Review

Iodine excess or not: analysis on the necessity of reducing the iodine content in edible salt based on the national monitoring results

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Using national monitoring data collected between 1995 and 2009, this paper describes the change in trend with regard to the coverage of qualified iodized household salt and iodine status of the population in China since the implementation of universal salt iodization. The review indicates that the iodine content in edible salt increased from 16.2 mg/kg in 1995 to 42.3 mg/kg in 1999, then declined to 30.8 mg/kg in 2005 and has retained this level through the most recent data collection cycle, which is considered sufficient to achieve optimal iodine status. However, the median urinary iodine excretion level for children aged 8-10 at the national level has been consistently classified as "excessive iodine intake" since 1997, suggesting that although three adjustments on the standard of iodine content in edible salt have been made, the current content of salt iodization is still on the high side. The iodine content in edible salt could be lowered, and possibly adapted to local specific conditions such as water iodine content and the average daily intake of salt among the population in order to achieve a balance between preventing deficiency and reducing the risk of excessive intake.

Key Words: iodine deficiency disorders, monitoring, salt iodization, iodine excess, iodine nutrition

INTRODUCTION

Since launching the Universal Salt Iodization (USI) program to prevent Iodine Deficiency Disorders (IDD) in 1995, China has achieved remarkable success. There has been a significant increase in the coverage of households using qualified iodized salt which had led to a decline in the incidence of clinical manifestations of IDD, and an overall improvement in the iodine status. This progress has led to a declaration that the main objective of sustainable elimination of IDD has been achieved at the national level.[1-2] Over the past decade, China's IDD monitoring system has been able to generate critical data on key aspects of program implementation, and has helped to guide modifications and adjustments in the overall program design. According to routine monitoring results, government agencies and related departments have been able to get timely and accurate information regarding the status of iodized salt coverage, determine the iodine status of the population, as well as identify problems and make adjustments to strategies and program measures.

This paper reviews and analyzes experiences over the past fifteen years with regard to salt iodization in China (1995-2009), and includes data presenting changes in iodized salt coverage, the iodine status of the population, and an increased understanding of other sources of iodine in the diet. These data are available in China at the sub-national level and have revealed the need to understand the risk of excessive iodine intake in some geographic areas. Equipped with these data, it has been possible to examine where adjustments are required in the USI strategy, including the need to remain vigilant with the provision and monitoring of qualified iodized salt in most parts of the country; and adapt the strategy as required, including reducing the concentration of iodine added to edible salt.

SUPPLY AND COVERAGE OF QUALIFIED IODIZED SALT

Since 1995, China has implemented a policy of USI in which it has been mandatory for all edible salt in the country to be iodized according to national standards, and the coverage of iodized salt throughout the country has been closely monitored by a comprehensive monitoring system. This system entails three distinct activities which track the quality of iodized salt from production to consumption:

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- Monitoring of all iodized salt at the point of production implemented by all factories of edible salt
- National IDD surveys conducted every 2-3 years provide data on iodized salt coverage and iodine status, representative of each of the provinces
- Routine annual monitoring of iodized salt coverage of all counties in the country.

The results of five national IDD surveys carried out between 1995-2005 indicate that the household coverage of iodized salt increased from 80.2% in 1995 to 94.9% in 2005, while the coverage of "qualified" iodized salt had also increased from 39.9% in 1995 to 90.2% in 2005 (The standard of qualified iodized salt has varied over time, see Table 1). The median iodine content in household salt increased from 16.2 mg/kg in 1995 to 42.3 mg/kg in 1999, which led to an adjustment on the iodine content in iodized salt and subsequently declined to 30.8 mg/kg by 2005. In fact, the standard for salt iodization was modified several times between 1995 and 2005.[3-7]

It is noteworthy that the original standard for 'qualified' iodized salt only included a minimum level (≥20 mg/kg), and it was only two years later that in 1997 that an upper limit was included in the standard. This was an important change as it enabled monitoring to focus not only on assuring that enough iodine was being added to salt at the time of production, but also to guarantee that excessive iodine was not being added. The annual county-level salt monitoring data has been in place since 2004 and shows that the national coverage of iodized salt at the household level has been higher than 95%, while the coverage of qualified iodized salt has been sustained above 90%. The median iodine level in salt assessed through the county-level monitoring has consistently been around 30 mg/kg (Table 2).[8-13]

