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Towards the eradication of iodine-deficiency disorders in Brazil through a salt iodination programme

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Iodine-deficiency disorders have been a serious public health problem in Brazil because of the failure of a salt iodination programme established in 1953. The reasons for this failure were logistical, e.g., potassium iodide was not supplied to all salt-producers, iodination of salt was largely erratic, and part of the population at risk used only non-refined salt, which was not iodinated. In 1978 a task force was therefore formed to implement measures to eliminate iodine-deficiency disorders from the country. For this purpose, potassium iodate was distributed, free-of-charge, to all salt mills and an iodate dosing spray was supplied without cost to small salt producers. Also, regional laboratories for determining iodine in salt were set up, inspectors made regular visits to the salt mills, and samples of salt from commerce and from the producers were analysed. More than 90% of the samples contained 10–30 mg iodine per kg. In three typical areas of the country with endemic goitre the urinary excretion of iodine increased from an average of less than 40 μg iodine to 125 ± 38 μg iodine per g creatinine. In conclusion, the salt iodination programme was a complete success and could serve as a model for other countries with a high prevalence of iodine-deficiency disorders.

INTRODUCTION

Iodine-deficiency disorders and related conditions have been a serious public health problem in Brazil, as shown by two national surveys of the prevalence of endemic goitre among schoolchildren in 1955 and 1975 as well as by the existence of areas with endemic cretinism, deaf-mutism, and an elevated prevalence of neonatal hypothyroidism (*1–10*). During the 1960s, the Ministry of Public Health developed a programme for iodinating cooking salt. However, this was largely a failure for the following logistical reasons: the potassium iodide was obtained from abroad and was supplied to salt works only at irregular intervals. Moreover, much of the salt consumed in the endemic areas was not iodinated.

Thus, much of the legislation introduced by the Brazilian House of Representatives since 1953, and amended by several decrees, failed, in part, to effectively control and eradicate iodine-deficiency disorders from the country (Table 1).

By 1974, salt iodination efforts in Brazil had become increasingly lax, for the following reasons: the uncertain economic position of the salt producers, many of which are small; lack of awareness, financial support, and control of the health authorities and of the salt producers; and use of unreliable iodinating procedures, including unsuitable equipment as well as of untrained personnel.

Because of the enormous socioeconomic consequences of endemic goitre for the country, in 1978 the Ministry of Health devised a programme to combat the problem. Responsibility for the effort was assigned to the Task Force for Specific Nutritional Deficiences. However, only after the Ministerial Regulation MSO27 had been signed, on 2 March

Table 1. Outline of legislation on salt iodination, and prevention and control of endemic goitre in Brazil, 1953–77

1. *Law No. 1944, 14 August 1953:* requires iodination of cooking salt (10 mg iodine/kg salt) destined for human consumption in the goitrous regions of the country.
2. *Decree No. 39 814, 17 August 1956:* designates the goitrous areas of Brazil and orders the use of iodinated salt.
3. *Law No. 6150, 3 December 1974:* requires the iodination of salt for human consumption and establishes its control by the sanitary authorities.
4. *Decree No. 75 697, 6 May 1975:* improves standards of identification and quality of salt for human consumption.
5. *Decree No. 80 563, 20 October 1977:* establishes standards of identification and quality of salt for animal consumption.

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1982, were procedures and activities formally established and a technical group for central coordination set up.

Under the programme, responsibility for implementing measures to eliminate endemic goitre rested with the Instituto Nacional de Alimentação e Nutriçao (INAN) and the Superintendencia de Campanhas de Saúde Pública (SUCAM). The programme's main action was to formulate a scheme to iodinate salt destined for human or animal consumption, beginning in January 1983. Also, a number of research epidemiologists were enlisted to assist in developing the programme.

Studies of the national prevalence of goitre among schoolchildren were made in Brazil in 1955 and again in 1975; overall, a decrease of only 6.5% for this condition occurred over this 20-year period, despite an enormous reduction in grade 3 goitre (*4*). The 1975-study covered 421 756 schoolchildren aged 7–14 years, 203 251 boys and 218 505 girls, who had goitre prevalences of 11.7% and 16.3%, respectively (see Table 2).

