

Review Article

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National Institute of Nutrition: 100 years of empowering the nation through nutrition

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The National Institute of Nutrition (NIN) has reached a remarkable milestone of completing 100 years of exemplary service to the nation. The long journey that started in a humble one-room laboratory at Coonoor (now in Tamil Nadu) in 1918 to a colossus of the nutrition research in the country today is dotted with several interesting vignettes. The NIN has always been at the forefront of need-based, pragmatic research. Its large-scale community-based interventions have been of great practical value in the nation's fight against malnutrition. The evolution of nutrition as a modern science almost coincides with the growth of the Institute. Being the oldest in the fraternity of institutes under the Indian Council of Medical Research (ICMR), the NIN has grown from strength to strength due to the sheer relevance of its contributions in furthering nutrition science and promoting public health in the country. This article provides a historical overview of the evolution and contributions of ICMR-NIN in the areas of nutrition, food safety, public health and policy.

Key words Food safety - NIN - Nutrition Research Laboratory - nutrition - public health nutrition

Introduction

The long journey of the National Institute of Nutrition (NIN) of the Indian Council of Medical Research (ICMR) at Hyderabad, India, from a humble one-room laboratory at Coonoor to the picturesque sprawling campus in the historic city of Hyderabad is dotted with several interesting landscapes. The NIN has completed its 100 years journey in November 2018. The emergence of nutrition as a modern science almost synchronized with the starting of systematic nutrition research in 1918 when Beri-beri Enquiry Unit was established at Coonoor by the Indian Research Fund Association (IRFA) (now ICMR). This enquiry

unit transformed into Deficiency Diseases Enquiry in 1925 and then to Nutrition Research Laboratories (NRLs), which in turn metamorphosed into the NIN in 1958. Being the oldest institute in the ICMR fraternity, the NIN has contributed significantly in the area of nutrition science and public health in the country.

The story of genesis

Sir Robert McCarrison, the founder Director of NIN, is justifiably credited to be the father of nutrition research in India. After some early studies on iodine deficiency disorders (IDDs) in the sub-Himalayan areas, McCarrison's research was kept in abeyance due

to the First World War. Returning from the active war service in 1918, McCarrison proceeded to south India to join the Pasteur Institute in Coonoor. It is here, in the salubrious Nilgiri hills, that the journey of nutrition research in India began from a one-room laboratory in the Pasteur Institute. McCarrison was recalled to Britain in 1920 and he returned only in 1922, but the Unit was axed on financial grounds in 1923¹. Two years later, due to McCarrison's concerted efforts, it was restored as the Deficiency Diseases Enquiry. Around the same time, the Royal Commission on Agriculture was appointed to report on the Indian agricultural practices and policy under Lord Linlithgow (who later became the Viceroy of India) and he was keenly interested in McCarrison's work. In 1926, the members of the Royal Commission paid a visit to Coonoor to acquaint themselves with the work, and McCarrison took this opportunity to submit a memorandum on 'Malnutrition as a cause of physical inefficiency and ill health among masses in India', which highlighted the connection between nutrition and agriculture. The memorandum also emphasised the need for closer co-ordination of research among diverse fields such as nutrition, medicine, veterinary and agricultural sciences in India. The Commission realized that nutrition research had a fundamental role in agricultural development in India and soon recommended in their report that there was a need to establish a central institute for nutrition research². Taking advantage of this recommendation, McCarrison submitted a proposal to the IRFA that the unit under him be recognized as equivalent to a central institution². It was in 1929 that the unit in Coonoor came to be known as the NRLs and became the only institution in India to be exclusively devoted to research in human nutrition. By 1935, the NRL had six rooms including a lecture hall and a nutrition museum on the second floor of the Pasteur Institute in Coonoor³. In 1949, the IRFA was re-designated as the ICMR with an additional scope of work and responsibilities. Under ICMR, earlier institutes, including NRL, were expanded and many new research institutes were set up. The year 1969 marked the Golden Jubilee celebrations of NRL on completion of 50 yr of its existence. In recognition of its yeomen contributions to nutrition research, the governing body of ICMR renamed and re-designated NRL as the National Institute of Nutrition (NIN)^{2,4}.

Objectives of NIN⁵

- (i) Identify various dietary and nutrition problems prevalent among different segments of the population.
- (ii) Continuously monitor diet and nutrition situation of the country.
- (iii) Evolve effective methods of management and prevention of nutritional problems keeping the existing economic, social and administrative set-up in view.
- (iv) Conduct operational research connected with planning and implementation of national nutrition programmes.
- (v) Dovetail nutrition research with other health programmes of the government.
- (vi) Develop a band of young scientists, teachers in medical schools and health workers, well trained in nutrition.
- (vii) Disseminate nutrition information for institutional and community benefit.
- (viii) Advise governments and other organizations on issues relating to nutrition.