THE IODINE STATUS OF THE POPULATION

The measurement of urinary iodine excretion is used to assess the iodine status of the population. National IDD survey results from 1995 noted that the median urinary iodine of schoolchildren aged 8-10 was 164.8 μg/L, reflecting an adequate level of iodine, but the percentage of low urinary iodine values (<100 μg/L) was 37.4%. The median urinary iodine in 1997 and 1999 had risen to over 300 μg/L for the country as a whole, and the percentage of low urinary iodine values (<100 μg/L) had declined to 16.8% by 1999. However, at that same time, the percentage of 'excessive' urinary iodine values (>300 μg/L) had rapidly risen to 44.3%. These data prompted a reduction in the upper limit of the standard for iodized salt (from 60 to 50 mg/kg). Subsequent data showed that the median urinary iodine declined to 241 μg/L and 246 μg/L in 2002 and 2005, respectively. The median urinary iodine of five provinces was still above 300 μg/L in 2005, indicating that there was a sustained risk of excessive iodine intake. At the national level, the frequency distribution of urinary iodine in 2005 noted 15.7% of the population with low values (<100 μg/L) and 30.6% with elevated levels (>300 μg/L) (Figures 1 and 2).[3-7] Urinary iodine status indicate that iodine content consumed as edible household salt does not capture all sources of iodine in the diet, and salt iodization policy should consider local specific conditions such as iodine content in drinking water and the average quantity of daily salt intake among the local population.

THE SUPPLY STATUS OF NON-IODIZED EDIBLE SALT IN IODINE EXCESS AREAS

Over time, an analysis of the IDD monitoring data suggested that there were additional sources of iodine in the diet beyond that being provided exclusively from iodized table salt. This conclusion was based on the observation of excessive urinary iodine levels in spite of the fact that the level of iodine in salt was well within the range of what was deemed 'acceptable', and the salt consumption patterns would not have explained that iodized salt in the diet was the sole determinant of the population iodine status. As a result, the Ministry of Health (MOH)

Table 1. Iodized salt indicators from five national IDD surveys, 1995-2005

Iodized salt of household	1995	1997	1999	2002	2005
Coverage of iodized salt – containing any iodine (%)	80.2	90.2	93.9	95.2	94.9
Coverage of qualified iodized salt (%)					
Set ≥20 mg/kg as standard	39.9	-	-	-	-
Set 20-60 mg/kg as standard	-	69.0	80.6	-	-
Set 20-50 mg/kg as standard	-	-	-	88.9	90.2
Median of salt iodine (mg/kg)	16.2	37.0	42.3	31.4	30.8

Table 2. National salt monitoring results of households level, 2004-2009

Iodized salt of household	2004*	2005*	2006	2007	2008	2009
Number of counties included in the monitoring	2328	2529	2652	2751	2862	2882
Coverage of iodized salt (%)	96.9	98.1	96.9	97.1	97.5	98.4
Coverage of qualified iodized salt (%)	93.5	95.4	93.8	94.3	95.0	96.4
Median of iodine concentration in iodized salt (mg/kg)	30.4	30.6	30.9	30.9	31.2	31.3

* Most counties in Xinjiang and Tibet didn't carry out the monitoring of iodized salt in 2004 and 2005, so the national data was higher than the actual level.

