Network for Sustained Elimination of Iodine Deficiency

A Presentation on Iodine and Pregnancy

This piece on Iodine and Pregnancy can also be found on the website of the Network for Sustained Elimination of Iodine Deficiency (http://www.IodinePartnership.net) in the “What’s New” section.
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A little theory first:

An *Adequate Intake (AI)* level is based on clinical research results or by determining the average amount of intake for a particular nutrient in a healthy population. Although the AI is more subjective than the Recommended Daily Allowance, it can be used as a goal for intake levels.

The *Recommended Daily Allowance (RDA)* is the average daily dietary intake level that is sufficient to meet the nutrient requirement of virtually all healthy individuals in a particular age range and gender group.

The *Estimated Average Requirement (EAR)* is the daily intake that meets the typical requirement of the average individual in a specific age range and gender group.

A RDA cannot be set without first establishing an EAR. While many clinical and population-based studies are analyzed in establishing an EAR, the establishment of a RDA from an EAR is strictly a mathematical process ([click the link for details](#)). If the requirement for a nutrient is normally distributed for a particular population and we know the standard deviation of the EAR, then we arrive at the RDA by adding 2 standard deviations to the actual value of the EAR. In the case that the standard deviation is not known, the variation in the requirement for the nutrient across a population is taken into account by using a coefficient of variation equal to 10% ([see details](#)).

For children, the EAR, and consequently the RDA, are often extrapolated from levels set for adults. This is because there are few nutritional requirement studies that involve children. When an EAR cannot be established, an AI level is determined without the exact knowledge of what the requirement is for a particular age range and gender group. Establishment of an AI therefore involves a more subjective assumption than the establishment of a RDA.

The advantages of being able to establish a RDA (instead of an AI) are that:

1. The RDA is founded on a much greater amount of clinical and population-based research than the AI.

2. The RDA takes into account the variation in the requirement for a nutrient across a population (for a particular age range and gender group), while the AI does not.

By taking into account the variation in the nutritional requirement across a population, a recommended level of intake can be set that will supply 97% - 98% of people with the nutrient level that they need to stay healthy, while exposing virtually no one to potentially harmful amounts of the particular nutrient.

The *Tolerable Upper Intake Level (UL)* is the highest level of daily intake of a nutrient that is likely to pose no health risk for almost all individuals in a particular age range and gender group. It is the intake level above which undesirable effects may occur from the intake of the nutrient in question.
The figure below shows the relationship between the EAR, RDA, and the UL:

![Graph showing EAR, RDA, and UL](image)

FIGURE 1-1 Dietary reference intakes. This figure shows that the Estimated Average Requirement (EAR) is the intake at which the risk of inadequacy is 0.5 (50 percent) to an individual. The Recommended Dietary Allowance (RDA) is the intake at which the risk of inadequacy is very small—only 0.02 to 0.03 (2 to 3 percent). The Adequate Intake (AI) does not bear a consistent relationship to the EAR or the RDA because it is set without being able to estimate the requirement. At intakes between the RDA and the Tolerable Upper Intake Level (UL), the risks of inadequacy and of excess are both close to 0. At intakes above the UL, the risk of adverse effects may increase.

(Food and Nutrition Board, Institute of Medicine, 2002)

And now to practice: Iodine recommendations

Sufficient iodine intake by the pregnant woman is vital for her health and for the optimal development of the fetus, particularly the fetal brain.

Based on body weight, infants require more iodine (as thyroid hormone) than any other age group. The newborn thyroid turns over 100% of the iodine it takes in every day. The needs of the developing fetus are proportionally as great as, if not greater than, that of the newborn infant.
The table below describes the recommendations for the iodine intake published by the U.S. Institute of Medicine (2002):

