CLINICAL STUDY

A programme of iodine supplementation using only iodised household salt is efficient – the case of Poland

Z Szybinski, F Delange¹, A Lewinski², J Podoba³, M Rybakowa⁴, R Wasik⁵, L Szewczyk⁶, B Huszno, F Gołkowski, E Przybylik-Mazurek, M Karbownik², T Zak⁵, J Pantoflinski, M Trofimiuk and I Kinalska⁷

Department of Endocrinology, Medical College, Jagiellonian University in Krakow, Poland, ¹International Council for Control of Iodine Deficiency Disorders, Brussels, Belgium, ²Department of Thyroidology, Institute of Endocrinology Medical University in Łódź, Poland, ³Institute of Endocrinology, Bratislava, Slovak Republic, ⁴Polish-American Children's Hospital, Medical College, Jagiellonian University in Krakow, Poland, ⁵Department of Endocrinology for Children and Adolescents, Medical Academy in Wrocław, Poland, ⁶Department of Paediatric Endocrinology and Adolescent Diseases, Medical Academy in Lublin, Poland and ⁷Department of Endocrinology, Medical Academy in Białystok, Poland

(Correspondence should be addressed to Z Szybinski, Department of Endocrinology, Collegium Medicum, Jagiellonian University, Ul. Kopernika 17, 31-501 Krakow, Poland; Email: szybin@endo.cm-uj.krakow.pl)

Abstract

Background: Iodine prophylaxis in Poland started in 1935 and has been interrupted twice: by World War II and in 1980 for economic reasons. Epidemiological surveys carried out after the Chernobyl accident in 1989 as well as in 1992/1993 and in 1994 as a 'ThyroMobil' study, revealed increased prevalence of goitre in children and adults. Ninety per cent of Poland was classified as an area of moderate iodine deficiency, and 10%, in the seaside area, as mild iodine deficiency territory. Iodine prophylaxis based on iodisation of household salt was introduced again in 1986 as a voluntary model and in 1997 as a mandatory model with 30 ± 10 mg KI/kg salt.

Objective: The evaluation of the obligatory model of iodine prophylaxis in schoolchildren from the same schools in 1994 and 1999.

Methods: Thyroid volume was determined by ultrasonography. Ioduria in casual morning urine samples was measured using Sandell–Kolthoff's method, within the framework of the ThyroMobil study.

Results: Goitre prevalence decreased from 38.4 to 7% and urinary iodine concentration increased from 60.4 to 96.2 µg/l mean values between 1994 and 1999. In four schools the prevalence of goitre diminished below 5%. In 1999, 70% of children excreted over 60 µg I/l, and 36% over 100 µg I/l, whereas in 1994 the values were 44 and 13% respectively.

Conclusion: The present findings indicate that iodine prophylaxis based only on iodised household salt is highly effective.

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Introduction

Poland belongs to the European area of iodine deficiency known for years in the south-east as the old Carpathian endemia of goitre representing, 50 years ago, a severe grade of iodine deficiency with endemic cretinism. In the south-western part of the country a Sudeten endemia developed in the Polish population which migrated from the eastern territories after World War II. Iodine prophylaxis started in the Carpathian endemia in 1935 and was interrupted by World War II. For a period of 30 years iodine prophylaxis had spread almost all over the country when in 1980 it was interrupted again for economic reasons (1–3). Epidemiological surveys after the Chernobyl accident and the results of neonatal screening in the Krakow region revealed an increased

prevalence of goitre and transient hypothyroidism in neonates indicating a dangerous trend towards a severe iodine deficiency again (3–4). At the 42nd World Health Assembly in New York in 1990, Poland pledged the elimination of iodine deficiency by the year 2000 (5). In 1991 the Polish Council for Control of Iodine Deficiency Disorders (PCCIDD) was established in Krakow (3). In 1992/1993 a nationwide epidemiological survey, sponsored by the State Committee for Scientific Research and the Ministry of Health, was carried out in 20 000 randomised schoolchildren (3). To our knowledge it was one of the first European nationwide epidemiological surveys on endemic goitre and iodine deficiency in schoolchildren, based on sonography of the thyroid gland and determination of iodine excretion in urine. In 1994/1995 an international project: 'Standardised evaluation of iodine

