Sustainable control of iodine deficiency in Iran: Beneficial results of the implementation of the mandatory law on salt iodization

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ABSTRACT. Iodine deficiency disorders (IDD) were prevalent in the Islamic Republic (IR) of IRAN before 1989, when the national salt iodization program with 40 mg I/k of salt was initiated. Despite a comprehensive IDD control program, less than 50% of the households in rural areas consumed iodized salt by 1994. A law for the mandatory production of iodized salt for households was passed in 1994. The purpose of this study was to evaluate goiter status and urinary iodine excretion 2 yr after this law was implemented. In each of 26 provinces, 30 groups of 40 schoolchildren, total 36,178, were examined for goiter and classified according to World Health Organization (WHO) classification. Urinary iodine excretion was measured in 2,917 children by digestion method. Goiter was endemic in all provinces, but the majority were small (grade 1) goiter. Median urinary iodine was 20.5 µg/dl 85.1% had urinary iodine ≥10 µg/dl. Median urinary iodine was above 13 µg/dl in all 26 provinces. In all provinces the percentage of schoolchildren with urinary iodine <5 µg/dl was less than 16%. In nine provinces the median urinary iodine was between 13 to 20 µg/dl; urinary iodine of their schoolchildren was <5 µg/dl in 10.8% and <2 µg/dl in 6-9%. No significant difference was observed between boys and girls or children of rural and urban regions in urinary iodine excretion. We conclude that 7 yr after the beginning of salt iodization and 2 yr following mandatory iodized salt consumption, urinary iodine excretion is adequate in schoolchildren; considering the data of the percent of households consuming iodized salt and programmatic setting of the IDD program, The IR of Iran has reached a sustainable control program for iodine deficiency.

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INTRODUCTION

Iodine deficiency leads to a spectrum of disorders, from simple goiter, to hypothyroidism, impaired psychosomatic performance, decreased intelligent quotient, auditory disturbance, neurological deficit and finally clinical presentation of typical cretinism, which are collectively referred to as iodine deficiency disorders (IDD) (1). It is estimated that more than 1.5 billion people in 117 countries around the world are at risk of iodine deficiency. This constitutes 29% of the world's population. Globally, the prevalence of goiter is estimated to be 12% of the world population (2).

The prevalence of goiter in the Islamic Republic (IR) of Iran was found to be between 10-60% in 1968 (3); However, no preventive measures for the control of iodine deficiency was undertaken. In the 1980's several studies showed the existence of various forms of IDD in the country (4-7). A nationwide survey of goiter in 1989, showed that goiter existed in schoolchildren in most provinces at a rate of between 30-80% (8) and it was estimated that 20 million people were at risk of iodine deficiency. The Minister of Health and Medical Education set up the Iranian National Committee for Control of IDD in 1989. The production and distribution of iodized salt, with 40 mg of potassium iodide per kg of sodi-

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um chloride began and the education of policy makers, health personnel and public was started in 1990. However, a rapid survey of iodized salt consumption showed that less than 50% of the population consumed iodized salt in 1993 with mean urinary iodine of 5.0 to 8.2 µg/dl in spot locations. Therefore, the first law requiring mandatory iodination of all salts for household use was passed in 1994. Multiple rapid surveys of iodized salt consumption have demonstrated that from 1997 more than 90% of households consume iodized salt (9). This study was conducted in 1996, 2 yr after the introduction of a new law on iodized salt consumption to determine the prevalence of goiter and urinary iodine excretion in schoolchildren in 26 provinces in the IR of Iran.

SUBJECTS AND METHODS

Subjects

A total of 36,178 schoolchildren of both sexes, aged 8 to 10 yr were included in this cross-sectional study. Expanded Program of Immunization (EPI) cluster sampling, as recommended by the joint World Health Organization/United Nations Children's Fund/International Council for Control of Iodine Deficiency Disorders (WHO/UNICEF/ICCIDD) Consultation in 1992, was used (10). In each of the 26 provinces, 30 clusters of 40 children each were selected by probability proportionate to size method. Therefore, at least 1,200 schoolchildren, 600 females and 600 males, were studied in each province. Medium altitude in 25 provinces of Iran is above 900 meters above sea level. In the South-East province of Sistan-Baluchestan, there are 2 regions of above and below 900 m; therefore 1,200 schoolchildren were studied in each region. Since findings of goiter prevalence and urinary iodine was not significantly different in the 2 regions, the results of both regions were added.