Establishment of research centres

In the 1970s, the Institute further widened its scope of research with the establishment of the following three important centres:

- (i) National Nutrition Monitoring Bureau (NNMB) was set up under the ICMR in 1972 in 10 States. The Bureau through regular and periodic surveys generated a dynamic database on diet and nutritional status of the communities regularly till since 1975. These studies included repeat surveys among rural, tribal and urban population.
- (ii) Laboratory Animals Information Service (LAIS) which was earlier housed in Haffkines Institute, Bombay (now Mumbai) was shifted to the premises of the NIN in 1976. It was renamed as Laboratory Animal Information Service Centre (LAISC). In 1995, it was re-designated as the National Cancer for Laboratory Animal Sciences (NCLAs). This has been elevated as a full-fledged research institute, National Animal Resource Facility for Biomedical Research (NARFBR) in 2017.
- (iii) Recognising the significant contributions made by the NIN in food toxins research, Food and Drug Toxicology Research Centre (FDTRC) was established by the ICMR in 1978.

Highlights of research achievements

Early studies on nutrient deficiency disorders

While epidemiological studies on beriberi were continued during the early decades of its founding¹, special surveys were conducted on beriberi in endemic areas as well as among tribal population in Bihar

region. The studies on parboiled and milled rice helped to explain the incidence of beriberi among rice eaters in the east coast of Andhra region where milled rice was consumed largely and no incidence in Madras where parboiled rice was consumed more^{6,7}. Systematic epidemiological investigations have demonstrated that beriberi has characteristic effects on the chronological pattern of infant mortality^{8,9}. NRL's focus also turned towards goitrogenic substances, epidemic dropsy, burning feet and bladder stones. Stomatitis associated with the deficiency of B group of vitamins, particularly riboflavin, was described for the first time in India, and a treatment with yeast and skimmed milk was found to be effective^{2,10,11}.

The need to add a clinical dimension and conduct systematic clinical trials was felt, and C. Gopalan was appointed as the clinical assistant to study diarrhoea and nutritional disorders at the Clinical Unit established at Stanley Hospital in Madras (Chennai). This clinical unit was the first to describe a clinical condition called 'burning feet syndrome', which was found to be due to vitamin B deficiency, and prescribed its treatment with vitamin B (pantothenic acid)^{2, 12,13}.

Nutritive values of Indian foods

One of the important contributions of NIN has been the assessment of nutritive values of commonly consumed Indian foods. This was first taken up in 1935 and was completed in two years. Chemical analysis was performed on more than 200 foods for nutritive values (energy, carbohydrate, protein, fat, vitamin and mineral contents). Besides employing the already established methods for vitamin analyses, newer and improved methods of analyses were employed, especially for the estimation of niacin, carotene and some B vitamins^{10,14}. 'The Nutritive Value of Indian Foods and Planning of Satisfactory Diets' was published in 1937, in Health Bulletin No. 23, which turned out to be a very popular contribution¹⁵. Apart from this, the nutritive values of fruits and vegetables were also determined during 1960s. The project on nutritive values of Indian foods was initiated at four centres (Coonoor, Bombay, Ambala and Mysore) and this work helped to fill gaps in the earlier 'Health Bulletin'. This work generated new data on nutrient as well as non-nutrient components in a number of foods. The data from all the centres were compiled, and Health Bulletin No. 23, brought out earlier, was updated and revised. The revised edition was published as ICMR Special Report No. 42¹⁶ in 1962. This publication was thoroughly revised

and rewritten with data obtained after updating some methods of nutrient estimation and was published as 'Nutritive Value of Indian Foods' in 1970s¹⁷. Analysis of foods for their nutrient composition has been the basis for the periodical revision of this publication.

More recently, the database profiling the nutritive values of Indian foods has been readied in 2017. Adopting the 'key foods approach', that contributes up to 75 per cent of the nutrient intakes considered. Using latest techniques and precision tools, the new 'Indian Food Composition Tables (IFCT) 2017, were brought out. The IFCT 2017 is the compilation of nutritional information on 151 discrete food components for 528 key foods. The IFCT, for the first time in the Indian context, attempted to provide information on almost all regular nutrients in foods alongside a whole range of bioactive substances¹⁸.

Formulation of recommended dietary allowances (RDAs)

The first recommendations on Recommended Dietary Allowances (RDA) were made for the Indian context in 1944 based on the recommendations of the Health Committee of the League of Nations (1937)^{3,4}. Later, the RDAs were modified in the early 1960s, and then in the early 1970s, 1980, 1991 and last in 2010¹⁹. An expert group constituted by the ICMR in 2008 revised and updated the nutrient requirements as well as dietary allowances for Indians. Data generated in India by NIN earlier became the basis and RDAs were revised compared to the previous versions of 1944, 1958 and 1968. Recommendations for minerals such as calcium, phosphorus, zinc, selenium and iodine have been included as separate chapters.

Dietary guidelines for Indians

A manual with information on the key practicable points for diets and physical activity for Indians to ensure optimal health and freedom from disease was proposed for the first time in 1998. In 2011, after the RDAs were revised and the guidelines were redrafted, the revised version was released²⁰.