<table>
<thead>
<tr>
<th>Age Group</th>
<th>AI (mcg/day)</th>
<th>EAR (mcg/day)</th>
<th>RDA (mcg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 6 months</td>
<td>110</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>7 – 12 months</td>
<td>130</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>1 – 8 years</td>
<td>--</td>
<td>65</td>
<td>90</td>
</tr>
<tr>
<td>9 – 13 years</td>
<td>--</td>
<td>73</td>
<td>120</td>
</tr>
<tr>
<td>14 – 18 years</td>
<td>--</td>
<td>95</td>
<td>150</td>
</tr>
<tr>
<td>Men 19+ years</td>
<td>--</td>
<td>95</td>
<td>150</td>
</tr>
<tr>
<td>Women 19+ years</td>
<td>--</td>
<td>95</td>
<td>150</td>
</tr>
<tr>
<td>Pregnant</td>
<td>--</td>
<td>160</td>
<td>220</td>
</tr>
<tr>
<td>Lactating</td>
<td>--</td>
<td>209</td>
<td>290</td>
</tr>
</tbody>
</table>

Except for women who are breastfeeding, pregnant women have the greatest need for iodine. When the EAR of non-pregnant women (95 mcg/day) is added to the estimated iodine uptake of the fetal thyroid gland (approx 75 mcg/day max), the total is 170 mcg/day. If in addition, we consider that women when pregnant lose considerably more iodine through the urine than non-pregnant women, it would seem logical that pregnant women would require more than 170 mcg/day. However, one study published in 1966 showed that pregnant women had biochemically balanced iodine status when they were consuming 160 mcg/day, and the experts of IOM accepted that value for the estimated average requirement.

Lactating women need to consume iodine sufficient to meet the needs for themselves and the nursing infant, and this explains why they have the highest need of iodine.

In 1996, the World Health Organization convened a group of experts to recommend safe, effective levels of iodine for use in universal iodization of food-grade salt. In the context of that meeting, recommended daily dietary iodine intake requirements were stated as follows:

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Intake (mcg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 12 months</td>
<td>50</td>
</tr>
<tr>
<td>2 – 6 years</td>
<td>90</td>
</tr>
<tr>
<td>7 – 12 years</td>
<td>120</td>
</tr>
<tr>
<td>12+ years</td>
<td>150</td>
</tr>
<tr>
<td>Pregnant or Lactating</td>
<td>200</td>
</tr>
</tbody>
</table>

It is noteworthy that the recommended intake for pregnant women by the two expert groups do not differ significantly.
References:


Currently, the iodine nutrition status of a population is often approximated by special surveys of school children. Although it may be relatively convenient to measure goiter and collect urine samples among children in schools, the results from assessments among school children will not always be representative of the iodine nutrition status of other groups in the population.

The developing brain of the fetus is most susceptible to low iodine intake, and pregnant women have the second greatest need for iodine (lactating women have the greatest need for iodine). In population studies, it would therefore seem appropriate to focus the data collection efforts on pregnant women in order to ensure optimal protection from iodine nutrition in the developing fetus.

The recommended cut-off level for adequate urinary iodine excretion of 100 mcg/l of urine, while perhaps appropriate for children (RDA for iodine for ages 1 - 8 is 90 mcg/day, and 120 mcg/day for ages 9-13), is likely too low for pregnant women (RDA for iodine during pregnancy is 200-220 mcg/day).

Studies from countries and regions of countries once thought to be iodine sufficient are now starting to show that, even in the most industrialized parts of the world, there is more work to be done to eliminate iodine deficiency disorders in a meaningful and sustainable manner. The following paragraphs highlight some selected findings of recent studies to underscore the need to enhance our efforts in evaluating the iodine status of populations and protect the brains of each next generation of children.

**Recent surveys of iodine status**

In 1998 in Switzerland, Zimmermann et al. reported evidence that the urinary iodine excretions in school children (96 mcg/l) and pregnant women (100 mcg/g creatinine) were falling below optimal. In response, the Swiss government increased the mandated table salt iodization level from 15 to 20 mg/kg. A proportionate to population size survey in 2001 by Hess et al. showed that the increase in household salt iodine content improved the urinary iodine excretions among pregnant women (138 mcg/l, 207 mcg/g creatinine) and school children (115 mcg/l). The study by Hess et al. was planned as the first of a series of regular surveys of the iodine nutrition status in Switzerland.

