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Has iodized salt reduced iodine-deficiency disorders among school-aged children in north-west Iran? A 9-year prospective study

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Abstract

Objective: Low iodine intakes are associated with goitre and other iodine-deficiency disorders (IDD) that have affected billions of people worldwide. We aimed to assess total goitre rate (TGR) and urinary iodine concentration (UIC) in schoolchildren between 2007 and 2015, percentage of iodized salt consumption by households, and salt iodine content at production, distribution and household levels in north-west Iran.

Design/Setting/Subjects: UIC assessed among schoolchildren in nine consecutive years; 240 schoolchildren aged 8–10 years selected by systematic random sampling each year in the West Azerbaijan Province.

Results: Median UIC was >100 μg/l in all years. More than 50 % of children had iodine deficiency (UIC ≤ 99 μg/l) in 2010 and 2011, while this rate was approximately 15–35 % in other years. Proportion with UIC below 50 μg/l was <20 % in all years except 2010 and 2011. Excessive UIC (≥300 μg/l) rate was between 5·4 and 27·5 %. TGR decreased from 44 % in 1996 to 7·6 % and 0·4 % in 2001 and 2007, respectively. Regular surveys from 2002 to 2015 showed that 98 % or more of households consumed iodized salt. Iodine level ≥20 ppm was observed in 87·5, 83 and 73 % of salt at production, distribution and household level, respectively (data from national study in 2007). The last national study in 2014 showed that median iodine level in household salt was 27 ppm.

Conclusions: Our focused data suggest that the universal salt iodization programme is improving the iodine status of schoolchildren in the West Azerbaijan Province of Iran. Reduction of TGR to less than 5 % in schoolchildren indicates successful elimination of IDD as a major public health problem.

Keywords
Iodine-deficiency disorders
Iodized salt
School-aged children
Iran

Iodine is an essential mineral for thyroid hormone function[1,2]. Iodine-deficiency disorders (IDD) are still a public health problem in some countries[3]. The WHO estimates that nearly two billion people worldwide have insufficient iodine intakes, including one-third of all school-aged children[4,5].

Iodine is found in small amounts in many foods[6], but major sources are the marine foods group, milk and dairy products, and also drinking-water in some areas[7]. Iodine deficiency is associated with several abnormalities which are named as IDD[8]. Some complications of iodine deficiency include goitre, lack of physical and mental development, and poor learning ability in children[9–11]. Iodine deficiency also leads to abortion, stillbirth and congenital anomalies, and increases prenatal death and infant mortality[1,12–14]. IDD are preventable using methods such as iodized salt[15,16]. The elimination of IDD should be implemented as a critical development issue by governments.

Recognizing the importance of IDD elimination, in 1994, the WHO and UNICEF Joint Committee on Health Policy recommended universal salt iodization (USI) as a safe, cost-effective and sustainable strategy to eliminate IDD[3,4,17]. The USI strategy is recommended because salt is consumed by everyone and the quantity of iodine in salt can be monitored simply at the production, distribution and household levels[18–20]. Most iodine absorbed in the body eventually appears in the urine. Therefore, median urinary iodine concentration (UIC) is the main indicator to be used to assess the iodine status of a population[21,22].

Studies in the Islamic Republic of Iran showed that goitre was endemic in the majority of provinces and the total goitre rate (TGR) in the country was 68 %, being

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30–80 % in school-aged children[23–25]. Therefore, the first law requiring mandatory iodization of all salt for household use was passed in 1994. Multiple rapid surveys on iodized salt consumption demonstrated that, from 1997, more than 90 % of households consumed iodized salt[26]. Because more than 75 % of households in Azerbaijan Province consume marine foods including fish rarely or never, the main source of iodine is therefore iodized salt[27]. Regular surveys of median UIC levels in school-aged children where feasible are useful indicators of thyroid function. School-aged children are a useful target group for IDD surveillance because of their combined high vulnerability, easy access and applicability to a variety of surveillance activities. The aim of the current study was to assess the TGR and UIC in school-aged children in the West Azerbaijan Province of north-west Iran between the years 2007 and 2015.

