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CONTROL OF IODINE DEFICIENCY THROUGH SAFE USE OF IODIZED SALT

Iodine, one of the essential trace elements, occupies a prominent place in human health. It is an important constituent of thyroid hormones, produced in the thyroid gland which is necessary for normal growth and development. Goitre or enlargement of the thyroid gland is one of the common and visible consequences of iodine deficiency.

Role of Iodine in Development of Goitre

Iodine is rapidly absorbed from the ingested food and water, and is accumulated in the thyroid gland by a concentrating mechanism. By means of enzyme reactions in the thyroid gland, iodine is organified to produce thyroxine (T4) and triiodothyronine (T3), the thyroid hormones. The lower blood levels of these hormones due to inadequate intake of iodine in food and water, induce increased formation of a pituitary hormone, thyroid stimulating hormone (TSH), which increases the multiplication and growth of the cells in the thyroid gland. This is the mechanism by which goitre occurs in iodine deficiency.

The development of goitre is considered to be an adaptive response to sequester more iodine to compensate for iodine deficiency. Other factors responsible for goitre are intake of goitrogenic substances like thiocyanates in diet, which interfere with iodine metabolism.

Iodine Deficiency Disorders

In endemic areas, the entire population is at risk of developing iodine deficiency disorders (IDD), with different age groups manifesting a spectrum of consequences (Table I). Iodine deficiency in women leads to pregnancy wastage in the form of abortions or still-births, and in the newborns, mental deficiency and dwarfism (cretinism) are encountered. Different grades of goitre, reduced physical capacity due to loss of energy and impaired coordination, learning and poor intellectual development are often associated with children and adults exposed to iodine deficient environment.

Table I. Consequences of iodine deficiency at different stages of life

Foetus	Neonates	Children/ Adolescents	Adults
Abortions	Goitre	Goitre Juvenile hypothyroidism	Goitre
Still births	Neonatal clinical hypothyroidism	Impaired mental function	Impaired mental function
Cretinism		Retarded physical development	Hypothyroidism

Causes and Magnitude of IDD

IDD are a significant global public health problem affecting 118 countries, including India. It is estimated that about 167 million persons are at the risk of IDD in India, including the 54 million with goitre, 2.2 million with cretinism and 6.6 million with mild neurological deficits. No state in the country is believed to be free from IDD (Fig. 1)[1].

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Fig 1. Map of India depicting prevalence of endemic goitre

While at one time, endemic iodine deficiency was considered to be confined to the Himalayan mountain areas, over the years, the sub-Himalayan plains and coastal regions of India have been added to the list of endemic areas, making IDD a widespread problem all over India.

Food (90%) and water provide the daily requirement of iodine in human beings. Among the animal foods, sea fish feeding on iodine-rich sea weeds, poultry and eggs and dairy products form rich sources of iodine. The iodine content of common food items like cereals, pulses, vegetables and fruits is dependent on the soil content of iodine. Depletion of iodine in the soil as a result of chain of eco-degradative activities like deforestation, frequent floods and rivers changing course was mainly responsible for the increasing magnitude of environmental iodine deficiency.

Iodine Requirements

The minimum iodine requirements, sufficient to meet growth and functional needs for different age groups, are different, and are given in Table II (WHO/UNICEF/ ICCIDD, 1993)[2]. The iodine requirement for children increases with age. In the case of adults, an intake of about 150 µg/day is considered to be sufficient to meet the physiological needs. At all levels of intake, a fraction of the body iodine is excreted in urine. Urinary iodine is sensitive to dietary iodine intakes and is usually used as a biochemical indicator of iodine status of the community, along with the prevalence of goitre.

