
   Pino et al., Clin Chem, 1996

5. Population indicator:
   - Intra and inter individual variation (35%)
   - n > 500  
   Andersen et al., Br J Nutr, 2008
Global estimate of iodine status

UIC data


References:
Andersson et al., WHO Bull, 2005
De Benoist et al., Food Nutr Bull, 2008
Andersson et al., J Nutr, 2012
Global estimate of iodine status

Data sources

- WHO VMNIS database (WHO website)
- ICCIDD, UNICEF, national sources
- Systematic literature review

Inclusion criteria for each country:

UIC surveys following WHO criteria:

- The most recent national survey (subnational)
- Data from school-age children
- Cross-sectional population-based
- Standard UIC assay techniques
Global estimate of iodine status

Key data for each country:

- **Median UIC**
  - Define overall iodine status

- **% UIC < 100 μg/L**
  - Prevalence of inadequate intakes

- **% UIC < 20 μg/L, 20-49 μg/L, 50-99 μg/L**
  - Prevalence of mild, moderate and severe deficiency

WHO, 2007
UIC surveys cover 97% of all children worldwide

Proportion of school-age children covered by national and subnational data by WHO region, 2012

150 countries
National data: 117
Subnational data: 33
(India, Russia, Argentina, Italy, Spain)

97% national coverage
32% subnational coverage
64% overall coverage

AFR  AMR  EMR  EUR  SEAR  WPR  Global
UIC surveys cover 97% of all children worldwide

Proportion of school-age children covered by national and subnational data by WHO region, 2012

<table>
<thead>
<tr>
<th>Region</th>
<th>National</th>
<th>Subnational</th>
<th>No data</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AMR</td>
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<tr>
<td>EMR</td>
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<tr>
<td>EUR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEAR</td>
<td></td>
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<td></td>
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<tr>
<td>WPR</td>
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<td></td>
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<tr>
<td>Global</td>
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</tbody>
</table>
32 countries are still iodine deficient

Progress 2003-2012
Number of countries with iodine deficiency

Number of countries

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>54</td>
</tr>
<tr>
<td>2007</td>
<td>47</td>
</tr>
<tr>
<td>2012</td>
<td>32</td>
</tr>
</tbody>
</table>
Progress 2003-2012
Number of school-age children with inadequate intakes

Only \(\frac{1}{4}\) are in ‘iodine deficient’ countries

<table>
<thead>
<tr>
<th>Year</th>
<th>Millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>285</td>
</tr>
<tr>
<td>2007</td>
<td>266</td>
</tr>
<tr>
<td>2012</td>
<td>246</td>
</tr>
</tbody>
</table>

Percentage:
- 2003: 36.5%
- 2007: 31.5%
- 2012: 30.0%
Prevalence of inadequate iodine intake in school children, by WHO region, 2012

Proportion (%)

AFR  AMR  EMR  EUR  SEAR  WPR  Global

Mild  Moderate  Severe

16%  8%  5%
11 countries are still iodine deficient

- Mild, n=11
- Adequate, n=29
- High, n=6
- Excessive, n=2
- No data, n=5
- Subnational data
Most of the children with insufficient iodine intakes are living in countries with median UIC > 100 µg/L

<table>
<thead>
<tr>
<th>EUR</th>
<th>Insufficient iodine intake (UI &lt; 100 µg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. countries</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>23</td>
</tr>
<tr>
<td>2007</td>
<td>19</td>
</tr>
<tr>
<td>2012</td>
<td>11</td>
</tr>
</tbody>
</table>

Only 13.9 million (46%) live in **iodine deficient countries**
Why is iodine deficiency still present in Europe?

Salt intake in the European population:
> 75% from processed foods
< 25% from household salt

Much of the salt used in food production
-> is not iodized
Decreasing iodine intake in German 6-12 y old children

Johner et al., Br J Nutr, 2011
Decreasing iodine intake can be attributed to the low use of iodized salt in processed foods.

<table>
<thead>
<tr>
<th>Food</th>
<th>CONTRIBUTION (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt</td>
<td>48.4%</td>
</tr>
<tr>
<td>Milk</td>
<td>37.9%</td>
</tr>
<tr>
<td>Meat</td>
<td>5.4%</td>
</tr>
<tr>
<td>Eggs</td>
<td>4.8%</td>
</tr>
<tr>
<td>Fish</td>
<td>3.4%</td>
</tr>
</tbody>
</table>

Johner et al., Br J Nutr, 2011
Salt intake in the European population:
> 75% from processed foods
< 25% from household salt

Much of the salt used in food production
- > is not iodized

Dietary salt reduction initiatives to reduce the risk of coronary heart disease:
- Salt iodine levels to be adapted
Alternative intervention strategies:

- Iodized salt in bread (DK, NL, AUS, NZ)
- Iodized cooking oil (Rumania)
- Iodized mineral water (Poland)

Iodine supplementation to vulnerable population groups:

- Pregnant women
Iodine bioavailability

Iodine in foods

- Iodide: $\text{I}^-$
- Iodate: $\text{IO}_3^-$
- Protein bound
Iodine bioavailability

The Na+/I-symporter present in the intestine:

- Active iodide uptake?
- Passive diffusion

Nicola et al., Am J Physiol Cell Physiol, 2009
Iodine bioavailability

- 8-day balance study
- n=12 adults,
- Marginal iodine status
- Controlled diet
- Salt (KI)
- Dose response

Nath et al., Internat J vit Nutr Res, 1991
Iodine bioavailability

- 9-day balance study x 2 periods
- n=12 women, adequate iodine status

- Controlled diet:
  - Mean iodine intake: **202 µg/d** (solid and fluid)
  - Iodine excretion:
    - 89% urine (**171 µg/d**)
    - 11% faeces (20 µg/d)

No difference for milk content

Johreis *et al.*, Exp Clin Endocrinol Diab, 2001
Nutrients and food components interacting with thyroid metabolism

- **Iron deficiency** (Zimmermann, Ann Rev Nutr, 2006)
- **Vitamin A deficiency** (Zimmermann, JCEM, 2004)
- **Selenium deficiency** (Schomburg & Köhrle, Mol Nutr Food Res, 2008; Duntas, JCEM, 2010)
- **Environmental pollutants** (Pearce & Bravemann, Best Prac Res Clin Endo Metab, 2009)
- **Goitrogens** (Hurrell, EJCN, 1997)
Conclusion

- Mild iodine deficiency still a public health problem
- The native iodine content of foods is low
- Iodine bioavailability is high
- Close interaction with other nutrients and food components
Biofortification?