Methods and materials

In the present cross-sectional study, TGR, UIC, percentage of iodized salt consumption by households and iodine content of salt at production, distribution and household levels were assessed in schoolchildren in the north-west of Iran in 2007–2015. This study was approved by the ethics committee of Urmia University of Medical Science (Urmia, Islamic Republic of Iran).

Subjects

Two hundred and forty schoolchildren of both sexes, aged 8–10 years (grades 2, 3 and 4), were included. A multistage stratified sampling followed by a systematic random sampling technique was used to recruit participants (a separate sample was taken each year). According to the national guidelines, forty-eight schools with five samples from each school randomly should be selected. Initially, all primary schools were stratified into urban and rural. Therefore, considering the percentage of the rural and urban population (approximately 58 % in urban and 42 % in rural areas), twenty-eight schools in urban and twenty schools in rural areas (equal numbers of both sexes in each area) were selected by systematic random sampling. In this way, the first school was randomly selected; then, according to the sampling interval, the next schools were selected until the last school. The sampling interval was calculated as the total number of schools in each area (stratified by sex) divided by the number of schools needed. Finally, in each school, one subject for grade 2 and two subjects each for grades 3 and 4 were randomly enrolled.

Goitre grading and urinary iodine concentration measurement

Goitre grading was determined by physicians trained by one of the researchers in Tehran. Classification of the goitre grading was performed according to the criteria recommended by the WHO/UNICEF/International Council for Control of Iodine Deficiency Disorders (ICCIDD)[4], as follows: grade 0, no palpable or visible goitre; grade 1, a goitre that is palpable, but not visible when the neck is in the normal position (i.e. the thyroid is not visibly enlarged; thyroid nodules in a thyroid which is otherwise not enlarged fall into this category); and grade 2: a swelling in the neck that is clearly visible when the neck is in a normal position and is consistent with an enlarged thyroid when the neck is palpated.

One hundred and twenty subjects were randomly selected for UIC determination (equal numbers of girls and boys). Urine samples were transferred on ice to the reference laboratory of Urmia University of Medical Sciences in screw-topped plastic bottles and kept frozen at –20°C until the time of iodine measurement at the end of the study. All laboratory measurements were done in one laboratory by physicians trained in using the acid digestion method. Based on the WHO/UNICEF/ICCIDD recommendation[4], UIC was classified as follows: <20 µg/l as indicating severe iodine deficiency; 20–49 µg/l as moderate iodine deficiency; 50–99 µg/l as mild iodine deficiency; 100–199 µg/l as adequate iodine; 200–299 µg/l as above requirements; and ≥300 µg/l as excessive iodine.

Iodine content of salt

At household level

After an interview with parents about the type of household salt used, iodine content of the salt present in the household was measured in the field using a rapid testing kit. Four hundred samples were selected using simple one-stage cluster sampling. According to the national guidelines, twenty clusters with twenty samples in each cluster randomly should be recruited. Therefore, considering the percentage of the rural and urban population (approximately 58 % in urban and 42 % in rural areas), twelve clusters for the urban and eight clusters for the rural areas were chosen. Finally, households were randomly selected within the clusters. Approximately 10 % of salt samples were randomly selected and assessed using the iodometric titration method for quantifying iodine content, and values are shown in parts per million (ppm). Iodine level was recorded as <20, 20–40 and ≥40 ppm.

At production and distribution levels

Samples from different parts of the factory site at each factory producing iodized salt, and 100 samples from distribution sites with different brands, were sent to the laboratory of food and drug deputy in Urmia University of Medical Sciences. Quantitative iodine measurement was performed at the centre.