Studies on protein-energy malnutrition (PEM)

Studies were conducted on protein-energy malnutrition (PEM) among infants, and some feeding trials were also conducted among children to study the effect of skimmed milk on their nutritional status, which Aykroyd³ claimed as the first-ever studies to give reconstituted skimmed milk powder to children in a developing country and to show that this supplement

accelerated growth and improved the general condition. In fact, in later years, skimmed milk powder has been given to a large number of children suffering from PEM and has proved a lifesaver³. The two severe forms of protein-calorie malnutrition investigated during the 1960s by the Institute were kwashiorkor and nutritional marasmus²¹⁻²³. Detailed studies have been undertaken on the dietary intakes and the biochemical status of children manifesting these different forms of malnutrition with a view to understand the common aetiological background. It was around this time that the dietary intake data from urban-rural multicentric community studies on the diets of preschool children were thoroughly examined for their energy and protein intakes. It turned out to be a surprising revelation that the protein concentration of their diets was nearly adequate contributing to about 10 per cent of their energy; however, the average energy intake was grossly deficient²⁴. This analysis paved way for a new hypothesis that the malnutrition among underprivileged children was due to energy deficiency and not solely due to protein deficiency. The large-scale community studies were initiated to test this hypothesis and this view was soon endorsed even by UN organizations like WHO and UNICEF².

Studies were carried out to assess whether the poor mental performance of the children is solely attributable to the earlier episode of kwashiorkor or to other causes as well. The observations showed that non-nutritional factors, particularly maternal attitudes, played an equally important role in the mental development of children²⁵.

Contribution to national programmes and policies

Providing nutrient requirements for national programmes aimed at vulnerable groups

The NIN through NNMB carried out nutritional assessment surveys on individuals as well as on families, covering different age groups and different socio-economic groups. NNMB reports have been used by nutritionists, epidemiologists, policymakers and more so by the Planning Commission in those days. One of the most significant research findings of the Institute in the 1960s was that the prevalence of severe forms of malnutrition among preschool children was mainly due to energy deficiency and not due to protein deficiency, as was assumed for many decades²⁴. This was one of the bases for the Government of India in the 1970s, to launch a supplementary feeding programme to provide 300 Kcal/day to improve the

nutritional status of children in rural areas and in urban slums, which was operated under the Integrated Child Development Scheme (ICDS)⁴.

Contribution to the National Prophylaxis Programme against nutritional blindness due to vitamin A deficiency (NPPNB due to VAD)

During the 1960s, after some preliminary clinical trials, the effect of oral administration of a large dose of vitamin A on serum vitamin A of 2500 children was studied. Based on this study outcome, the NIN recommended administration of 200,000 IU each to children at six-monthly intervals to avoid immediate toxic manifestations and for providing effective and consistent cover against vitamin A deficiency (VAD)². This paved the way for a nationwide vitamin A prophylaxis programme with its inclusion in the Fourth Five-year plan in 1969²⁶.

Another landmark operational research carried out by the NIN was the feasibility study to link the National Programme for Vitamin A Supplementation to prevent nutritional blindness among young children with a universal immunization programme (UIP) to increase its coverage. In spite of its implementation for over two decades, the coverage for vitamin A supplementation was very poor. The NIN had carried out the above operational research in seven States of India and showed that it was feasible to link Vitamin A Supplementation Programme with the existing high-coverage trends of UIP²⁷. Based on the recommendations of the NIN, it became a national programme and is being implemented throughout India, and the coverage of vitamin A supplementation has increased to over 70-80 per cent in the later years. The prevalence of VAD disorders such as Bitot spots and other ocular signs has significantly declined in later years².

Supplementation of iron and folic acid to pregnant women

In 1968, a professional body that emanated earlier from NIN, the Nutrition Society of India, set up a study group on nutritional anaemias under the leadership of Gopalan with leading nutritionists and haematologists of those times as members. After carefully examining various studies carried out in India till then, the study group recommended that a programme of iron folate supplementation be taken up for pregnant women and preschool children as a prophylactic measure. The government introduced the National Nutritional Anaemia Prophylaxis Programme aimed at pregnant women and young children in 1970²⁸.

Operational research to strengthen nutrition programmes

The Institute carried out operational research studies on ICDS to assess its impact on the nutritional status of children, including process and input evaluation. The study results helped in strengthening of the programme and subsequently, it was expanded in all the villages by universalizing ICDS services. Another study assessed the psychosocial development of children, who were beneficiaries and non-beneficiaries of the ICDS for the estimation of ICDS service impact. The study indicated that the outreach of health, nutrition and child care was better in ICDS compared to that of non-ICDS areas²⁹.

Development of Nutrition Surveillance System (NSS)

In order to promote effective functioning of ICDS and nutritional well-being of the beneficiaries, the NIN developed 'AAA' (triple A) approach covering Assessment, Analysis and Action involving the entire ICDS mechanism from the grassroots level to the supervisory level^{30,31}. This involved 'Assessment' of health and nutritional status on a continuous basis amongst vulnerable population groups, identifying area-specific determinants (Analysis) of nutrition problems and food insecurity and integrating various departments to take appropriate 'Action' in the prevention and control of undernutrition.