In the United States, Hollowell et al. (1998) saw a dramatic decrease in urinary iodine excretions between the National Health and Nutrition Examination Surveys I and III (1971 - 1974 and 1988 - 1994, respectively). In a nation where salt iodization is voluntary (100 mg KI/kg salt), where two-thirds of the table salt purchased at the household level is iodized, and the vast majority of the food industry does not use iodized salt, the median urinary iodine level fell from 320 mcg/l during 1971 - 1974 (293 mcg/g creatinine) to 145 mcg/l during 1988 - 1994 (125 mcg/g creatinine). The median urinary iodine level for pregnant women also fell from 327 mcg/l during 1971 - 1974 (373 mcg/g creatinine) to 141 mcg/l during 1988 - 1994 (132 mcg/g creatinine). Women of child-bearing age had an urinary iodine level of 293 mcg/l during 1971 - 1974 (284 mcg/g creatinine), while during 1988 - 1994 they had an urinary iodine level of 127 mcg/l (112 mcg/g creatinine).
A law in Macedonia dating from 1956 mandated that iodized salt should contain 10 mg potassium iodide per kg (7 mcg iodine/kg). Surveys during 1995-1999 showed that the median urinary iodine among school children in various districts of the country varied between 100 and 115 mcg/l and that the goiter rate among school children was not falling below levels of public health concern. An amendment to the law was put in place by late 1999, which required 20 - 30 mg of iodine per kg in all food-grade salt, including salt used in industrial food manufacturing. Two national surveys after the new regulation have been conducted, showing a median urinary iodine in 8-10 year-old school children of 155-165 mcg/l, and a median urinary iodine among pregnant women of 141 mcg/l.

In Australia, the combination of facts that only 10% of households use iodized table salt, food industry does not widely use iodized salt in food processing, and a sharp decline in the use of iodine-containing germicidal products in the dairy industry have led to a halving of urinary iodine levels. While a 1993 study (Eastman et al.) showed average urinary iodine levels in excess of 200 mcg/day, a study conducted in 1998 and 1999 (Li et al.) revealed median levels less than 90 mcg/l for pregnant women, school children, and healthy adults.

Based on studies from the 1960s among members of the general population, using goiter as the indicator for iodine deficiency, the eastern region of Hungary was believed to have adequate iodine nutrition. However, a recent study by Mezosi et al. (2000) of pregnant and non-pregnant women in this region showed that the iodine status of pregnant women should be considered separately from that of the general population. Pregnant women who were not consuming iodized salt or supplements had a median urinary iodine level of 57 mcg/l, pregnant women who were consuming iodized salt had a median level of 68 mcg/l, pregnant women not consuming iodized salt but taking a nutritional supplement containing 150 mcg of KI per day had a median level of 130 mcg/l, and pregnant women consuming both iodized salt and iodine supplements had a median level of 115 mcg/l. Non-pregnant women from the general population displayed mild iodine deficiency. Pregnant women in eastern Hungary, unless they were consuming iodine-containing multi-vitamin supplements, were iodine deficient. However, only 55% of women taking an iodine-containing multivitamin supplement had urinary iodine values greater than 100 mcg/l.
Conclusions

Although the spectrum of iodine deficiency disorders in a population includes a range of human illness, the most significant focus for elimination is the damage to the developing brain of the fetus that occurs in pregnancy. It would thus seem more suitable to assess the iodine nutrition of pregnant women in monitoring the effect of universal salt iodization. Pregnant women, who have significantly higher iodine requirements, are often assessed by the standard of iodine status derived from school children. If on this basis adjustments are made in legislation, the national strategy to supply additional iodine to the population may not be optimal in protecting newborns against the brain damage caused by iodine deficiency.

References:

http://www.nap.edu/openbook/0309072794/html/258.html (Chapters 1, 2, and 8)


Karanfilski B. Report: On the implementation of the project "Iodine status of pregnant and breastfeeding women in Macedonia". UNICEF. 2001.