Statistical analysis

The data are presented as medians, means and standard deviations, or numbers and percentages. The normal distribution of data was tested using the Kolmogorov–Smirnov test. Mean UIC was compared by sex and area

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using the Mann–Whitney *U* test. Pearson's χ^2 test was used for the comparison of iodine status distribution of subjects by sex and area. All statistical analyses were performed using the statistical software package IBM SPSS Statistics version 20. *P* values of less than 0·05 were assumed to be statistically significant.

Results

Urinary iodine concentration

Table 1 shows the urinary iodine levels in schoolchildren between 2007 and 2015. A total of 240 school-aged children were included in each year. Median UIC was ≥100 µg/l in all years except 2010 and 2011. There was no significant difference in mean UIC between boys and girls between 2007 and 2015. As the results show, the median and mean UIC were greater in urban children than in rural children in all years except 2012 and this difference was significant in all years except 2011 and 2012. Also, regular surveys from 2003 to 2006 indicated that the median UIC was ≥100 µg/l. Before the USI programme, it was <100 µg/l (data not shown).

Totally, the highest frequency of children with severe deficiency (UIC < 20 µg/l) was 21·3, 13·3 and 8·8 % in 2012, 2011 and 2010, respectively, while its frequency was ≤5 % in other years. More than 50 % of children had insufficient iodine status (UIC ≤ 99 µg/l) in both 2010 and 2011, while this rate was approximately 15–35 % in other years. More than 65 % of schoolchildren had UIC > 100 µg/l in all years except 2010 and 2011. The highest and lowest rate of UIC ≥ 300 µg/l was observed in 27·5 and 5·4 % of children, respectively. The proportion with UIC < 50 µg/l was <20 % and with UIC > 100 µg/l was more than 50 % among schoolchildren in all years except 2010 and 2011. Of children, 26·5 and 22·3 % had UIC < 50 µg/l and 45·0 and 40·4 % had UIC > 100 µg/l in 2010 and 2011, respectively. The lowest frequency of children with UIC < 50 µg/l was 6·9 % in 2008 (Table 2).

Our findings showed that in six years the frequency of UIC ≤ 99 µg/l was higher in boys than in girls; so that among boys its highest frequency was 55·0 % in 2010 and its lowest frequency was 16·7 % in 2013, while for girls these rates were 55·0 % in 2011 and 15·0 % in both 2008 and 2013, respectively. In all years, more than 50 % of both boys and girls had UIC > 100 µg/l; except its frequency among both boys and girls was 45·0 % in 2010 and 2011, respectively. The highest frequency of excessive iodine status (UIC ≥ 300 µg/l) was 31·7 % in 2015 and 27·5 % in 2008 for boys and girls, respectively. There was no significant difference in iodine deficiency by sex in all years except 2007 (*P* = 0·02; Table 3).

Table 4 shows the comparison of iodine status distribution of the schoolchildren by area. Rural children had iodine deficiency more than urban children in all years except 2012 and this difference was statistically significant

Table 1 Urinary iodine concentration (UIC) by gender and area among schoolchildren aged 8–10 years (*n* 240 per year, selected by systematic random sampling each year) in West Azerbaijan Province, north-west Iran (2007–2015)