Table II. Recommended daily intake of iodine[2]

Age	Intake (µg)
0 - 6 months	40
6 - 12 months	50
1 - 10 years	70 - 120
11 years - Adulthood	120 - 150
Pregnancy	175
Lactation	200

Superscript number refers to the reference number

Control of IDD

Following the pioneering Kangra Valley study between 1956-62, in which the efficacy of iodised salt was proven in the control of IDD[3], the Government of India adopted the National Goitre Control Programme (NGCP) in 1962 to supply iodized salt in endemic areas. However, even after decades of implementation of the NGCP, the desired objectives were not achieved. Various factors attributed for the failure are inadequate production and supply of iodised salt, ignorance of the community about the ill effects of iodine deficiency, apathy of local health personnel, lack of coordination in implementation and deficiences in monitoring and enforcement of Prevention of Food Adulteration (PFA) Act.

Universal Iodization of Salt

With mounting evidence of the increasing magnitude of IDD in the country on the one hand, the resulting heavy burden on society, the poor quality of life and the drain of human resources on the other, the Government of India, in 1984, adopted the policy of Universal Iodization of Salt by 1995, and accordingly modified the organisation and management of the NGCP. The NGCP was changed to the National IDD Control Programme (NIDDCP) in 1992. The National Nutrition Policy of the Government of India has set a goal of reducing IDD to less than 10 per cent by the year 2000 AD. The PFA Act was amended in 1988, as per this the iodised salt should contain at least 30 ppm of iodine at the production level and a minimum of 15 ppm at the retail level.

The technology involved in fortification of salt with iodine is simple and the country has resources and production capabilities to handle huge quantities of iodized salt necessary for covering the requirements of both man and

animals in India[4]. Considering a requirement of about 6 kg per individual, per annum (including requirements for animals), about 56 lakh tonnes of salt are required for the country and more than 60 per cent of this is being currently produced. The capability to enhance the production to meet the increasing demand of iodised salt, exists. Ban on the sale of non-iodized salt by the state governments to create a demand for iodized salt is an important component in the universal iodization approach. By 1996, almost all the state governments except one state and two union territories have issued such ban notifications (Information presented by the Salt Commissioner at the "State level meeting on universal access to iodized salt in Kerala, Thiruvananthapuram", May, 1996).

Concern for Safety in Non-iodine Deficient Population

In the past 50 years, many countries in the globe have eliminated IDD or substantially controlled them largely as a result of salt iodisation. While universal salt iodisation has been endorsed in a number of international forums, a question often raised is whether exposure to additional supplements of iodine may result in undesirable effects, especially in those already taking adequate iodine

Safe Limits of Iodine Intake

As with many trace elements, changing dose tends to diminish response at both extremes of intake. However, the safety level of nutrient should be from the point of view of providing minimum requirements, and not exceeding the level compatible with normal functions. A series of studies on the habitual intakes of iodine reported from different countries is presented in Table III[5-8]. In many countries including India the daily intakes range from 0.17-1.29 mg. In countries like FRG and Denmark the levels are lower. Intakes less than 50 µg/day are definitely deficient, and amounts in the range of 100-300 µg are considered optimal, functionally. There are a series of long-term studies showing the upper limits of iodine intake and their effects on the health of normal population (Table IV)[5,6]. Daily intakes above 2000 µg are possibly excessive and are accompanied by toxicity. A typical dose response curve depicting the zones of safety according to van der Haar[9] but modified in the light of recent studies is depicted in Fig. 2. Intake of iodine in the range of 300-1000 µg are consistent with normal function and could be considered safe.

Table III. Reported dietary intakes of iodine in different countries[5-8]

S.No.	Country	Year	Total iodine intake mg/day	
			Mean	Range
1.	USA	1986-89	0.34, 0.39, 0.65, 0.29, 0.47, 0.27, 0.36	0.16-0.95
2.	Canada	1987	1.04	
3.	Japan	1986	0.54, 0.19, 1.29	0.059-4.746
4.	Australia	1971 & 73	0.20	
5.	Netherlands	1954 & 82	0.21	
6.	England	1985 & 91	0.28 (Normalized 0.17) 0.17	
7.	FRG	1985		0.05-0.06
8.	Denmark	1985		0.06-0.07
9.	France	1985		0.10-0.15
10.	India	1989 1993		0.17-0.30 0.28-0.36