Goiter grading

Informed verbal consent was obtained from each school principal, teachers of the classes involved and local city and village authorities. Seven physicians were trained by one of the researchers for goiter grading and their clinical examination and classification of goiter was validated. The grading of goiter was performed according to the classification recommended by the joint WHO/UNICEF/ICCIDD consultation (10).

Iodine measurement

Casual urine samples were collected on the spot from one every tenth-fifteenth children in each region using wide-mouth screw-capped plastic bottles. The first child in each school was selected randomly and then one every tenth or fifteenth schoolchildren was enrolled. A total of 2,917 urine samples were collected throughout the country. Urinary iodine estimation was done using the digestion method (11). All the laboratory work was done in the Research Laboratory of the Endocrine Research Center in Tehran. In accordance with WHO recommendations, urinary iodine excretion was evaluated as follows: ≥10 µg/dl=no deficiency, 5-99=mild, 2 to 4.9=moderate and <2 µg/dl=severe iodine deficiency (10).

Data analysis

The data were entered into the database and analyzed using the SPSS version 9 for Windows. To compare goiter prevalence and urinary iodine excretion between sexes and schoolchildren of rural and urban areas, chi square and *t* test were employed, respectively.

RESULTS

The total number of surveyed children was 36,178 out of which 2,917 had urinary iodine determination. The percentage of girls surveyed in each province was between 49-51%, and the sex ratio was 1 in the country. 33%, 34% and 34% of all surveyed children were 8, 9 and 10 yr of age, respectively. Approximately half of the schoolchildren in each province were from rural regions.

Table 1 - *Prevalence of goiter in 26 provinces of the Islamic Republic of Iran, according to WHO/UNICEF/ICCID classification.*

Province	Grades of goiter (%)		
	0	1	2
E. Azerbaijan	62	34	4
W. Azerbaijan	56	39	5
Ardabil	61	36	3
Isfahan	39	50	11
Ilam	13	75	12
Boushehr	45	52	3
Tehran	49	43	8
Charmahal	45	40	15
Khorasan	56	43	1
Khosestan	42	42	16
Zanjan	49	39	12
Semnan	51	35	14
Sistan-Balouchestan	77	22	1
Ghom	75	24	1
Fars	32	61	7
Kerman	41	52	7
Kermanshah	21	65	14
Kohkilyoh	12	70	18
Kordestan	34	54	12
Guilan	28	40	32
Lorestan	31	55	14
Mazandaran	46	39	15
Markazi	65	33	2
Hormozgan	84	15	1
Hamedan	14	76	10
Yazd	52	46	2

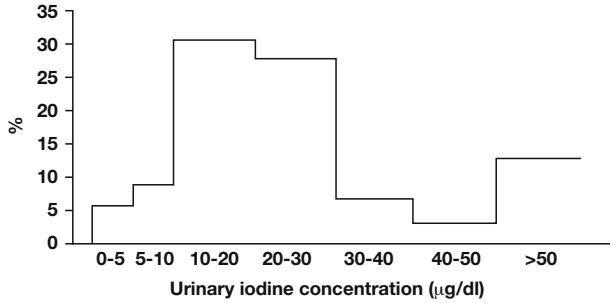

Fig. 1 - *Distribution of urinary iodine concentration in 8 to 10-yr-old schoolchildren of the Islamic Republic of Iran, 1996.*

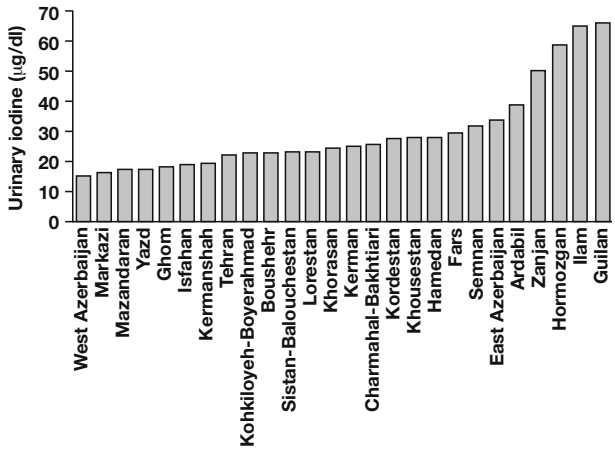

Fig. 2 - *Median urinary iodine concentration in 8 to 10-yr-old schoolchildren of 26 provinces the Islamic Republic of Iran, 1996.*

Goiter prevalence

In 16 out of 26 provinces, total goiter rate was more than 40% in boys and over 50% in girls (Table 1) However, the majority of schoolchildren had small goiters of grade 1.