	UIC (µg/l)																
	Total (*n* 240)			Boys (*n* 120)			Girls (*n* 120)			Urban (*n* 140)			Rural (*n* 100)				
Year	Mean	SD	Median	Mean	SD	Median	Mean	SD	Median	Mean	SD	Median	Mean	SD	Median	*P**	*P*†
2007‡	153·38	86·11	140	141·00	76·65	130	165·75	93·32	145	167·00	86·06	150	139·75	84·33	130	0·06	0·02
2008	205·67	113·71	180	197·42	117·73	170	213·92	109·41	190	229·57	106·76	210	172·20	115·21	145	0·17	<0·001
2009	155·67	101·67	130	149·50	89·56	130	161·83	112·53	130	163·43	100·54	140	144·80	102·75	110	0·9	0·05
2010	141·04	122·36	90	128·08	111·38	80	154·00	131·62	125	165·14	134·35	150	107·30	93·97	70	0·22	<0·001
2011	143·96	126·12	90	149·17	118·45	105	138·75	133·65	90	155·14	131·21	100	128·30	117·50	90	0·19	0·09
2012	171·45	120·49	160	174·67	131·93	160	167·33	108·28	155	169·36	130·49	150	173·30	105·49	165	0·83	0·53
2013	149·85	70·38	142·5	153·83	77·31	140	145·87	62·77	147·5	157·21	71·68	150	139·55	67·53	140	0·91	0·03
2014	169·79	105·28	140	167·50	111·62	140	172·08	98·96	200	184·00	110·94	220	149·90	93·78	125	0·64	0·007
2015	213·54	179·04	145	234·75	194·13	155	192·33	160·57	140	263·43	201·98	210	143·70	107·95	120	0·15	<0·001

**P* value from Mann–Whitney *U* test comparing between boys and girls.
†*P* value from Mann–Whitney *U* test comparing between urban and rural areas.
‡Number of children for both urban and rural areas was 120 subjects in 2007.

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Table 2 Iodine status distribution among schoolchildren aged 8–10 years (*n* 240 per year, selected by systematic random sampling each year) in West Azerbaijan Province, north-west Iran (2007–2015)

	Iodine status													
	Insufficient								Adequate		UIC ≥ 200 µg/l			
	Severe (UIC < 20 µg/l)		Moderate (UIC = 20–49 µg/l)		Mild (UIC = 50–99 µg/l)		Total (UIC ≤ 99 µg/l)		Adequate (UIC = 100–199 µg/l)		Above requirement (UIC = 200–299 µg/l)		Excessive (UIC ≥300 µg/l)	
Year	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
2007	12	5·0	12	5·0	46	19·2	70	29·2	96	40·0	46	19·2	28	11·7
2008	4	1·7	7	2·9	42	17·5	53	22·1	100	41·7	31	12·9	30	12·5
2009	8	3·3	10	4·2	61	25·4	79	32·9	100	41·7	31	12·9	20	12·5
2010	21	8·8	29	12·1	72	30·0	122	50·8	62	25·8	24	10·4	31	12·9
2011	32	13·3	10	4·2	80	33·3	122	50·8	52	21·7	46	19·2	20	8·3
2012	51	21·3	0	0·0	11	4·6	62	25·8	94	39·2	35	14·6	49	20·4
2013	6	2·5	7	2·9	25	10·4	38	15·8	169	70·4	19	7·9	14	5·8
2014	10	4·2	18	7·5	55	22·9	83	34·6	40	16·7	104	43·3	13	5·4
2015	10	4·2	21	8·8	47	19·6	78	32·5	61	25·4	35	14·6	66	27·5

UIC, urinary iodine concentration.

Table 3 Comparison of iodine status distribution by sex among schoolchildren aged 8–10 years (*n* 240 per year, selected by systematic random sampling each year) in West Azerbaijan Province, north-west Iran (2007–2015)

	Iodine status																
	Boys (*n* 120)								Girls (*n* 120)								
	Insufficient (UIC ≤ 99 µg/l)		Adequate (UIC = 100–199 µg/l)		Above requirement (UIC = 200–299 µg/l)		Excessive (UIC ≥ 300 µg/l)		Insufficient (UIC ≤ 99 µg/l)		Adequate (UIC = 100–199 µg/l)		Above requirement (UIC = 200–299 µg/l)		Excessive (UIC ≥ 300 µg/l)		
Year	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*P**
2007	39	32·5	55	45·8	18	15·0	8	6·7	31	25·8	41	34·2	28	23·3	20	16·7	0·02
2008	35	29·2	32	26·7	23	19·2	30	25·0	18	15·0	44	36·7	25	20·8	33	27·5	0·06
2009	36	30·0	59	49·2	14	11·7	11	9·2	43	35·8	41	34·2	17	14·2	19	15·8	0·1
2010	66	55·0	34	28·3	8	6·7	12	10·0	56	46·7	28	23·3	17	14·2	19	15·8	0·1
2011	56	46·7	31	25·8	26	21·7	7	5·8	66	55·0	21	17·5	20	16·7	13	10·8	0·15
2012	35	29·2	42	35·0	14	11·7	29	24·2	27	22·5	52	43·3	21	17·5	20	16·7	0·16
2013	20	16·7	82	68·3	9	7·5	9	7·5	18	15·0	87	72·5	10	8·3	5	4·2	0·69
2014	48	40·0	16	13·3	47	39·2	9	7·5	35	29·2	24	20·0	57	47·5	4	3·3	0·09
2015	35	29·2	31	25·8	16	13·3	38	31·7	43	35·8	30	25·0	19	15·8	28	23·3	0·46