Recommended intake : 150 µg/day (WHO, 1993)[2]
Superscript numbers refer to the reference numbers

Table IV. Upper limits of safety for iodine intake[5,6]

	Author	Year	Iodine intake/day
1.	Nelson, UK Lee	1985 1994	200 to 380 µg
2.	Pennington, USA	1989	210 to 950 µg (no side effects)
3.	Wolff, Global	1969	10 times requirements level equivalent to 1.8 mg only produced toxicity and goitre
4.	FNB, RDA 9th Edn. USA	1980	500 to 1000 µg–Safe for adults
5.	FNB, RDA 10th Edn. USA	1989	Safe upto 1 mg/day for children and 2 mg for adults
6.	AMA, USA	1980	Less than 1 mg non-hazardous
7.	Thomas WC, USA	1978	Iodinated water supply 1 to 2 mg–no changes in thyroxine–no toxicity even in neonates born to mothers taking 1 mg iodine
8.	Joint FAO/WHO Expert Committee on Food Additives	1989	Maximum acceptable daily intake 1 mg
9.	Pennington, USA	1990	Intake equal to or less than 1 mg probably safe but may cause side effects in some individuals

Superscript numbers refer to the reference numbers

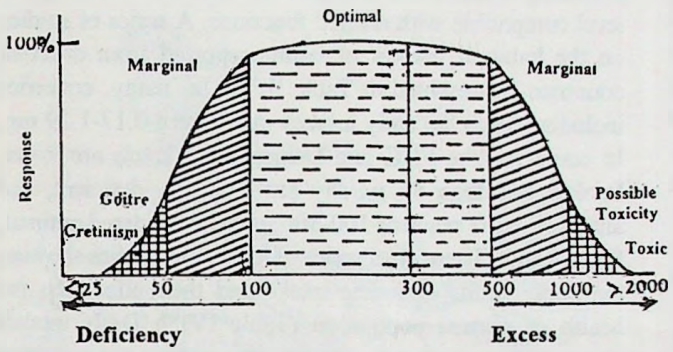

Fig 2. Dose response curve of iodine in human

Toxicity

Many of the earlier reported adverse effects associated with high intakes like allergic reactions and thyrotoxicosis have not been encountered in the more systematic follow up studies. Allergic reactions have been extremely rare and are unlikely to occur following salt iodization, though normal population exposed to excess iodine remain in euthyroid state through adoptive mechanisms. Many subsequent studies revealed that a very few instances of thyroiditis and iodidegoitre were found only in those individuals with preexisting thyroid disease, and not due to intake of iodized salt *per se*. In such cases, incidence of hyperthyroidism was observed. In other instances the phenomenon of hyperthyroidism occuring in endemic areas was very transient and ceased after corrections of iodine deficiency through supplementation of iodine, and did not occur in those with sufficient normal iodine intake[5,10].

To derive safe lower and higher limits of iodine, particularly from iodized salt, it is essential to consider the stability of iodine and the amount of salt consumed. The moisture content in salt, humidity in the air, acidity of the salt and chemical form of the iodine are important factors limiting the stability of iodine. Losses in cooking and extent of absorption are often the other factors which will determine the ultimate availability of iodine to the body.

Stability of Iodine in the Salt

As per the Salt Commissioner's report (Information presented at the "Strategy workshop for eliminating micronutrient malnutrition in India" in Jaipur, November 1-2, 1995) about 72 per cent of the iodized salt samples supplied had adequte levels of iodine, in different states. According to studies conducted at the National Institute of Nutrition (NIN)[11], Hyderabad, under the standard conditions including transport by rail or road, 25-30 per cent of iodine was lost in 3 months and 40-60 per cent in one year. In another study[12] on 2140 households where salt fortified with 40 ppm of iodine was supplied, 98 per cent samples had iodine content more than 15 ppm. A more recent study (NIN, Unpublished, 1996) revealed that, 17 per cent of iodine was lost in 3 months and 36 per cent in 6 months, when the salt is prepared and used as in 1986 study. In "UP Citizens' Study" where iodine was tested in market samples at the retail/consumer level, 61 per cent of the samples contained less than 15 ppm (Citizens report on iodine content in salt at consumer level in UP, AIIMS, 1994). Thus stability of the iodine in salt is variabale, and ensuring this is a very important factor for the success of the Programme.