Nutritional surveys

The NNMB carried out surveys in 10 States and generated a dynamic database on diet and nutritional status of the communities. Many surveys were regularly conducted among rural, tribal and urban populations. The most recent survey was the 'Diet and nutritional status of urban population in India and prevalence of obesity, hypertension, diabetes and hyperlipidaemia in urban men and women' released in 2017³². Diet and nutritional status of primitive tribes of Andaman and Nicobar Islands was carried out, and the NIN, for the first time, reported that the diet and nutritional status of tribal population was very poor and needed special attention³³. Surveys were also conducted among special groups such as Bangladeshi refugees³⁴, tribal populations^{35,36} and people in drought-hit areas³⁷.

Studies on supplementation of micronutrient fortified foods

Several studies were conducted on the impact of micronutrient fortified foods in various supplementary nutrition programmes. Some of them are as follows:

Project Grow Smart

The ICMR-NIN designed a study using a micronutrient formulation (iron folic acid, B12, B2, zinc, vitamin A and vitamin C), which should be blended with food supplement provided to preschool beneficiaries of ICDS. A cluster-randomized, double-blind, placebo-controlled study was conducted in 22 villages of Telangana. The results showed reduction in anaemia within a short span of six months accompanied with higher iron stores in the intervention group as compared to the controls. In addition, there was improvement in the linear growth in the intervention group³⁸.

Balamrutham

The ICMR-NIN in collaboration with State governments has developed micronutrient-fortified (iron, folic acid, B1, B2, B12, niacin, zinc, vitamin A, vitamin C, calcium) take-home ration called *Balamrutham* for 6-36 month old children, which is being implemented in all districts of Andhra Pradesh and Telangana. Earlier, the integrated State of Andhra Pradesh used to provide Modified Therapeutic Food (MTF) to children (aged 6-35 months) under Supplementary Nutrition Programme of ICDS. The NIN conducted a study comparing the new ready-to-eat (RTE) formulation with the existing MTF and proved that it was a superior food supplement. This led to the introduction of *Balamrutham*, which reached the mothers and caregivers of over 10 lakh children in Telangana State, making them empowered to take care of their children's nutrition³⁹.

Ultra rice

A study was aimed to determine the impact of ultra rice - micronized ferric pyrophosphate supplied through extruded rice kernels - in a rice-based meal on iron status of children who were beneficiaries of the midday meal (MDM) scheme. The double-blind randomized controlled efficacy trial on delivering an additional 19 mg Fe/day through fortified rice as part of the MDM programme regularly for eight months improved the body iron stores by 8 µg/l and reduced iron deficiency from 33 to 14 per cent in 5-11 yr old schoolchildren, compared to those consuming natural unfortified rice (3 µg/l and 31-37%, respectively). The effects on haemoglobin status, anaemia and iron deficiency anaemia (IDA) were similar in the two groups of children, suggesting that factors other than the additional iron intake had a larger influence. The iron-fortified rice was similar to natural rice in sensory qualities and was well accepted by the children⁴⁰.

Food safety and toxicology

Food toxins

Studies on food toxins explored some major areas such as neurotoxicity, aflatoxicosis, argemone toxicity and epidemic dropsy and erucic acid toxicity in edible oil. Significant contributions have been made by the Institute in identifying the nature of the toxic factors and in providing solutions for prevention and control². In 1963, a major breakthrough was achieved, when neurotoxic symptoms were induced in baby chicks by the administration of aqueous alcoholic extracts of the *khesari dal* (*Lathyrus sativus*) seeds. The toxic factor was identified to be an unusual amino acid, called β -(N)-oxalyl amino alanine^{41,42}. Later, steeping or parboiling of the pulse at home or on commercial scale has been shown to lessen the toxicity⁴².

Investigations on epidemic dropsy

In 1998, epidemic dropsy was reported from several States such as West Bengal, Bihar, Orissa (now Odisha), Madhya Pradesh, Haryana, Assam, Jammu and Kashmir, Uttar Pradesh, Gujarat, Delhi and Maharashtra, mainly due to consumption of food cooked in argemone oil mixed with mustard oil. The NIN carried out a study on epidemic dropsy prevalent in the areas of State of Madhya Pradesh and recommended to the government to stop the unauthorised use of adulterated oil. Selective cultivation of yellow mustard, strict enforcement of regulation and exemplary punishment to unscrupulous traders were followed as preventive measures².

Knowledge, attitude, belief and practice (KABP) study on food safety

The FDTRC (then a separate centre within NIN) spearheaded the knowledge, attitude, belief and practice study on food safety in 2005-06 which was conducted among households and other stakeholders such as doctors, regulators and teachers in 28 States of the country. The findings of the study were used by the Ministry of Health & Family Welfare for food safety education using electronic media⁴³.

Pre-clinical toxicology

The Preclinical Toxicology Centre (PCT) was established in 1999 in NIN. Since its inception, the Centre has screened recombinant products (anti-rabies vaccine, interferon, tetravalent vaccine and HPV oral vaccine), indigenously developed peptides, and involved in traditional preparations such as *Bhasmas*

(herbomineral preparations, Ayurvedic formulations) and food additives. About 80 per cent of the products screened by the PCT are in clinical trials and a few are in clinical use.