UIC, urinary iodine concentration.
**P* value from χ^2 test comparing between boys and girls.

in 2008, 2009, 2010 and 2015. The highest frequency of UIC ≤ 99 µg/l was 62·0 % and 47·9 % in rural and urban children, respectively.

Elimination indicators of iodine-deficiency disorders

Elimination indicators of IDD are shown in Table 5. Iodized salt was consumed by 98 % of households. The TGR was 0·4 % and 97 % of salt samples examined at the household level by rapid testing kit showed iodization. Iodine levels <20, 20–40 and >40 ppm were observed in 12·5, 69·5 and 18·0 % of salt at the production level; 17·0, 52·0 and 31·0 % of salt at the distribution level; and 27·0, 52·5 and 20·5 % of salt at the household level, respectively, in the last national survey (in 2007). According to national guidelines, goitre was evaluated every 5 years in children. Because of the reduction of TGR to less than 5 % according to WHO/UNICEF/ICCIDD criteria[4], the last survey was conducted in 2007. The first national survey 2 years after iodization of salt in 1996 showed that the TGR was 44 % among children aged 8–10 years in West Azerbaijan Province. TGR decreased to 7·6 and 0·4 % in 2001 and 2007, respectively (Fig. 1). Regular surveys from 2002 to 2015 showed that 98 % or more of households consumed iodized salt. The last national study in 2014 showed that the median iodine content of household salt in West Azerbaijan was 27 ppm (data not shown).

Discussion

According to WHO statistics, IDD remain a public health problem in several countries[4]. There are still numerous places in the world where iodized salt is not available[3].

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Table 4 Comparison of iodine status distribution by area among schoolchildren aged 8–10 years (*n* 240 per year, selected by systematic random sampling each year) in West Azerbaijan Province, north-west Iran (2007–2015)

	Iodine status (*n* 240)																
	Urban (*n* 120)								Rural (*n* 120)								
	Insufficient (UIC ≤ 99 µg/l)		Adequate (UIC = 100–199 µg/l)		Above requirement (UIC = 200–299 µg/l)		Excessive (UIC ≥ 300 µg/l)		Insufficient (UIC ≤ 99 µg/l)		Adequate (UIC = 100–199 µg/l)		Above requirement (UIC = 200–299 µg/l)		Excessive (UIC ≥ 300 µg/l)		
Year	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*P**
2007	27	22·5	51	42·5	24	20·0	18	15·0	43	35·8	45	37·5	22	18·3	10	8·3	0·09
2008	18	12·9	46	32·9	32	22·9	44	31·4	35	35·0	30	30·0	16	16·0	19	19·0	<0·001
2009	37	26·4	67	47·9	15	10·7	21	15·0	42	42·0	33	33·0	16	16·0	9	9·0	0·02
2010	60	42·9	41	29·3	15	10·7	24	17·1	62	62·0	21	21·0	10	10·0	7	7·0	0·015
2011	67	47·9	30	21·4	29	20·7	14	10·0	55	55·0	22	22·0	17	17·0	6	6·0	0·55
2012	41	29·3	49	35·0	17	12·1	33	23·6	21	21·0	45	45·0	18	18·0	16	16·0	0·11
2013	18	12·9	99	70·7	13	9·3	10	7·1	20	20·0	70	70·0	6	6·0	4	4·0	0·3
2014	43	30·7	23	16·4	63	45·0	11	7·9	40	40·0	17	17·0	41	41·0	2	2·0	0·15
2015	36	25·7	31	22·1	21	15·0	52	37·1	42	42·0	30	30·0	14	14·0	14	14·0	0·001