In the province of Guilan, the prevalence of grade 2 goiter was 32%; in the other 25 provinces grade 2 goiter appeared in <20% of children. There was no significant difference in goiter prevalence between boys and girls or schoolchildren of rural and urban regions.

Urinary iodine

In all 2,917 schoolchildren the median urinary iodine excretion was 20.5 μg/dl. Two thirds of the schoolchildren had urinary iodine between 10 to 30 μg/dl. 85.1% of children had urinary iodine equal or in excess of 10 μg/dl. 9, 2.3 and 3.6% had mild, moderate and severe iodine deficiency, respectively. Figure 1 illustrates urinary iodine distribution in 8 to 10 yr old schoolchildren of the country. There was no significant difference in urinary iodine excretion between boys and girls and schoolchildren of the rural and urban regions.

Figure 2 shows median urinary iodine excretion in schoolchildren of each of the 26 provinces. The highest and lowest values belong to Guilan (North) and West-Azerbaijan (North-West) provinces, 65 and 13 μg/dl, respectively.

In Table 2, on the basis of urinary iodine excretion, all 26 provinces were divided into 4 groups. In nine provinces the median urinary iodine was between 13-19 μg/dl. In these provinces, 6.9% of schoolchildren had severe iodine deficiency. In eleven provinces the median urinary iodine was between 20-29 μg/dl and 2.0% of the children had severe iodine deficiency. Median urinary iodine was between 30-39 and ≥50 μg/dl was registered in 2 and 4 provinces, the percentage of schoolchildren having severe iodine deficiency being 0.4 and 1.7%, respectively. In none of the 26 provinces did the occurrence of urinary iodine of <50 μg/dl exceede 7% of schoolchildren. There was no correlation between the prevalence or severity of goiter and urinary iodine excretion.

DISCUSSION

In the present survey, we found that goiter is still endemic and hyperendemic in the Iranian school-

Table 2 - *Urinary iodine excretion in 26 provinces of the Islamic Republic of Iran, according to WHO/UNICEF/ICCIDD classification.*

Median urinary iodine (μg/dl)	Provinces	Urinary iodine (μg/dl) <2	2-4.9	5-9.9	>10
13-19	W Azerbaijan, Isfahan, Ghom, Kerman, Kermanshah, Lorestan, Mazandaran, Yazd, Markazi	6.9*	3.9	13.8	75.4
20-29	Boushehr, Tehran, Charmahal, Khorasan, Sistan-Balouchestan, Semnan, Fars, Kordestan, Kohkiloyeh, Hamedan, Khousestan	2.0	1.7	7.0	89.4
30-39	E. Azerbaijan, Ardabil	0.4	1.6	9.0	89.0
≥50	Ilam, Guilan, Hormozgan, Zanjan	1.7	0.9	3.2	94.2

*Numbers indicate percentage.

children after an effective salt iodization program. However, median urinary excretion is in an adequate or more than adequate range in schoolchildren of all provinces.

Goiter is prevalent in the majority of countries in the Eastern Mediterranean region, in particular in regìons with high altitudes (12-14). The IR of Iran has been known as a country in which goiter has frequently been seen in the population. However, the first goiter survey reported in 1968 showed that goiter was prevalent in many provinces (3). In 1983, 15 yr after the original study, since no program for the control of IDD was implemented in the country, we began a series of investigations in Shahriar (4), Tehran (5), and Kohkiloyeh and Boyerahmadi (6); the findings of these investigations showed the existence of hyperendemicity in many regions. In schoolchildren of villages north and north-west of Tehran, manifestations of severe IDD such as defective physical, mental and psychomotor development, neurologic, and auditory abnormalities along with frequent occurrence of hypothyroidism were found (15, 16). The results of these studies prompted the formation of "The National Committee for Control of IDD" in 1989 and the national survey of goiter (8). The results of this survey showed that 20 provinces had a total goiter rate of over 40%. Urinary iodine excretion in many regions of the country was below 10 µg/dl and in some less than 2 µg/dl (4, 6, 19, 20). The salt iodization program began in 1989, the production, distribution and consumption of iodized salt gradually increased. Qualitative and quantitative monitoring of iodized salt was performed on a regular basis in salt factories, retailers. Consumers in all provinces were also involved in the monitoring. Despite the launching of widespread education programs for the health personnel and for the public between 1989 and 1994, the rapid survey of iodized salt consumption in 1994 showed that less than of 50% of households used iodized salt. Therefore, a law was passed and production of salt for household use was limited to one kg bags containing iodized salt. Rapid surveys from 1996 have shown than more that 90% of households consumes iodized salt.