Non-communicable diseases (NCDs)

Generated data on the prevalence of non-communicable diseases (NCDs)

Most recently, in 2017, the NIN has generated data on the prevalence of overweight/obesity and non-communicable diseases (NCDs) in urban and rural areas from 16 States of India. The urban survey alone covered as many as 1,71,928 individuals from over 52,500 households of 1097 wards of 16 States³².

Fenugreek seeds in the management of diabetes

It was found out that fenugreek seeds could improve the glucose tolerance and ameliorate other symptoms of diabetes mellitus (type 2). It was reported that the mechanism of action of fenugreek seeds on improving glucose tolerance in diabetes was due to improvement in glucose utilization at the cellular level⁴⁴.

Research on edible oils

In the 1980s when there was a concern about the inadequate production of edible oil in India, the Government of India's policy of looking at promoting the use of unconventional edible oils got attention. Systematic studies on the nutritional quality and safety evaluations of unconventional edible oils such as rice bran oil, mango kernel oil, palm oil, neem oil, tumba oil and crude palm oil were carried out at the NIN⁴⁵⁻⁵¹.

Recommended use of multiple oils

The relative role of n-3 and n-6 polyunsaturated fatty acids (PUFAs) in regulating the plasma profile was studied, and the desirable ratio of these fatty acids in Indian diets was worked out⁵². Based on these studies, it was advocated to blend or use a combination of oils to reap the benefits of n-3 and n-6 fatty acid form of different oils. Different socio-economic groups consuming different amounts and varieties of fat showed that n-6 PUFA nutritional status was good, while the status of n-3 PUFA needed improvement. Studies showed that long-term use of cooking oil (blend of sunflower oil and canola oil) containing 20-40 per cent n-6 PUFA and four per cent alpha-linolenic acid (with n-6/n-3 ratio = 6-9) in cereal pulse-based total diets improved n-3 PUFA status. Based on these studies, the NIN recommended the use of more than one oil as diverse sources of oils confer

the additional advantage of providing a variety of minor components (present in non-glyceride fraction of oils)^{53,54}.

Health effects of trans fats

The health effects of dietary trans fatty acids present in the partially hydrogenated vegetable oil (*vanaspati*) were investigated^{55,56}. Studies showed that compared to saturated fats, trans fats present in *vanaspati* decreased the insulin sensitivity to a greater extent⁵³. Considering the detrimental effects of trans fatty acids, the Food Safety and Standards Authority of India (FSSAI) fixed the norms for trans fatty acid content of *vanaspati*, limiting to 10 per cent, and proposes to bring it down to five per cent and to two per cent or lesser than that in the next couple of years⁵⁷.

Studies on anticancer properties of Indian spices

Studies on nutrition and cancer elucidated the role of micronutrients in susceptibility to/prevention of cancer of the gastrointestinal tract. Studies on micronutrients/trace element status of cancer patients and age- and economic group-matched normal controls showed that cancer patients had lower vitamin A, riboflavin, folate and selenium^{58,59}. Studies on Indian spices, especially on turmeric and ginger, had demonstrated their anticancer properties^{60,61}. Antimutagenic properties of some foods such as turmeric, ginger and garlic were also explored^{62,63}.

Outreach and human resource development

The Extension and Training Division was established in the NIN in the 1960s. It organised several training programmes for various categories of personnel. Many scientific, semi-scientific and popular publications have been brought out by this Division and made available to the public for disseminating the results of NIN research⁴. Further, nutrition education and communication research has established the usefulness of various media and methods including folk art forms, classroom-based education and computer-aided education for disseminating nutrition messages in different settings⁶⁴⁻⁷⁰.

Training programmes/ courses

Two systematic training programmes for medical college faculty and public health personnel were initiated to impart training in the current concepts of nutritional science and their application for promoting public health. One was the 12 wk Post Graduate Certificate Course (started in 1963) and the other was

the nine-month MSc (Applied Nutrition) Postgraduate Programme (initiated in 1968). The World Health Organization (WHO), UNICEF and Food and Agriculture Organization (FAO) also sponsored many candidates to take part in these training courses annually. The nine-month M.Sc. (Applied Nutrition) Postgraduate Programme was discontinued in 2004 and, in its place, a two-year master's programme (affiliated to Dr. NTR University of Health Sciences, Vijayawada) was introduced in 2009 and later the affiliation was shifted to Dr. Kaloji Narayana Rao University of Health Sciences, Warangal, in the State of Telangana. In 2018, with the support from the Ministry of Youth Affairs and Sports, an MSc Programme in Sports Nutrition was initiated.

Information Communication Technologies (ICTs) for nutrition outreach

The NIN initiated efforts to use ICTs for public dissemination of nutrition messages. A series of mobile applications on Dietary Guidelines for Indians, RDAs, were developed and put on public domain for free downloads and use. In 2018, Nutrifly India Now (NIN App), a mobile App developed by the NIN was launched, which helps users assess their nutrient intake from food and also keep track of energy balance. The usability is extended to majority of the Indian States as all food names are provided in 17 Indian languages.