Dietary Iodine

Based on the analysis of iodine in raw food items, Mahesh *et al*[7], reported from NIN, the iodine content of regional diets ranged from 173-265 µg/day in low socio-economic group and 206-302 µg/day in high socio-economic group. More recently Dodd and Dighe[8] have estimated the iodine content of regional diets obtained from families living in Bombay (Mumbai) and found that the raw foods contained 282-362 µg and after 37-70 per cent cooking losses, the actual dietary intakes were 102-184 µg/day. This study highlights that cooking losses of iodine were considerably higher than what was assumed earlier.

Salt Intake

Data of NNMB[13] show that, daily intake of salt is around 10g. Dodd and Dighe[8] reported that the average intake of salt in Mumbai is around 7-8 g, and the actual contribution of iodine from iodised salt worked out to be less than 60 µg in a state with partial ban on non-iodised salt. In view of available evidence of cooking losses, more realistic guidelines for iodisation of salt were advocated.

Considering a minimum requirement at 10g salt intake, fortification of salt at a level of 50 ppm of iodine seems to be a practical measure, and this has been actually suggested by WHO[2]. Thus, mandatory limits of salt fortification with iodine may have to be revised to 50 ppm.

Assuming that all the iodine in the fortified salt is available, the total daily intake from salt is not beyond 500 µg (50 ppm x 10 g). Considering additional amounts received from diet, the total intake would be far below the

maximum safe limit of iodine intake (1000 µg). Keeping the stability and cooking losses in view, the net iodine assimilated will be well within the physiological range.

Iodine Content of Foods and Water from Non-endemic and Endemic Areas

Foods and water from goitre areas (MP) contained relatively low amounts of iodine. However, in endemic areas in East Godavari district (A.P.), the iodine content of food and water were low but not low enough to account for the high prevalence of goitre. The role of other dietary factors like goitrogens is suspected[7]. There are reports from other countries indicating that goitrogenic principles from food could also cause goitre endemias[14]

As the goitrogens inhibit iodine uptake and organification reaction in the thyroid gland in a reversible way, increasing the availability of iodine could overcome this inhibition. Thus, even in situations where goitre endemia may not be due to primary iodine deficiency, iodine obtained from iodised salt could reverse the process of goitrogenesis.

Efficacy of Iodised Salt : Recent Experiences at NIN

In the Kangra Valley study iodized salt was used without any stabilizer[3]. Subsequently calcium carbonate has been introduced as a component stabilizing the iodine in the salt. Recently, NIN has carried out a large scale community-based study in the tribal areas of East Godavari district (A.P.), to assess the feasibility of production and distribution, stability, acceptability and bioeffect of salt fortified with iodine and iron[12]. Four groups of villages, 20-25 each with a population of about 5000 were included in the study. Three areas received salt fortified with iron or iodine either singly or in combination, while the fourth area received unfortified salt. The fortification of salt was done so as to provide about 150 µg of iodine and or 10 mg of iron per 10g of salt, depending upon the type of salt. It may be mentioned here that stabilizers were added to the fortified salt to increase its stability. Sodium hexametaphosphate (10 g/kg) was used as a stabiliser in double fortified salt (DFS) and iron fortified salt, while calcium carbonate (0.63 g/kg) was used as stabiliser in iodised salt (IS).

At the end of two year supplementation trial, the results indicated that all the three types of fortified salts were found to be stable and were readily accepted by the community. No instances of undesirable effects or toxicity or allergy were noted in the community.