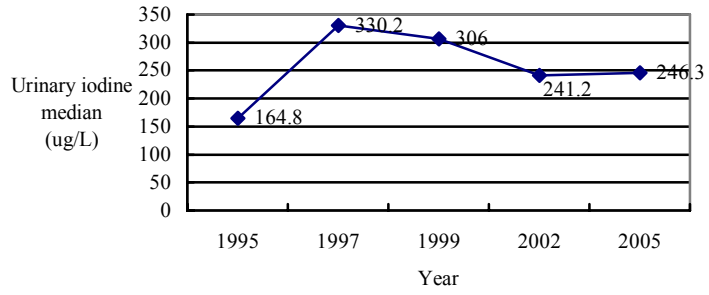

Figure 1. Urinary Iodine in Schoolchildren – National level, 1995-2005

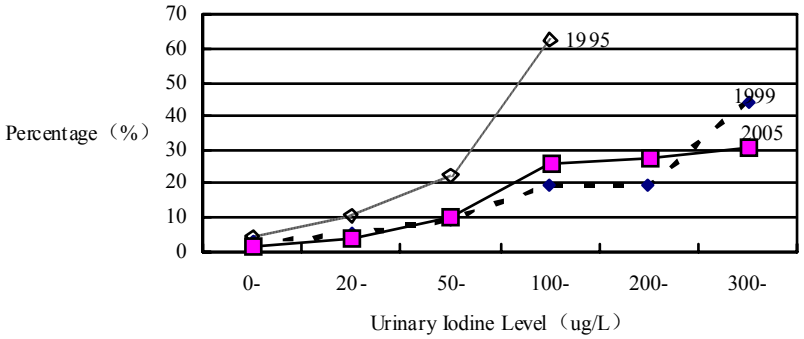

Figure 2. Population frequency distribution of urinary iodine in 1995, 1999 and 2005. *The data of frequency distribution >100 μg/L in 1995 was missing.

embarked on an ambitious effort to identify other sources of iodine, primarily in the water supply and local foods during 2005-2009. This led to the identification of iodine excess areas in 11 provinces (districts, cities) of China, involving some 122 counties. In these areas, considered to have 'high iodine intake', the government and the National Salt Corporation decided to limit the distribution and availability of iodized salt to households, although there are logistical challenges since the iodine excess areas are located in close proximity to iodine deficiency areas. Although the supply of non-iodized edible salt in these areas has recently become compulsorily according to national salt iodization regulations, iodized salt was provided in some of those areas with excessive iodine in 1995, when USI was first implemented. Prior to 2007, there was no systematic monitoring in iodine excess areas, and as such, detailed data are not available. Since 2007, iodine excess areas have been formally incorporated into the national monitoring system and routine data on the coverage of households with iodized and non-iodized salt are collected. The monitoring results show that the coverage of non-iodized salt of household had risen from 73.1% in 2007 to 90.6% in 2009,[11-13] indicating that most households have access to non-iodized salt. At the county level, out of 84 monitored counties (cities, districts), 65 have coverage of non-iodized salt above 90%, including 26 where coverage is 100%. At the same time, the coverage of households in terms of non-iodized salt in 8 counties (cities, districts) is still under 50%, demonstrating that more vigilant efforts are required to limit the supply and availability of iodized salt in these areas.

THE PROGRESS ON ADJUSTING IODINE CONTENT IN SALT

Owing to the vast territory and diversity of China, it is not surprising that there would be variations in the prevalence of IDD and its various influencing factors such as salt consumption patterns, dietary habits, culture and customs, and so on. Consequently, the implementation of a 'universal' salt iodization program and the provision of iodized salt with the appropriate iodine content to all areas in the country have been challenging. Through reviewing the monitoring data since 1995, it is clear that China has gone through a process of program maturation in which evidence has helped to make adjustments in program strategy and design towards the goal of eliminating IDD, primarily through salt iodization.

Data generated by the National IDD monitoring system fifteen years ago indicated that, owing to less sophisticated processing equipment and limited quality management in the iodized salt producing factories, most of the provinces had variable coverage of iodized salt and inconsistencies in the iodine content in salt. At that time, the regulation for iodine content in salt only prescribed a lower limit, while there was no relative regulation for the upper limit. In order to increase the proportion of iodized salt being classified as "qualified", most salt producers at that time tended to iodized salt with an iodine content