Figure 1 Production of iodised household salt in Poland (1991–1999).

deficiency in Europe' chaired by F Delange (6) under the auspices of ICCIDD, UNICEF and WHO, sponsored by Merck KGaA Darmstadt and in Poland by Merck Polska SA – known as the 'ThyroMobil' study – was carried out in schoolchildren aged 6–13 years. The Polish part of the project focused on the selected areas with the highest prevalence of goitre not recognised previously in the nationwide project (7–10). The results of both surveys based on thyroid sonography and determination of urine iodine concentration demonstrated that Poland may be divided into two areas: the seaside area with mild iodine deficiency, representing less than 10% of the country, and the rest of the territory with moderate iodine deficiency (3, 7–12). In 1986 a voluntary model of iodine prophylaxis was introduced again with 25 ± 10 mg KI/kg household salt. In accordance with PCCIDD recommendations obligatory iodine prophylaxis was introduced in 1997 with 30 ± 10 mg KI/kg household salt (1). The dynamics of the iodised household salt production between 1990 and 1999 is shown in Fig. 1. In order to sustain elimination of iodine deficiency it is necessary to enter a phase of monitoring and evaluating the model of iodine prophylaxis – according to the recommendations of the National Programme of Elimination of Iodine Deficiency, which started in Poland in 1999 (13). As a first step in 1999 the ThyroMobil programme was repeated in the same schools and age groups as investigated in 1994.

The aims of the present study were: (i) To compare ioduria and prevalence of goitre in schoolchildren investigated in 1994 with the data obtained in the same schools and age groups in 1999, i.e. 5 years after dynamic increase of iodised salt production and 3 years

after introducing mandatory iodine prophylaxis. (ii) To analyse regional differences in the effectiveness of iodine prophylaxis.

Methods

The ThyroMobil study was developed in Poland in 12 primary schools (1371 children) selected in goitrogenic areas not randomised in the nationwide survey performed in 1992/1993. Of the schools investigated in 1994/1995, eight schools which were representative in terms of geographical and endemic features were selected for a comparative study carried out in 1999: two schools in the most goitrogenic areas in the Carpathians (Rychwald) and Sudetens (Karpacz), one school in Opoczno, two schools in Lublin district (Tomaszow Lubelski and Zwierzyniec), two schools in Tarnobrzeg district (Rudnik and Nowa Deba) and one school in the Vistula River area (Bobrek), a contrasting area with the lowest prevalence of goitre in the southern part of the country. In this way 884 schoolchildren aged 6–15 years, 466 girls and 418 boys, were investigated according to the same questionnaire and protocol as in 1994 (6).

The ThyroMobil van was equipped with an ultrasonographic (USG) device (Siemens Sonoline I-400 and 7.5 MHz linear array transducer). The thyroid volume was calculated as the sum of both lobe volumes, estimated according to the formula: $V(\text{ml}) = 0.479 \times \text{width} \times \text{depth} \times \text{length}$, without isthmus. USG measurements were performed in 1994 by the same sonographer (J Podoba) and in 1999 by newly trained physicians using real-time sonography according to Brunn *et al.* (14). To evaluate a prevalence of goitre the

Table 1 Comparison of goitre prevalence and ioduria in schoolchildren in the ThyroMobil programme in Poland between 1994 and 1999.

Schools	Investigation of 1994					Investigation of 1999				
	Prevalence of goitre		Ioduria ($\mu\text{g/l}$)			Prevalence of goitre		Ioduria ($\mu\text{g/l}$)		
	<i>n</i>	(%)	<i>n</i>	Mean	Vc	<i>n</i>	(%)	<i>n</i>	Mean	Vc
Rychwald	113	33.0	109	42.7	57.4	94	8.5	91	117.7	82.9
Karpacz	113	56.6	113	32.0	63.8	84	4.8	81	82.0	57.5
Tomaszow Lubelski	83	41.0	79	65.3	56.2	81	4.9	82	78.9	57.0
Zwierzyniec	128	37.2	125	55.9	64.0	118	13.7	117	80.9	70.7
Rudnik n/Sanem	206	35.0	202	93.1	60.9	98	13.3	98	107.2	61.4
Nowa Deba	101	55.4	99	82.1	57.6	102	10.8	99	98.1	58.3
Opoczno	107	35.2	98	32.0	64.1	207	1.5	207	110.6	68.2
Bobrek	101	16.8	100	54.3	57.5	100	3.0	98	76.9	75.3
Total	952	38.4	925	60.4	66.4	884	7.0	873	96.2	65.9

Vc, variation coefficient.

international standard of thyroid volume according to Delange *et al.* (6) was used.