The prevalence of goitre decreased significantly from initial 28 per cent to about 14 per cent in DFS areas and from about 26 per cent to 16.1 per cent in IS area, while in the control area, there was no perceptible change (13.5% and 14.1%). The urinary iodine excretion levels increased from 15.7 to 22.0 µg/dl in DFS areas, 7.6 to 18.7 µg/dl in IS areas, while it decreased from 16.3 to 11.4 µg/dl in the control area. No toxic effects attributable to either consumption of fortified salt or stabilisers were observed in the population[12].

These studies, thus, indicate that consumption of iodised salt containing stabilisers over a long duration is quite safe and effective in the prevention and control of IDD.

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This write-up has been contributed by B. Sivakumar, K. Madhavan Nair, G.N.V. Brahmam and M. Mohan Ram, National Institute of Nutrition, Hyderabad, based on the presentations at the state level meeting on universal access to iodised salt in Kerala, Thiruvananthapuram, May 1996.

85TH ANNIVERSARY CELEBRATIONS OF ICMR

The Regional Medical Research Centre for Tribals, Jabalpur celebrated the 85th Anniversary of the Council (theme tribal health) on May 27, 1996. A number of popular publications/folders produced by the Centre were released on the occasion by the Chief guest Dr. S.K. Tiwary, Professor and Head, Department of Tribal Studies at R.D. University, Jabalpur. Dr. R.S. Tiwary, Director, RMRC, Jabalpur gave a detailed account of research work being carried out at the RMRC, Jabalpur in the field of tribal health and mentioned the various diseases *viz* sickle cell anaemia, thalassaemia, tuberculosis, gonorrhoea, syphilis, yaws, *etc.*, prevalent in the tribes of Madhya Pradesh. Dr. G.D. Pandey, Asstt. Director of the Centre highlighted the demographic, social and cultural aspects of tribes and effects of these factors on the health of the tribals.

The Rajendra Memorial Research Institute of Medical Sciences, Patna, organised a symposium on tribal health on April 30, 1996. Dr. K.K. Verma, Professor and Head, Deptt. of Anthropology and Sociology, A.N. Sinha Institute of Social Sciences, Patna, delivered a lecture on the tribals of India and their health situation. Other topices covered in the symposium included concept of health and sickness among the tribals of M.P., health of tribals, tribal malaria, *etc.* Dr. S.K. Kar, Director of the Institute highlighted the research work being carried out at the various ICMR Institutes/Centres in the field of tribal health.

ICMR NEWS

The following meetings of various technical committees/groups of the Council were held :

Meetings of the Expert Committees (ECS), Project Review Committees (PRCs) and Toxicology Review Panel held at New Delhi

EC on Otolaryngology	May 16, 1996
Special PRC on HIV Infection and Other Viral Diseases	May 31, 1996
PRC for Projects on Non-communicable Diseases	June 5, 1996
Toxicology Review Panel of the Division of Reproductive Health and Nutrition	June 12, 1996

Participation of ICMR Scientists in Scientific Events:

Dr. Kalpagam Polasa, Senior Research Officer, National Institute of Nutrition (NIN) Hyderabad, participated in the II International Conference of Food and Cancer Prevention at Ede, The Netherlands (May 18-23, 1996).

Dr. M. Mohan Ram, Director, NIN, Hyderabad, participated in the IV meeting of the South-East Asia Nutrition Research-cum-Action Network at Jakarta (June 10-14, 1996).

Dr. K.N. Panicker, Dy. Director, Vector Control Research Centre, Pondicherry, participated in the workshop on control of filariasis in the Asia Pacific at Bali (June 14-17, 1996).

Appointments :

Dr. J.M. Deshpande took over as the Director of the Enterovirus Research Centre, Bombay w.e.f. June 3, 1996.

Dr. J. Mahanta took over as the Director of the Regional Medical Research Centre, Dibrugarh w.e.f. June 4, 1996.