The present survey was conducted 7 yr after the initiation of iodized salt production and 2 yr after the implementation of the new law for mandatory consumption of iodized salt by households. It is evident that the prevalence of goiter is high in many provinces. Since the study was performed as the majority of people have used iodized salt only for 2 yr, it is too early to expect that the consumption of iodide should result in the reduction of goiter prevalence. It has been. shown that thyroid size in children exposed to iodine deficiency in the first years of life might fail to regress completely following consumption of iodized salt, and children born prior to iodine prophylaxis, even 10 yr after intervention, had larger thyroid volume than children from iodine sufficient areas (17). In fact a recent survey of thyroid volume by sonography has shown further decrease in goiter rate in schoolchildren in Tehran in 1999 (18).

The most sensitive method for the monitoring and evaluation of an IDD control program is the determination of urinary iodine excretion (19). Findings of the present study show that the median of urinary iodine secretion in schoolchildren in Iran (20.5 µg/dl) is into the optimal range, *i.e.* 10 to 20 µg/dl, as recommended by WHO/UNICEF/ICCIDD (20). In 20 out of 26 provinces the median urinary iodine is between 13-30 µg/dl and in 6 provinces is in a range that might be linked to the increased risk of iodine induced hyperthyroidism (20, 21), or transient elevation of thyroid hormones (22). The reason for increase in urinary iodine was studied in the Guilan province and it was attributed to an increased consumption of salted food in the dietary habits of the population of this province (23). Guilan and 5 other provinces have been among the hyperendemic regions where in 1993 and 1994 iodine supplementation in the form of iodized oil injection was offered. A repeated survey in one of these provinces, Ilam, has shown a decrease in mean urinary iodine to 20.5 µg/dl (24).

The IR of Iran set up an excellent program for the control of IDD. A sustainable and well-functioning iodization program is functioning with the following programmatic indicators: 1) From 1989, an effective and functional national office (IDD National Committee), responsible to the government for the elimination of IDD has been active. This council is multidisciplinary, involving the relevant fields of nutrition, medicine, industry, education *etc*; 2) political commitment to universal salt iodization and the elimination of IDD was pledged in 1989 and has continued until today; 3) a responsible executive officer had been appointed for the IDD elimination program, since 1990; 4) legislation on universal salt iodization has been applied since 1992. The Ministry of Industry has announced that salt factories should produce only iodized salt for household use; 5) the country has performed an assessment and a re-assessment of progress in the elimination of IDD, with access to laboratories able to provide data on salt and urine iodine; 6) a program of public education and social mobilization on the importance of IDD and the consumption of iodized salt has been vigorously followed over the last 11 years. The program is integrated into the health network, with full participation of Behvarz (rural health workers) in education and

monitoring; 7) regular data on salt iodine at factory (daily), retail (monthly) and household levels (yearly) are collected in each province and analyzed by the IDD executive officer; 8) regular laboratory data on urine iodine in school aged children with appropriate sampling for higher risk areas is being collected and processed in each province on a yearly basis and nationally every 5 yr; 9) cooperation from the salt industry for the maintenance of quality control is excellent and it is supervised by the IDD executive officer; 10) a database with the records of results or regular monitoring procedures, particularly for salt iodine and urine iodine is available in the Ministry of Health. Neonatal TSH was measured in 1989 and 1997-1999. This shows a significant decrease in transient hyperthyrotropinemia and recall rate.

Therefore, the IR of Iran fulfills all 10 programmatic indicators set by WHO/UNICEF/ICCIDD (20). According to these criteria, the IR of Iran appears to have reached a sustainable IDD control program since 1996. The monitoring of the IDD control program is planned every 5 yr to evaluate the sustainability of the program. We conclude that the implementation of an adequate and sustainable program of IDD control needs many effective programmatic steps, in particular its integration into the health network. Furthermore it may require mandatory iodized salt consumption in certain situations.

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