Table 2. Prevalence of goitre among schoolchildren, Brazil, 1975[a]

State	No. of children examined	Percentage with goitre
Rondônia	2019	31.3
Acre	1840	15.4
Amazonas	8680	12.0
Roraima	1106	1.3
Pará	14 536	12.3
Amapá	3725	4.9
Maranhão	13 150	25.7
Piauí	9216	3.1
Ceará	19 547	6.3
Rio Grande do Norte	12 400	0.7
Paraíba	11 571	1.0
Pernambuco	17 331	10.0
Alagoas	10 650	9.6
Sergipe	6084	1.5
Bahia	26 239	33.3
Minas Gerais	55 527	28.6
Espirito Santo	10 525	12.4
Rio de Janeiro	27 070	14.5
São Paulo	51 115	18.7
Paraná	31 587	1.5
Santa Catarina	16 054	1.3
Rio Grande do Sul	30 592	7.2
Mato Grosso	15 152	16.3
Goiás	17 243	13.8
Distrito Federal	8793	3.0
Total	421 752	14.1

[a] See reference (*4*).

Structure of salt production in Brazil

Before 1976 in Brazil, all salt was extracted and processed from sea water; today, only sea salt accounts for human or animal consumption. Exploration for terrestrial sources of salt began in the states of Alagoas and Bahia, in the north-east of the country, in 1977, with all such salt being designated for use in the chemical industry.

Approximately 73% of the crude sea salt extracted is improved through milling and refining; the production of milled and refined salt in 1983 reached 2.1 million tonnes, 70% of which was milled, while the rest was refined. The technical specifications for sodium chloride assure that its quality is comparable with that of internationally competitive sources.

METHODS

Programme to combat endemic goitre

In February 1982, the Ministry of Health set up a technical group to coordinate the programme, while in November 1982, the INAN appointed the group members and established their responsibilities. In 1983, this group proposed legislation aimed at preventing endemic goitre and submitted it for approval. The programme's objective was to reduce the prevalence of endemic goitre to acceptable public health levels and to eliminate endemic cretinism from the country.

The effort called for the resumption of salt iodination programmes at the national level, and examples of its implementation have included the following:

— assuring that iodine in the form of potassium iodate is acquired for distribution to all salt producers;
— registering all salt producers;
— developing simplified iodate-dosing equipment for distribution to salt producers;
— increasing the iodine content of salt from 10 mg/kg to 30 mg/kg;
— proposing modifications in the present legislation dealing with salt iodination and the prevention of endemic goitre;
— providing technical assistance to salt producers and exercising systematic control of iodination; and
— setting up planning and operational mechanisms for surveillance and funding of salt iodination at the production and marketing levels.

A further objective was to define goals for programme improvement, including:

—implementation of studies and of periodic epidemiological research in areas with low and high prevalences of endemic goitre;
—correlation of the data obtained with those on consumption of iodinated salt;
—evaluation of the technical aspects of the programme; and
—promotion of education and publicity campaigns.

Outline of the salt iodination programme

Implementation of the salt iodination programme began in January 1983. The programme was initiated in the principal salt-producing states of Rio Grande do Norte, Rio de Janeiro, Rio Grande do Sul, São Paulo, Ceará, and Paraná, which together account for about 90% of Brazil's refined and milled salt production. Subsequently, the programme expanded to encompass all salt-producing states in the country. Altogether, 172 refineries and milling plants in 50 communities are covered.

Since it is common practice in rural areas of Brazil to use agricultural salt for human consumption, the concern of the Ministry of Health about assuring also iodination of salt intended for agricultural use is justifiable. Generally, such rural areas coincide with those that exhibit the greatest prevalence of goitre. Also, it is impossible to distinguish between the consumers of the final product—agricultural users or the rural population. For this reason, the legislation proposed to the National Congress stipulates that all salt produced for human and animal consumption should be iodinated.

The technical group of the programme has the following responsibilities:

—to establish, with the participation of the regional directors of SUCAM, basic norms and standards relating to the distribution of dosing equipment and of iodate;
—to provide technical information and other assistance to salt producers;
—to propose modifications in the legislation;
—to promote acquisition of iodate and iodination equipment by the state;
—to establish a model dosing protocol for distribution to the salt industry;
—to establish permanent mechanisms of financing the purchase of and standards of purity for the iodate;
—to train the personnel responsible for carrying out the activities of the project;
—to make yearly proposals of goals and a detailed work schedule, to be developed jointly with SUCAM and INAN;
—to establish medium- and long-term goals for improving the programme;
—to collaborate with the regional directors of SUCAM in establishing the structure and technical support for carrying out these activities; and
—to coordinate and evaluate the iodination project.