ICMR AIDED SYMPOSIA/SEMINARS/WORKSHOPS/COURSES/CONFERENCES

Symposium/Seminar/Workshop/ Course/Conference	Date & Place	Contact Address
Seminar on Communicable and Water-borne Diseases	June 5-6, 1996; (at Darjeeling)	Dr. S. Mukhopadhyay, Executive Convenor of the Seminar, Department of Plant Pathology, Bidhan Chandra Krishi Vishwavidyalaya, Kalyani, Distt. Nadia.
Internationl Congress on Ageing	August 19-21, 1996; (at Thiruvanantapuram)	Dr. P.K.B. Nair, Coordinator of the Congress, Centre for Gerontological Studies, Thiruvantapuram.
Workshop on Design and Evaluation of Targeted Drug Delivery System	September, 1996; (at Manipal)	Dr. N. Udupa, Convenor of Workshop, College of Pharmaceutical Sciences, Manipal.

COUNCIL'S TRAINING PROGRAMMES FOR 1996-97

Leprosy

At the Central Jalma Institute for Leprosy, Agra:

- Multidrug Therapy Orientation Course in Leprosy for Medical Officers (September 9–20, 1996).

Virology

At the National Institute of Virology, Pune:

- Diploma in Medical Virology (June 1996–May 1997).

Reproductive Biology

At the Institute for Research in Reproduction, Bombay:

- Training Course on Immunoassay Techniques (June 3–15, 1996).
- Training Course on Current Trends in Management of Infertility and Reproductive Disorders (September 2–13, 1996).

Endocrinology

At the National Institute of Nutrition, Hyderabad:

- Annual Training Course on Endocrinological Techniques and their Applications (August 1– September 15, 1996).

Nutrition

At the National Institute of Nutrition, Hyderabad:

- M.Sc. in Applied Nutrition (June 1, 1996–February 28, 1997).
- Annual Training Course in Nutrition (December 1, 1996–February 28, 1997).

Occupational Health

At the National Institute of Occupational Health, Ahmedabad:

- Orientation Course on Occupational Health for Industrial Medical Officers (September 17-29, 1996).

Medical Entomology

At the Vector Control Research Centre, Pondicherry:

- M.Sc. in Medical Entomology (from August 1996; for 2 years).

Laboratory Animal Technology

At the National Centre for Laboratory Animal Science, National Institute of Nutrition, Hyderabad:

- Training Course for Laboratory Animal Technicians (June 15–July 31, 1996).
- Training Course for Laboratory Animal Supervisors (September 1–November 30, 1996.

Haematology

At the Institute of Immunohaematology, Bombay:

- Training Course in Transfusion Medicine for Blood Bank Medical Officers (August 5–October 4, 1996).
- Training Course in Blood Group Serology and Blood Bank Methodology for Technicians (August 5–September 4, 1996).
- Training Course in Advanced Haematology and Immunohaematology (September 17–October 4, 1996).

EMERITUS MEDICAL SCIENTISTS

INDIAN COUNCIL OF MEDICAL RESEARCH

Nominations/applications are invited from distinguished retiring scientists engaged in research in the field of biomedicine for consideration for appointment as Emeritus Medical Scientists under the Council. Full particulars can be obtained from the office of the Director-General, (Personnel Section), Indian Council of Medical Research, Post Box No. 4911, New Delhi-110 029. Scientists who have retired or are going to retire upto 31st March, 1997 may apply for the appointment as Emeritus Medical Scientist under the Council.

Last date for receipt of applications is **30th September, 1996.**

INDIAN COUNCIL OF MEDICAL RESEARCH

Grant-in-aid for organising Seminars/Symposia/Workshops

The Council provides partial financial assistance for organising Seminars/Symposia/Workshops. Applications for grant of financial assistance (complete in all respects in the prescribed proforma), will be considered only if furnished **at least four months before the date of commencementt of the Seminar/ Symposium/Workshop,** *etc.*

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