Studies on food label information use in India

Studies conducted at NIN are among the first in India to assess the consumer use of food labels. The studies pointed that literate consumers were more likely to read the label information for food choice^{71,72}. A nutritional education intervention study among adolescents evaluated the impact of 'Read-B4-U-Eat' - a label information education module - on the label-related knowledge and usage of such information for food choices. Theories of social cognition and shared learning were used to develop the module's five components - booklet for self-learning; interactive lecture sessions for guided learning; posters for shared learning; an animation film for edutainment and printed notes for teachers to reiterate. The kit was efficacious and effective in inculcating label-reading skills among adolescents⁷³.

Scientific outreach for the visually challenged

The NIN brought out three of its popular publications - 'Dietary Guidelines for Indians', 'Diet and Diabetes' and 'Diet and Heart Diseases' - in Braille

format for the benefit of the visually challenged. This is part of ICMR's inclusive approach for science and technology dissemination and promoting public health. These books have been distributed to visually challenged individuals and institutions catering to such students across the country free of cost.

Technologies developed by NIN

Double-fortified salt (DFS)

NIN's research efforts focused on developing a technology for double fortification of salt with both iodine and iron to combat both IDD and iron deficiency anaemia (IDA)⁷⁴ led to the development of a successful formula after exploring several stabilizers to ensure the stability of iodine on storage, no discolouration and bioavailability of both micronutrients when taken with food. Community trials were conducted in late 1990s to test the acceptability of double-fortified salt (DFS). To know its stability, safety and impact in the reduction of IDA and IDD, a landmark randomized clinical trial was carried out in the Rampachodavaram tribal areas of Andhra Pradesh, where the twin problems were highly prevalent. The study showed a significant reduction in the prevalence of IDD and a moderate impact on anaemia^{75,76}.

Transfer of DFS technology and contribution to regulation on fortification

The technologies for DFS and fortification of wheat flour with iron and other nutrients such as vitamin A and folic acid have been transferred to the industry. The NIN also contributed to the preparation of the regulatory specifications for FSSAI for DFS. In 2011, the government issued instructions for the introduction of DFS in ICDS, MDM and PDS and to conduct Information, Education and Communication campaign on the promotion of DFS⁷⁷.

Dried blood spot (DBS) facility for vitamin A estimation

A dried blood spot (DBS) method for the estimation of serum retinol, a marker of vitamin A status, was established and validated at the NIN with technical support from Craft Technologies, USA. Further, *in vitro* bioavailability screening methods of iron, zinc and carotenoids were established⁴. These methods were extensively used for testing the efficacy of fortified food and beverages as part of the public-private partnership programmes. A national facility for DBS estimation of micronutrients was established in the NIN in 2006⁴.

ELISA diagnostic kit for measuring serum ferritin

This kit uses the ELISA method to screen serum ferritin and is accurate, convenient and cost-effective compared to other available technologies. This test helps diagnose, with certainty, the extent of iron deficiency in the body. This kit can also be used to assess bioavailable iron in foods fortified with iron⁴.

The way forward

On the threshold of the 100th year, with the current health and nutrition scenario in India, facing a double/triple burden of malnutrition, the NIN looks forward to recast its focus with renewed commitment, not just to nutrition science, but also for building a healthy and nutritious nation. The Institute will foray into broader domains of research in a multitude of areas with a view to integrating basic, clinical and community-based approaches with translational value, in line with the National Nutrition Strategy and National Nutrition Mission unveiled by the government^{78,79}.

Maternal, child and adolescent health

Nutrition, during the first 1000 days, is an important area for intervention for all developing countries and countries in transition with high burden of malnutrition. The NIN will focus not only on the 1000 days, but also on nutrition before pregnancy to break the intergenerational cycle of malnutrition. To this end, the research will focus on nutrition during pregnancy, lactation and infant and young child feeding practices for reducing low birth weight and stunting as a short-term strategy and on adolescent girl nutrition as a long-term strategy to improve the peri-conceptual nutritional status. This approach will also help explore ways and means to minimize the early onset of coronary heart disease and/or type 2 diabetes in young adults related to early-life nutritional deprivation.

Geriatric nutrition

While India is home to a fifth of the world's young and productive population, the burgeoning nutritional problems of the growing geriatric population cannot be left behind. The Institute would endeavour to take up mapping of micronutrient deficiencies mainly looking at the influence of dietary intakes on dementia, Alzheimer's disease, *etc.*

Outreach through ICTs and e-learning modules

Use of ICT tools and mHealth (mobile health) technologies such as mobile apps for nutrition, food safety and health message dissemination are key

priorities. The NIN is also developing e-learning modules to empower the people across the economic, social and regional spectra of the country. The NIN would serve as a nodal knowledge and dissemination hub for this initiative supported by the Ministry of Women and Child Development, Government of India.

Easy-to-use indices

Studies are also on to develop easy-to-use indices to assess diet diversity, food safety and healthy eating and living of adolescents at household level that can be used for rapid assessment, cutting short the elaborate studies otherwise required.

Dietary reference intakes (DRIs)

The Institute is initiating efforts to generate data on adequate dietary intakes of apparently healthy Indian population from various regions of the country and also generate data on their anthropometry, body composition and micronutrient status. This along with RDAs and tolerable upper limits of nutrients would help arrive at the dietary reference intakes for Indians.