In turn, the responsibilities of the SUCAM regional directors include the following:

—to establish baseline data, by means of a questionnaire, on the status of salt production;
—to promote the allocation of specific personnel in sufficient numbers to handle the prescribed activities, including a coordinator who is responsible to the technical group;
—to aid in the acquisition and distribution of equipment for iodate dosing, especially to those plants with the greatest need;
—to encourage and reactivate laboratories dedicated to the control of salt iodination, including providing reagents and other materials for determination of iodine;
—to inform the industry of the proper procedures for salt iodination and to collect samples for analysis;
—to supply producers with information about the importance of iodination;
—to make weekly visits to plants, through an agent designated for this purpose, to collect salt samples, and to obtain the results of the analyses of these samples;
—to designate another agent to visit plants at least once monthly, without prior announcement, to conduct on-site analyses of the iodine content of salt using portable laboratory equipment, as well as to inspect, *inter alia*, the dosing equipment and iodate stock; and
—to propose any changes or modifications needed in the operation of the programme.

Finally, the salt producers have the following responsibilities:

—to follow conscientiously salt iodination procedures;
—to permit free access by the SUCAM agents to installations;
—to be receptive to the educational and control efforts of the SUCAM agents;
—to follow rigorously a daily schedule of collecting salt for analysis, with each machine and each shift providing two samples daily; and
—to designate an individual to be responsible for receiving the potassium iodate and dosing equipment.

RESULTS

All the 172 salt refining and milling plants surveyed from 1983 to 1986 were offered appropriate technical

Table 3. Summary of the results of the salt iodination programme, Brazil, 1983–86[a]

Year	No. of salt mills	Salt produced (tonnes x 10^3)	Potassium iodate consumed (kg)	No. of samples analysed	% of samples with no iodine	% of samples with >30 mg iodine/kg	% of samples with 10–30 mg iodine/kg
1983	172	1597	55.65	63 830	10.8	1.8	88.4
1984	171	1621	56.69	84 926	0.5	9.8	89.6
1985	187	1735	59.47	76 367	0.3	8.6	91.1
1986	189	1578	54.79	70 900	0.1	12.2	89.7

[a] Data provided by INAN/SUCAM, Ministry of Health, Brazil.

assistance. Dosing equipment has been developed and 176 of the 200 units needed have already been put into operation in salt plants. A total of 43 SUCAM employees, including sanitarians, inspectors, laboratory technicians, and public health agents, have been trained to carry out, assist, and control the iodination of salt at the national level. This allows a ratio of one trained person per four salt plants assisted.

In December 1986, 33 support laboratories, both permanent and mobile, were set up to analyse and control the dosage of salt with iodate. Annually, 55–65 kg of potassium iodate was acquired, of which 34.4 kg was distributed to the plants; of this amount, however, 30.58 kg was used to produce iodinated salt. The potassium iodate used in the programme is produced in Brazil, but the iodine required for its preparation has to be imported.

Table 3 summarizes the results of the analysis of randomized salt samples carried out by the SUCAM laboratories, which are located in several states of Brazil.

From 1983 to 1986 there was a modest increase in the number of salt mills and refineries from 172 to 189, but the total amount of salt produced annually remained basically constant at 1.57 million tonnes. Altogether, the iodine content of 63 830–84 926 samples of salt was determined each year. In 1983 about 10% of the salt produced in the country contained no iodine and, unfortunately, the majority of the regions with the highest goitre received this low quality salt. By the end of 1986, however, only 0.1% of the samples analysed had not been iodinated. A few samples, nevertheless, contained more than 30 mg iodine per kg salt, which was caused by excessive exposure to the potassium iodate spray. Most samples of salt contained 10–30 mg iodine per kg.

As a result of this effective salt iodination programme, the mean urinary excretion of iodine for the populations in three of the main areas with endemic goitre (Pocone, Luziania, and Balsas) increased from less than 40 μg iodine per g creatinine (1975–79) to 125 ± 38 μg iodine per g creatinine in 1987.