above 40 mg/kg. Therefore, the iodine intake of households was generally too high, and this was reflected in the excessive urinary iodine levels seen in national surveys in 1997 and 1999. In order to address this problem, the Ministry of Health established the upper limits in the designation of criteria for "qualified" iodized salt, recommending that the iodine content in salt should not exceed 60 mg/kg. The National IDD survey data from 1997 demonstrated that the median urinary iodine of children had reached 314.0 μg/L, exceeding the adequate range of 100-200 μg/L recommended by international organizations. At the time, 18 of the 31 provinces surveyed had a median urinary iodine higher than 300 μg/L. In addition to the excessive levels of iodine in iodized salt at that time, another possible explanation for the excessive urinary iodine may have been the widespread and inappropriate use of iodine-oil capsules. Following analysis of the 1997 data, the Ministry of Health also decided to limit the application and reach of iodine-oil capsules, relying increasingly on iodized salt as the sole intervention to assure adequate iodine status. The national IDD survey of 1999 showed that the median urinary iodine of children was in the range considered to be "more than adequate" (200-300 μg/L) in 13 provinces, while the median urinary iodine was classified as excessive (more than 300 μg/L) in 14 provinces. After removing the sample of individuals taking iodine-oil capsules from the analysis of urinary iodine data, the iodine status of the country as a whole was still classified as "more than adequate". The interpretation of this was that the high urinary iodine levels observed had a close relation with iodized salt. This was further revealed through monitoring data that indicated that the median iodine levels in salt ranged from 30.7-51.7 mg/kg in 30 provinces, including 24 provinces for which the median level of iodine in salt was higher than 40 mg/kg. On the basis of these monitoring results, the Ministry of Health and related departments again agreed on adjusting the iodine content in salt to 35(±15) mg/kg, or (20~50 mg/kg).[14] After the adjustment, two national surveys were conducted in 2002 and 2005 respectively, and the results showed that the national average level of urinary iodine had declined to 240~250 μg/L, which was still classified as "more than adequate",[15] while the median urinary iodine of five provinces continued to exceed 300 μg/L, and the percentage of the national population with a median urinary iodine >300 μg/L was still above 30%.

CURRENT CONCERN ON EXCESSIVE IODINE INTAKE

The current standard for "qualified iodized salt" of 35 ± 15 mg/kg has been consistently applied by all major salt producers in China, following three adjustments resulting from ongoing surveillance of the iodine status of the population. It has become evident that through the intensive efforts of many partners, universal salt iodization in China has been effective in improving the iodine status of the population and the spectrum of IDD have been effectively controlled. However, as the program matured, there has been increasing concerns on problems of excessive iodine intake.[16-18] The IDD program monitoring results provide evidence that excessive iodine intake among populations has existed in some areas for many years, including those with naturally occurring iodine. Chronic excessive iodine intake in some areas may have resulted in side effects of iodine toxicity among certain sensitive individuals, who have a genetic predisposition to thyroid disease. Taken together, monitoring data suggest that the iodine content in edible salt could be lowered and adapted to local specific conditions to reduce the risk of excessive iodine intake, rather than adopting a single, "one size fits all" standard.

CONCLUSION

Salt iodization has been a major success in China and can be credited for the virtual elimination of IDD in the country. There is no question that for the vast majority of the population, iodized salt provides the necessary iodine to meet physiological needs, and should be sustained. Any change in broad policy could have negative consequences. At the same time, monitoring results indicate that there may be excessive iodine intake in some areas, which may have an adverse impact on sensitive individuals. The current content of salt iodization is still on the high side. The iodine content in edible salt could be lowered, and possibly adapted to local specific conditions in order to achieve a balance between preventing deficiency and reducing the risk of excessive intake.

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AUTHOR DISCLOSURES

None.

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Iodine excess or not: analysis on the necessity of reducing the iodine content in edible salt based on the national monitoring results

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碘过量或没有：基于国民监测结果分析食用盐降低碘含量的必要性

本文利用 1995 年至 2009 年全国监测搜集的数据，描述了自普及食盐加碘 (USI) 以来，中国居民合格碘盐覆盖率和人群碘营养状态的变化趋势。文章指出，中国居民食盐中碘的浓度 1995 年、1999 年和 2005 年分别为 16.2 mg/kg、42.3 mg/kg 和 30.8 mg/kg，直至最近仍维持 2005 年的水平，这一水平被认为能够获得充足的碘营养状态。然而，全国 8-10 岁儿童的尿碘水平从 1997 年起一直在碘摄入过量的水平，表明虽然食盐中碘的浓度经过 3 次调整，但当前的浓度依然偏高。食盐中碘的浓度仍有下调的空间，并要适合当地的具体条件，例如水碘含量和人群平均每日食盐摄入量，以便获得防治碘缺乏和降低碘摄入过量风险的平衡。

关键词：碘缺乏失调、监测、加碘盐、碘过量、碘营养