India Nutrition Report (INR)

Several large datasets, on a wide range of health and nutrition indicators across India, collected through surveys periodically by agencies such as National Family Health Survey (NFHS), National Sample Survey Organization (NSSO) and NNMB are available. There is a need for triangulation detailed analysis of these datasets using advanced statistical methods. The INR would be an attempt by the NIN to comprehensively analyze all the information together for understanding the complex relationships between various factors affecting the health and nutrition, with special focus on childhood malnutrition and NCDs, using multilevel modelling, regressions, structured equation models and decision tree techniques to identify the determinants. This will take into consideration the epidemiological transition of different States based on disease burden and also the performance of states on various health system indicators.

The philosophy and the guiding principles of the NIN over a century of its existence have been the understanding of major nutritional problems that confront the country from time to time and finding practical solutions to counter these. The NIN has always been a harbinger of nutrition research in the country and has been a trailblazer in ways more than one. During its centenary year, the NIN rededicates itself to contributing to the well-being of people by empowering the nation through nutrition.

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References

1. Sinclair HM, editor. *The work of Sir Robert McCarrison*. London: Faber and Faber Limited; 1953.
2. Narsinga Rao BS. *Development of nutrition science in India*. New Delhi: Allied Publishers; 2005.
3. Aykroyd WR. Some recollections and reflections. *Souvenir of golden jubilee celebrations of NRL*. Hyderabad: Nutrition Research Laboratories; 1969. p. 31-6.
4. SubbaRao GM, Sesikeran B. *NIN: 1918-2011 – Nine decades of leadership in nutrition*. Hyderabad: National Institute of Nutrition; 2011.
5. National Institute of Nutrition. Available from: www.ninindia.org/nin.htm, accessed on November 9, 2018.
6. Swaminathan M. The effect of washing and cooking on the nicotinic acid content of raw and parboiled rice. *Indian J Med Res* 1941; 29 : 83-8.
7. Swaminathan M. The effect of washing and cooking on the Vitamin B1 content of raw and parboiled milled rice. *Indian J Med Res* 1942; 30 : 409-16.
8. Aykroyd WR, Krishnan BG. Infantile mortality and beri-beri. *Curr Sci* 1941; 10 : 169-71.
9. Aykroyd WR, Krishnan BG. Infantile mortality in the beri-beri area of the Madras presidency. *Indian J Med Res* 1941; 29 : 703-8.
10. Swaminathan M. Note on the Vitamin B1 riboflavin and nicotinic acid content of dried yeast. *Indian J Med Res* 1942; 30 : 403-8.
11. Swaminathan M. Riboflavin and its role in nutrition. *Ind Med Gaz* 1942; 77 : 650-6.
12. Gopalan C. The burning-feet syndrome. *Ind Med Gaz* 1946; 81 : 22-6.
13. Gopalan C. The etiology of phrynoderma. *Ind Med Gaz* 1949; 82 : 16-22.
14. Swaminathan M. A chemical method for the estimation of nicotinic acid in biological materials. *Indian J Med Res* 1938; 26 : 427-34.
15. Indian Research Fund Association. *Health bulletin, No. 23 of 1937, nutrition research laboratories*. Delhi, Coonoor: Manager of Publications, Government of India Press; 1937.
16. Aykroyd WR, Gopalan C, Balasubramanyan SC. *The nutritive value of Indian foods and planning of satisfactory diets*. Indian Council of Medical Research Special Report No.: 42. New Delhi (India): Indian Council of Medical Research; 1962.
17. Gopalan C, Rama Sastri BV, Balasubramanian SC. *Nutritive value of Indian foods*. Hyderabad: National Institute of Nutrition; 1980.
18. Longvah T, An-antan I, Bhaskarachary K, Venkaiah K. *Indian food composition tables*. Hyderabad: ICMR-National Institute of Nutrition; 2017.