UIC, urinary iodine concentration.
**P* value from χ^2 test comparing between boys and girls.

Table 5 Sustainability indicators of elimination of iodine-deficiency disorders in the West Azerbaijan Province, north-west Iran*

Indicator	Result		
1. Salt iodization: proportion of households using adequately iodized salt		98 %	
2. Total goitre rate		0·4 %	
3. Colour change of rapid testing kit		97 %	
4. Distribution of salt iodine content	<20 ppm	20–40 ppm	>40 ppm
Production level (%)	12·5	69·5	18·0
Distribution level (%)	17·0	52·0	31·0
Household level (%)	27·0	52·5	20·5

*Data from the last national survey in 2007.

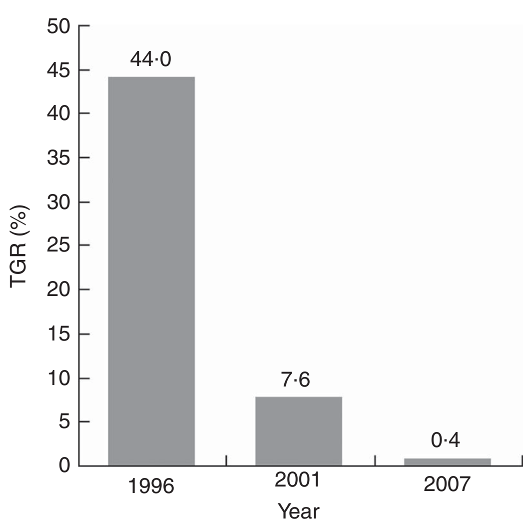

Fig. 1 Total goitre rate (TGR) among schoolchildren aged 8–10 years in three national surveys in West Azerbaijan Province, north-west Iran

Regarding the adverse effects of iodine deficiency on community health[9,28], baseline IDD prevalence studies and regular follow-up surveys, including measurement of urinary iodine levels and an analysis of the salt situation, are necessary. The current study aimed to assess the UIC, TGR and the sustainability of elimination indicators of IDD in the West Azerbaijan Province of north-west Iran in nine consecutive years.

The current study showed that mean and median UIC were not significantly different between boys and girls. In six years, iodine deficiency (UIC ≤ 99 µg/l) was more prevalent in boys than girls. Fifty-five per cent of children had iodine deficiency (UIC ≤ 99 µg/l) in both 2010 and 2011, while this rate was approximately 15–35 % in other years. McDonnell *et al.* reported that the frequency of iodine deficiency was 68 % in boys and 79 % in girls in Melbourne, Australia[29]. According to the WHO/UNICEF/ICCIDD recommended criteria[4], the indicator of IDD elimination is a median value for UIC of 100 µg/l, and UIC should not be lower than 50 µg/l in more than 20 % of subjects. Also, based on these criteria, more than 50 % of children have should have UIC above 100 µg/l[4]. In the current study, 26·5 and 22·3 % of children had iodine level below 50 µg/l only in 2010 and 2011, respectively, while this rate was less than 20 % in other years, so that its lowest frequency was 6·9 % in 2008. More than 50 %

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of schoolchildren had UIC > 100 μg/l in all years except 2010 (45·0 % of children) and 2011 (40·4 % of children). Median UIC less than 100 μg/l in these two years is due to rural areas. Its possible cause may be the rural areas that are near to Lake Urmia, because these rural areas use lake salt instead of iodized salt. In two studies by Keshteli *et al.* and Khalili *et al.* in the central area of Iran, 16 % of children had UIC below 100 μg/l and 3·7 % had UIC below 50 μg/l[30,31]. Zimmermann reported that the prevalence of UIC < 100 μg/l in schoolchildren was 40 %, and children with UIC > 100 μg/l increased from 60 to 86 % in 1999 and 2004, respectively[32].