Kiy et al. (*13*) have recently independently verified the effects of this highly effective salt iodination programme in a study of the thyrotropin (TSH) response to thyrotropin-releasing hormone (TRH) of patients with goitre—both before (1982) and after (1983–86) introduction of the programme. Patients in area M (Table 4), who consumed salt with a low iodine content, exhibited a significantly higher peak TSH response to TRH than those in the SP area, who received iodinated salt. The increase in the level of

Table 4. Serum concentrations (mean ± SD) of triiodothyronine, thyroxine, thyrotropin (TSH) (basal) and TSH (peak) after administration of thyrotropin-releasing hormone (TRH) to patients from areas with chronic iodine deficiency (M) and in individuals receiving iodine supplementation (SP)

Area	Serum concentration of:				
	Triiodothyronine (ng/dl)	Thyroxine (μg/dl)	TSH (μU/ml)		ΔTSH[a] (μU/ml)
			Basal	Peak	
M	160 ± 39	7.4 ± 1.9	6.6 ± 3.2	33.0 ± 20.4	24.8 ± 18.3
SP	189 ± 44[b]	9.8 ± 2.4	2.6 ± 5.5[b]	9.1 ± 15.9	6.6 ± 10.8[b]

[a] Difference between the basal and peak concentrations of TSH.

[b] $P < 0.001$ compared with patients in the area with chronic iodine deficiency (see reference (*13*)).

thyroid hormones produced after adequate dietary intake of iodine is the main reason for the improved thyroid-pituitary regulation pattern of these patients.

In a separate study involving two endemic areas with a very high prevalence of foci of goitre and endemic cretinism, young adults, children, and women of child-bearing age were injected with iodinated oil. The results indicate that after administration of the oil there was a marked reduction in goitre size, a tendency for normalization of the thyroid–pituitary relationship, an absence of circulating autoantibodies (antimicrosomal), and a progressively lower mean serum concentration of thyroglobulin (*11*, *12*).

In conclusion, it can be stated that the salt iodination programme described was a complete success and could serve as a model for other countries with a high prevalence of iodine-deficiency disorders.

RÉSUMÉ

VERS L'ÉRADICATION DES AFFECTIONS DUES À LA CARENCE IODÉE GRÂCE À UN PROGRAMME D'IODATION DU SEL DE CUISINE (BRÉSIL)

La législation introduite au Brésil en 1953 et stipulant que le sel destiné à la consommation humaine devait être iodé dans les régions où la carence iodée chronique est courante a été amendée à plusieurs reprises au cours des 20 années qui ont suivi. Toutefois, les législateurs n'ont pas totalement réussi à éradiquer les affections dues à la carence iodée, pour les raisons suivantes: situation économique fragile des producteurs de sel; insuffisance de l'information, du soutien financier et du contrôle de l'industrie du sel; utilisation d'un système peu fiable pour l'iodation du sel: importation d'iodure de potassium à des intervalles irréguliers, insuffisance du matériel et insuffisance de la formation du personnel. En raison des répercussions socio-économiques considérables des affections dues à la carence iodée au Brésil, un groupe spécial, composé de représentants de l'Agence nationale de l'Alimentation et de la Nutrition (INAN), de l'Agence pour les Campagnes de Santé publique (SUCAM), de l'industrie du sel et des universités, a été constitué en 1982. Le programme établi par ce groupe a été mis en œuvre, et a conduit à procéder à des enquêtes sur les 172 salines du pays et à leur offrir une assistance technique. L'iodate de potassium a été importé par le Gouvernement fédéral et a été fourni à titre gratuit à tous les producteurs de sel. Le matériel de dosage a été mis au point et les 176 unités nécessaires ont été mises en service. Enfin, 43 inspecteurs fédéraux (SUCAM) ont été formés afin de mettre en œuvre, d'encourager et de contrôler l'iodation du sel au niveau national. A la fin de 1986, 33 laboratoires de soutien ont été établis en vue d'analyser et de surveiller l'adjonction d'iode au sel. L'industrie privée a été encouragée à produire l'iodate de potassium à partir de l'iodure importé.

En 1983, sur 64 926 échantillons de sel analysés dans le cadre du programme, 10% environ étaient dépourvus d'iode. En 1986, cette proportion était tombée à 0,1%. Plus de 90% de tout le sel de cuisine consommé dans le pays contenait 10 à 30 milligrammes d'iode/kg. Parallèlement, on a observé dans les régions où le goitre était endémique une augmentation de l'excrétion urinaire d'iode, passant de moins de 40 μg/g de créatinine à 125 ± 38 μg/g de créatinine.

On peut donc conclure que le programme d'iodation du sel au Brésil est une réussite et peut servir de modèle pour d'autres pays dans lesquels il existe une forte prévalence d'affections dues à la carence iodée.

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