Topic 3: Important Indicators of Iodine Nutrition Status

There are multiple indicators that can be used to measure different aspects of the impact of iodine nutrition on iodine nutrition status. While goiter and urinary iodine have been established as population-scale iodine nutrition evaluation tools, the measurement of thyroid hormone (which has two components: triiodothyronine and thyroxine) and thyroid stimulating hormone (TSH) deserve more attention.

The focus on iodine nutrition is important because iodine is the basic substrate for the production of thyroid hormone, which is essential for body growth, development, and function. In particular, a developing child must receive and eventually produce sufficient thyroid hormone--particularly thyroxine (T4)--to experience normal brain development and function.

The following paragraphs will attempt to explain why maternal T4 and neonatal TSH should, as more direct proxies of brain function, receive increased interest and energy from those involved in monitoring iodine nutrition.

Iodine deficiency affects the composition of thyroid hormone

When an individual is iodine deficient, the proportions of the two components of thyroid hormone, triiodothyronine (T3) and T4, are altered. The thyroid becomes more efficient by increasing the proportion of T3 (which has 3 iodine atoms) relative to T4 (which has 4 iodine atoms) in the thyroid hormone that it secretes.

Relative T4 and T3 requirements in the body

The brain is unique among the body's organs in its requirement of a very high proportion of thyroid hormone to be T4. The following image shows that the brain needs to be supplied with T4 and T3 in an approximately 80%:20% ratio, whereas the liver needs to be supplied in an approximately 20%:80% ratio.
As the fetal brain develops, the types and amounts of the various nuclear thyroid hormone receptors (TRs) change. The presence of these nuclear receptors, which have been detected in human fetuses as early as 8 weeks into gestation, are essential for T3 (the majority of T3 in brain cells is a product of intracellularly deiodinated T4) to induce growth and specification within brain cells (Iskaros et al., Kilby et al.).

Interestingly, while the adult brain still requires T4 to function, the TRs which induce growth and specialization in the developing brain are not present in the adult brain. This underscores the importance of having sufficient T4 present during the critical months of gestation.

Iodine deficiency leads to low levels of T4 in the mother

In conditions of iodine deficiency, the thyroid becomes "efficient", as previously discussed. This leads to low levels of T4 in iodine deficient pregnant women, which has dire consequences for the fetus whose brain development is dependent on sufficient T4 from the mother, especially during the first half of gestation.

The following figure combines a brain development timeline with a schedule for the necessary delivery of T4 across the perinatal period.
The "double whammy"

During the first half of gestation, when the brain is developing in terms of its blood supply (subarachnoid pathways), logical thinking capacity (cerebral cortex), coordination between cerebral hemispheres (corpus callosum), and coordination of bodily movement (striatum), the fetus is dependent on its mother to supply it with T4. Maternal thyroid hormone is also essential for the proper development of the fetal thyroid, which by the 26th week of gestation should already be producing more of its own thyroid hormone than it is receiving from the mother.

However, when the mother cannot supply the developing fetus with sufficient thyroid hormone, or when the fetus cannot properly respond to the thyroid hormone that is supplied, not only is brain development in the first half of gestation stunted, but all subsequent brain development will be severely hindered because the fetus's own thyroid is underdeveloped.

This situation where both the maternal and fetal thyroid fail to supply T4 to the developing brain during gestation is the double whammy.
Maternal T4 and neonatal TSH as iodine status measurement tools

Maternal T4

Given that maternal T4 has been shown to be the essential substrate for fetal brain development (particularly in the first half of gestation), and that Pop et al. (1999) found that the children of women with no thyroid abnormalities, normal TSH, and low first trimester FT4 had a 5.8 times greater risk of having impaired psychomotor development, the consideration of T4 as a screening tool for determining iodine status in pregnancy should be strongly considered.

In a recent literature review (2001), Morreale de Escobar found that the mother's T4 levels, especially during the first trimester, are associated with significant reductions in IQ levels of the progeny on the order of 10 - 15 points, regardless of maternal TSH.