Casual morning urine samples were collected just before USG measurements, deep frozen and sent to the laboratory to determine iodine concentration by means of Sandell–Kolthoff's catalytic method (15). The reference control laboratory at the Department of Clinical Chemistry of the Medical College of Jagiellonian University in Krakow was standardised by control samples traced to the reference laboratory of ICCIDD at St Peter's Hospital in Brussels.

Correlation analysis and analysis of variance (Statistica; Excel Microsoft) were used to test for statistical significance of the results.

Results

Between 1994 and 1999 the prevalence of goitre decreased significantly from a mean value of 38.4 to

7.0% and urine iodine concentration increased from a mean value of 60.4 to 96.2 $\mu\text{g/l}$ in the study children (Table 1).

Figure 2 shows differences between the study areas. In most schools the prevalence of goitre decreased by 80–95% whereas in two schools (Zwierzyniec and Rudnik) goitre was reduced by about 60%. It should be stressed that in four areas, Karpacz, Tomaszow Lubelski, Bobrek and Opoczno, the prevalence of goitre decreased below 5% and endemic goitre in those schoolchildren disappeared.

Ioduria is expressed best by distribution curves. In 1999, 36% of children excreted over 100 $\mu\text{g I/l}$ and 70% over 60 $\mu\text{g I/l}$ whereas in 1994 it was 13 and 44% respectively (Figs 3 and 4).

Figure 5 shows the prevalence of goitre by age and sex in 1994 and 1999. The numbers of examined children in age groups in 1994 and 1999 were comparable. The most significant decrease in goitre

Figure 2 Prevalence of goitre between 1994 and 1999 – differences between the study areas.

Figure 3 Distribution of iodine concentration in urine in the ThyroMobil programme in 1994 and 1999.

Figure 4 Iodine concentration in urine in schoolchildren classified according to severity in the ThyroMobil programme in 1994 and 1999.

Figure 5 Prevalence of goitre by age and sex in the ThyroMobil programme in 1994 and 1999.

prevalence was observed in the youngest group aged 6–8 years: from 34.9 to 5.9% in girls and from 33.1 to 8% in boys. In a group of children aged 9–11 years, decrease in prevalence of goitre was markedly greater in boys, whereas in a group aged 12–15 years it was greater in girls.

Discussion

The present study was an attempt at evaluating the effectiveness of a mandatory model of salt iodisation with 30 mg KI/kg household salt in Poland. The terms 'mandatory' or 'obligatory' in our model mean that 100% of table (kitchen) salt provided to the consumers was iodised, and non-iodised salt was not available on the market, with the one exception of special therapeutic low-sodium salt recommended in hypertension and circulatory insufficiency, which is more expensive than iodised salt and whose low production level does not influence the overall iodised salt consumption in Poland. By the disposition of the Ministry of Health, iodised table salt is not allowed in food production and processing in the food industry. In such conditions a good marker of iodised salt consumption is the monitoring of its production, which has been successively increasing especially since 1994/1995. This model is based on the following assumptions: general consumption of sodium chloride varies from 6 to 14 g/day per capita, hidden salt represents 40% as compared with 60% of household salt, the lost salt due to distribution and technology of cooking is 40%. In this way an effective iodine consumption is 55–111 µg/day per capita and fulfils daily requirement for children, adolescents and adults (12, 16–18). However, these amounts do not cover daily iodine requirements of pregnant women who should be supplied with an

additional 100–150 µg iodine per day. The control of quality of iodisation of household salt performed by the State Sanitary Office in 1999 revealed that over 90% of the samples complied with the standard 20–40 mg KI/kg household salt (1, 13).