Our findings showed that rural children had iodine deficiency more than urban children and this difference was significant in some years. The results of Chirawurah and Addah's study showed that iodized salt consumption in rural households of northern Ghana was low; 20 % of households used iodized salt for cooking while 80 % did not cook with iodized salt[33]. Gupta *et al.* indicated that the prevalence of goitre was 18 % in rural areas and 7·5 % in urban areas of Lucknow, India[34].

Results of the current study showed that 98 % of households consumed iodized salt and 97 % of salt samples examined at the consumer level by rapid test kit showed iodization. Iodine level ≥20 ppm was observed in 87·5, 83·0 and 73·0 % of salt at the production, distribution and household level, respectively. The TGR decreased from 44 % in 1996 to 7·6 % in 2001 and 0·4 % in 2007. According to the WHO/UNICEF/ICCIDD recommended criteria, 95 % of salt for human consumption must be iodized and a salt iodine content of 20–40 ppm by titration must be found in ≥90 % of a representative sample of households. Also, these criteria suggest that the TGR should be less than 5 % in schoolchildren[4].

The availability and consumption of iodized salt in households in other studies have been reported as more than 90 %, consistent with the present results[35–37]. In a study by Kapil *et al.* conducted in Uttarakhand, India, only 46·7 % of the salt samples had iodine level ≥15 ppm[38]. In Jaiswal *et al.*'s study, the median (range) iodine concentration of household powdered and crystal salt was 55·9 (17·2–65·9) ppm and 18·9 (2·2–68·2) ppm, respectively, in Bangalore, India[39].

Before the USI programme, goitre was endemic in the majority of provinces in Iran including West Azerbaijan[24,25]. In a study by Azizi *et al.* in all provinces of Iran, the prevalence of goitre (grades 1 and 2) was 44 % in West Azerbaijan in 1996 (2 years after introduction of the law for the mandatory production of iodized salt)[25]. The results of another study by the same author indicated that the TGR decreased significantly from 53·8 % (in 1996) to 13·9 % (in 2001) after 7 years of uniformly iodized salt consumption by Iranian households[26]. Khalili *et al.* reported the overall goitre rate was 32·9 % in schoolchildren of Isfahan in 2005[31]. The overall goitre rate was 36·7 % in another study in the same area[40], while the overall goitre rate was 7·84 % in the study of Monajemzadeh and Moghadam in south-east Iran[41]. The overall prevalence of goitre was 12·6 % among children aged 6–12 years of Ambala, Haryana, India[42]. Coccaro *et al.* reported that the goitre prevalence was 3·8 % among schoolchildren living in urban central Italy[43]. The current study showed that the TGR was <5 %, which meets the WHO/UNICEF/ICCIDD criteria[4].

In summary, after the USI programme, West Azerbaijan Province achieved the WHO criteria on IDD elimination. Our study showed that, based WHO/UNICEF/ICCIDD recommendations[4], in the last national survey (13 years after USI) the TGR decreased to normal. The availability and consumption of iodized salt in households were 98 % or greater. The median UIC was ≥130 μg/l in all years except 2010 and 2011.

Conclusion

Our focused data suggest that the USI programme is improving the health of schoolchildren in the West Azerbaijan Province of north-west Iran since 1996, meeting all WHO/UNICEF/ICCIDD criteria for the sustainable elimination of IDD. The reduction of the TGR in schoolchildren to less than 5 % indicates the successful elimination of IDD as a major public health problem.

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