Using maternal TSH alone as an indicator of iodine deficiency in pregnancy can be dangerous because women who have low T4 levels commonly have normal TSH levels by virtue of the fact that their T3 levels are adequate. Morreale de Escobar (2001) calculated that researchers and data collectors are approximately 75 times more likely to be able to detect iodine deficiency by using maternal T4 as an indicator in the first trimester than they are by using maternal TSH, which is commonly measured at the first perinatal doctor's appointment in the second trimester.

Neonatal TSH

The second most vulnerable population to iodine deficiency are newborns (the most vulnerable would be the developing fetus). While the brain is very highly developed at birth, the speed with which the brain can operate (myelination), the ability to form new memories (hippocampus), and the coordination of complex motor functions (cerebellum) undergo the majority of their development in the months following birth.

Perhaps the most sensitive indicator of neonatal iodine status is TSH. Copeland et al. (2002) found that the use of neonatal TSH led to more severe classifications of iodine deficiency than did palpation and ultrasound for goiter in schoolchildren, urinary iodine in schoolchildren, and urinary iodine in mothers in Bangladesh, Guatemala, and the USA.

However, the interpretation of neonatal TSH from umbilical cord blood must be refined due to the presence of a number of complicating factors, which include the sensitivity of the assays that are used to detect TSH, the surge of a complex mixture of hormones related to the stress of birth, and the use of beta-iodine-containing antiseptics at birth.

Conclusions

Though population-based iodine nutrition monitoring methodologies do not include the measurement of maternal T4, this indicator's association to the neurodevelopmental outcome of children should cause it to come to the forefront of attention in the iodine nutrition status monitoring community.
In addition, monitoring neonatal iodine nutrition status is important since the majority of myelination and cerebellum development occur in the months following birth. The interpretation of such a direct measure of neonatal brain function as TSH should be researched and developed for use on a population scale.

References:


A historical perspective

Iodine is a trace nutrient required for the thyroid gland to produce thyroid hormone, which stimulates the development, growth and activity of the tissues of the body. Adults should consume at least 150 mcg/day (click here for more information on daily intake of iodine).

Before the 20th century, significant iodine intake was largely related to the consumption of saltwater products (e.g. fish and seaweed). For example, one study showed that saltwater fish have a mean iodine concentration of 832 mcg/kg, whereas freshwater fish have a mean iodine concentration of 30 mcg/kg. This contrast in iodine content reflects the fact that the oceans are one of the largest reservoirs of iodine.

Over time, the earth's weather patterns have stripped the soils and geological strata of much iodine. The majority of this iodine run-off has collected in the oceans. Because of this, societies that have lived near bodies of saltwater, and consequently had saltwater products as mainstays in their diets, have typically had better iodine nutrition status than populations living inland.

Some iodine is fed back into the soils and surface waters due to rainfall from weather systems that gather their moisture from evaporating seawater. However, this re-supply of iodine is not significant enough to produce a variety of grains, vegetables, fruits, and grazing fauna that are rich in bio-available iodine--even in coastal areas.

Because of our understanding of the importance of iodine nutrition as it relates to human health and intellectual function, and because of the evidence that iodine in many traditional diets is not sufficient, many countries have begun to add iodine (as KIO3, KI, NaI, etc.) to commonly consumed dietary products.
Iodine in the food chain

The dietary intake of iodine can come from multiple sources (Dunn, 1993):

1. Iodized salt
2. Dairy products
3. Fish (specifically saltwater inhabiting fish)
4. Seaweed
5. Grain and cereal products
6. Poultry products
7. Meat
8. Vitamin and mineral preparations
9. Iodine in water and other beverages
10. Iodine in medicines and antiseptics

Though salt iodization has been occurring in a handful of countries since WWII (Canada, Czechoslovakia, Sweden, Switzerland, USA), the World Health Assembly officially adopted salt iodization as the most universal way to promote proper iodine nutrition in 1992. Since that time, the percentage of households using iodized salt has increased from 20% to 70% globally (click here for more information on household use of iodized salt).