The schools selected for the ThyroMobil programme represented the areas with the highest prevalence of goitre and with the additional risk factors of goitre such as high concentrations of calcium or sulphur compounds in water and soil (1, 3, 8–10). Therefore we expected a moderate effectiveness of iodine prophylaxis in those areas. However, we noticed that in most schools goitre prevalence decreased by 80–90% and in four schools it fell below the epidemiological criterion of 5% (12). The mean value of urine iodine concentration increased by 30%, and in about 40% of children it was over 100 µg/l, as compared with 15% in 1994 (Table 1, Figs. 3 and 4). These very positive results raise the question of which factors in our model determined such high effectiveness. One of the important factors was a dynamic increase in the production of iodised household salt in the last 10 years. The production started with 4000 tons in 1990 and increased 10-fold between 1992 and 1994, although in the framework of a voluntary model, where about 50% was still non-iodised table salt. From 1996 to 1999 it was about 80 000 tons, replacing non-iodised table salt, reaching the full capacity of the market and then in 1997 a mandatory model was introduced (Fig. 1). This dynamic increase may account for the fact that the best results were achieved in younger age groups (6- to 8-year-old children), in whom goitre practically disappeared. In older age groups (9- to 11-year-old children), iodine prophylaxis was more effective among boys than in girls, probably due to female puberty, a well-known risk factor of goitre (12, 16–18).

In a group of 12- to 15-year-old children the prevalence of goitre in boys did not change; however, it was relatively low in 1994. The effectiveness of iodine prophylaxis could have been diminished by puberty, which usually appears later in boys. We observed regional differences in goitre prevalence and effectiveness of iodine prophylaxis. A relatively smaller decrease of goitre prevalence, about 60%, was observed in the schools in the areas with deposition of chalk (Zwierzyniec) and sulphur compounds (Rudnik and Nowa Deba) (19). The results were better in relatively younger endemic areas (Opoczno, Tomaszow Lubelski and Karpacz) in comparison to the oldest Carpathian area (Rychwald). In Bobrek, where high concentration of iodine in the Vistula River is observed (20), the mean iodine concentration in urine increased by about 50%, and the prevalence of goitre diminished from 16.8 to 3.0%, i.e. to the non-endemic level.

When we compare the magnitude of goitre prevalence reduction with the increase of iodine concentration in casual morning samples of urine, we may conclude that mean iodine concentration is a weak indicator of the effectiveness of iodine prophylaxis. Daily iodine intake is much better reflected by the distribution of the iodine concentration against its ranges. Our results indicate that when 40% of children excrete more than 100 µg/l per day of iodine and about 20% 80–100 µg/l per day, it is enough to achieve very good results in the most severe parts of endemic areas in the country in a relatively short period of time. However, it is worth noting that in older groups, especially among pubescent girls, endemic goitre has not been entirely eradicated. To achieve such an effect in endemic areas, especially in older groups of children, will require a longer time of consistent application of obligatory iodine prophylaxis.

Such high effectiveness of the mandatory model, when only table salt is iodised, raises the question whether eating habits could have modified the prevalence of goitre during the observation. In our studies carried out in schoolchildren in 1992, 1994 and 1999 we evaluated daily iodine intake based upon 24 h diet reports on consumption of iodine carriers such as fish, milk, eggs, vegetables and meat, and we obtained similar data where daily iodine intake varied from 30 to 70 µg. This problem is especially important if faced with the phenomenon of 'the silent iodine prophylaxis' based only on consumption of high iodine carriers (21). Such a situation is commonly observed in countries of high iodine intake in the daily diet, such as Japan or in some large regions of the USA. However, it has never been sufficiently proved that a change in eating habits on a population level in areas of iodine deficiency and endemic goitre, with low iodine concentration in water and soil and therefore low iodine carriers consumption, could eradicate endemic goitre (21). In Poland the situation is especially unfavourable and the increased consumption of iodine carriers cannot be seriously

taken into consideration. In the recently published report of the Polish Food and Nutrition Institute a marked decrease in consumption of the main iodine carriers such as fish, eggs and milk within the last few years was demonstrated (22). A new impact on daily iodine intake was introduced by increasing iodised salt consumption in the years from 1994 to 1996 and finally in the years 1997 to 1999 when the mandatory model was implemented.

Therefore we may assume a cause–effect relationship between our model and goitre prevalence reduction in schoolchildren in Poland (23–25).

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