Because domestic animals also greatly benefit from the addition of iodine to their diet, the dairy industry supplements its animals with iodine through iodine-fortified feed and iodized salt (added to salt licks, feed, or grazing areas). Iodine also makes its way into dairy products through iodophors (which may be used for equipment sterilization in the dairy industry) and EDDI (ethylenediaminedihydradioiodide; used for the prevention of foot rot in cattle). Supplementing cow fodder has been the primary public health initiative for maintaining healthy iodine nutrition status in Norway. In Denmark and Britain, the contribution by milk and milk products to the iodine intake from the diet are 27% and 35%, respectively. Significant fluctuations in the iodine content of milk have been noted due to season (usually higher in winter, when more iodine-fortified feed is used) and the geographic region that the milk was produced in.

Seafood products are among the richest sources of dietary iodine. In a British study, the iodine content in fish and shellfish (not necessarily fresh) ranged from 110 mcg/kg to 3,280 mcg/kg. In
the same study, various seaweed products ranged from 4,300 mcg/kg to 2,660,000 mcg/kg. Consistent daily intake of iodine in amounts upwards of 1,000 - 2,000 mcg/day is probably detrimental to the thyroid gland's ability to process and distribute iodine to the rest of the body.

While there are no cereals or grains that naturally have high enough levels of iodine to significantly increase dietary intake, some cereal or grain products have become foundational sources of iodine for certain people groups. The addition of iodate as a stabilizer to baked goods (particularly bread), the use of the food coloring erythrosine in cereals, and the use of iodized salt in baked goods and cereals are the primary ways that iodine can find its way into these products. While the bio-availability of the iodine in erythrosine is questionable, cereal products contribute 14% of British iodine intake (30 mcg/day).

The poultry industry is aware of the importance of iodine for reproductive success, among other benefits. In the poultry industry it is common to use fish meal or seaweed in animal feed and to sterilize drinking water with iodine. The consumption of eggs in Denmark is responsible for 10% of the average daily iodine intake. Individual eggs have been shown to have as little as 13 mcg of iodine and as much as 170 mcg, reflecting the amount of iodine in the animals' diets.

Cattle raised for slaughter are treated with EDDI and given iodine-fortified feed and salt licks. Because iodine is not concentrated in muscle tissue, meat is generally not the primary source of dietary iodine for a population. One study found 2 mcg/kg of iodine in meat products, while another study found 260 mcg/kg. Once again, this disparity is due to the iodine content of the animals' diet.

Also vitamin and mineral supplements, most commonly used in industrialized countries, can be rich sources of iodine. These dietary supplements often contain 100 - 150 mcg iodine as KI.

Iodine in water and other beverages can also provide significant amounts of iodine to the diet. In Britain, water-based beverages provide 16% of the daily intake of iodine (35 mcg). Regardless of the fact that the iodine content of groundwater can vary dramatically by region (variation of 6 - 19 mcg/l in Denmark), beverages like beer and coffee are considerable sources of iodine for some groups of people. When iodine is added to water for the purpose of purification, dramatic increases in iodine intake (and excretion) will be experienced.

People consistently using certain medical products (medications and antiseptics) or that are involved in providing medical services that involve the use of iodine are also subject to large influxes of iodine.
The following table provides estimates of the contributions of major dietary products to iodine intake in the adult populations of three nations (% of daily intake). Where two dash marks are present, no data could be located:

<table>
<thead>
<tr>
<th></th>
<th>Britain 1</th>
<th>Denmark 2</th>
<th>USA 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Dairy</td>
<td>35</td>
<td>27</td>
<td>22</td>
</tr>
<tr>
<td>Fish</td>
<td>8</td>
<td>16</td>
<td>--</td>
</tr>
<tr>
<td>Seaweed</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Grains/Cereals</td>
<td>14</td>
<td>--</td>
<td>32</td>
</tr>
<tr>
<td>Poultry Products</td>
<td>5 (eggs)</td>
<td>10 (eggs)</td>
<td>3 (eggs)</td>
</tr>
<tr>
<td>Meat</td>
<td>6</td>
<td>--</td>
<td>10 (animal flesh)</td>
</tr>
<tr>
<td>Water/Beverages</td>
<td>16</td>
<td>26</td>
<td>4</td>
</tr>
<tr>
<td>Vitamins</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Other</td>
<td>16</td>
<td>--</td>
<td>29</td>
</tr>
<tr>
<td><strong>Total %</strong></td>
<td>100</td>
<td>79</td>
<td>100</td>
</tr>
<tr>
<td><strong>Total mcg</strong></td>
<td>219</td>
<td>50-100</td>
<td>390</td>
</tr>
</tbody>
</table>

1 Data from the Dietary and Nutritional Survey of British Adults, 1986 - 1987 (Lee et al.). The most significant dietary categories included in "Other" were, "sugar, confectionery and preserves" (5%), "vegetables" (4%), and "fats" (3%).
2 Data taken from Larsen et al.
3 Data from the Total Diet Study, 1982 - 1989. Average of data for both sexes, ages 14-16 and 25-30 (Pennington et al.). The most significant dietary categories included in "Other" were, "mixed dishes" (11%), "desserts" (9%), and "vegetables" (8%).

Brussaard et al. used the Dutch food composition surveillance data for a computer simulation of iodine intakes in the Dutch population before and after iodization of selected food products. The products that were chosen for the simulation had widespread use, were consumed by few people in extreme amounts, and were within the capabilities of food producers to iodize, without causing effects on the taste, color, and texture of the food. These simulated interventions showed that it was possible to substantially increase the average daily intake of iodine, without establishing an undue risk of over-consumption of iodine in any age group, through the fortification of additional food products (previously, there was voluntary iodization of table salt and baker's salt only). The greatest benefits for iodine intake were achievable through the iodization of baker's salt (for bread) and salt for industrially manufactured food products such as ham, rusks, biscuits, and Dutch cheese. Additionally, substantial reductions in low dietary intakes were observed when milk and dairy products had increased levels of iodine (this increase would result from the iodization of salt for animal consumption and the iodization of animal fodder).

**Change of the diet with modernization**

As a nation's industrial production ability rises and it becomes increasingly common that no one is at home to spend significant time for preparing meals, more and more households turn to diets based on processed/prepared foods. While these trends take place, the overall quantity of salt sales that affect the human food chain (table salt, food industry salt, animal husbandry salt, hospitality industry salt, etc.) remains virtually stable (salt sales provide a rough estimate of salt...
consumption). However, what does change are the relative amounts of salt that are sold into the channels that provide salt for human consumption. In particular, the sales of table salt decrease, while sales of food-grade salt to industries that are involved in producing prepared foods for sale to the public increase.

Those of us who live in industrialized countries need only consider the products in our grocery carts to realize just how much of our diets are made up of items that are pre-processed, pre-seasoned, or pre-packaged. At some point along their way to our dinner table, the majority of foods that we eat have passed through the hands of someone who has shortened the time it takes for us to prepare a meal.

An example of this change in diet has been happening over the last half century in Micronesia (located in the Western Pacific) (Shell).

One of the main ways food producers and processors prepare our foods for us is by pre-seasoning them. While adding salt to a food-in-production is not only done for the sake of flavor, the vast majority of processed foods contain some amount of salt. Importantly, many products commonly consumed would not be adversely affected if producers began using iodized salt in their preparation. It is possible to find multiple food vehicles that have widespread use, few people consume in extreme amounts, and that are feasible to iodize (or be imported in iodized form) for any particular nation.

The global push to iodize all salt for human and animal consumption has led to the protection of more than 75 million newborn brains annually. However, currently, millions are still at risk for iodine deficiency disorders. Each nation's people must consider the gravity of the decision not to act or the consequences of indecision as it pertains to taking cost-effective measures to rectify the poor iodine nutrition status of its populace. Today, there are many unexplored opportunities to insert necessary amounts of iodine into the food chain of many promising countries.
References:


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