19. National Institute of Nutrition. *Recommended dietary allowances*. Hyderabad: National Institute of Nutrition; 2010.
20. National Institute of Nutrition. *Dietary guidelines for Indians*. Hyderabad: National Institute of Nutrition; 2011.
21. Venkatachalam PS, Srikantia SG, Gopalan C. Clinical features of nutritional oedema syndrome in children. *Indian J Med Res* 1954; 42 : 555-68.
22. Gopalan C, Mehta G, Srikantia SG, Venkatachalam PS. Treatment of nutritional oedema syndrome (kwashiorkor) with vegetable protein diets. *Indian J Med Res* 1956; 44 : 539-45.
23. Ganapati R, Swaminathan MC, Taskar AD, Someswara Rao K. Feeding trials with vegetable protein foods. *Indian J Med Res* 1961; 49 : 306-15.
24. Narasinga Rao BS, Visweswara Rao K, Naidu AN. Calorie - Protein adequacy of the dietaries of preschool children in India. *J Nutr Diet* 1969; 6 : 238-44.
25. Champakam S, Srikantia SG, Gopalan C. Kwashiorkor and mental development. *Am J Clin Nutr* 1968; 21 : 844-52.
26. Gopalan C. *Review of some current studies in the nutrition research laboratories, Hyderabad. Souvenir of golden jubilee celebrations of NRL*. Hyderabad: Nutrition Research Laboratories; 1969. p. 21-9.
27. Vijayaraghavan K. Control of micronutrient deficiencies in India: obstacles and strategies. *Nutr Rev* 2002; 60 (5 Pt 2) : S73-6.
28. Nutrition Society of India. *Nutritional anaemia – A report of the task force*. Hyderabad: Nutrition Society of India; 1968.
29. Vazir S, Kashinath K. Influence of the ICDS on psychosocial development of rural children in Southern India. *J Indian Acad Appl Psychol* 1999; 25 : 11-24.
30. Hanumantha Rao D, Vijayaraghavan K, Sarma KVR. Development of nutrition surveillance system. *Nutr News* 1998; 19 : 1-3.
31. Vijayaraghavan K, Hanumantha Rao D, Chaudhari SN, Lal S. *Identification of simple indicators and development of nutrition surveillance method at PHC level*. Indian Council of Medical Research Technical Report. New Delhi (India): ICMR; 1989.
32. National Nutrition Monitoring Bureau. *Diet and Nutritional status of urban population in India and prevalence of obesity, hypertension, diabetes and hyperlipidemia among urban men and women*. Technical Report No 27. Available from: <http://www.ninindia.org/NNMB%20Urban%20Nutrition%20Report%20-Brief%20report.pdf>, accessed on November 9, 2018.
33. Hanumantha Rao D, Brahmam GNV, Pralhad Rao N. *Primitive tribal groups of Andaman and Nicobar Islands - Health and nutrition survey*. Hyderabad: National Institute of Nutrition, 1989.
34. Swaminathan MC, Vijayaraghavan K, Rao DH. Nutritional status of refugees from Bangla Desh. *Indian J Med Res* 1973; 61 : 278-84.
35. Hanumantha Rao D, Satyanarayana K. Nutritional status of tribal preschool children of Andhra Pradesh. *Indian J Nutr Diet* 1974; 11 : 328-34.
36. Hanumantha Rao D, Satyanarayana K, Vijayaraghavan K, Gowrinath Sastry J, Nadamuni Naidu A, Swaminathan MC, et al. Evaluation of the special nutrition programme in the tribal areas of Andhra Pradesh. *Indian J Med Res* 1975; 63 : 652-60.
37. Krishnamachari KAVR, Pralhad Rao N, Visweswara Rao K. Food and nutritional situation in the drought affected areas of Maharashtra - A survey and recommendations. *Indian J Nutr Diet* 1974; 11 : 20-7.
38. National Institute of Nutrition. *Annual report 2015-16*. Hyderabad: National Institute of Nutrition; 2015-16.
39. Indian Council of Medical Research. *Touching lives - Improving health through research*. New Delhi: Roli Books; 2018. p. 46-51.
40. Radhika MS, Nair KM, Kumar RH, Rao MV, Ravinder P, Reddy CG, et al. Micronized ferric pyrophosphate supplied through extruded rice kernels improves body iron stores in children: A double-blind, randomized, placebo-controlled midday meal feeding trial in Indian school children. *Am J Clin Nutr* 2011; 94 : 1202-10.
41. Gopalan C. A report on the first fifty years of the nutrition research laboratories, Hyderabad. *Nutr Rev* 1970; 28 : 1-7.
42. Mohan VS, Nagarajan V, Gopalan C. Simple practical procedures for the removal of toxic factors in *Lathyrus sativus* (Khesari dhal). *Indian J Med Res* 1966; 54 : 410-4.
43. Polasa K, Sudershan RV, SubbaRao GM, VishnuVardhana Rao M, Rao P, Sivakumar B. *National report on KABP study on food safety in India*. Hyderabad: Food and Drug Toxicology Research Centre, National Institute of Nutrition; 2006.
44. Raghuram TC, Rao BU, Rukmini C. Studies on hypolipidemic effects of dietary rice bran oil in human subjects. *Nutr Rep Int* 1989; 39 : 889-95.
45. Raghuram TC, Sharma RD, Sivakumar B, Sahay BK. Effect of fenugreek seeds on intravenous glucose disposition in non-insulin dependent diabetic patients. *Phytother Res* 1994; 8 : 83-6.
46. Rukmini C, Vijayaraghavan M. Nutritional and toxicological evaluation of mango kernel oil. *J Am Oil Chem Soc* 1984; 61 : 789-92.
47. Rukmini C. Nutritional significance of rice bran oil. *Nutr News* 1985; 6 : 1-3.
48. Rukmini C, Udayasekhara Rao P. Chemical and nutritional studies on *Terminalia bellarica* Roxb kernel and its oil. *J Am Oil Chem Soc* 1986; 63 : 360-3.
49. Rukmini C. Chemical, nutritional and toxicological studies of rice bran oil. *Food Chem* 1988; 30 : 257-68.
50. Sharma RD, Rukmini C. Rice bran oil and hypo-cholesterolemia in rats. *Lipids* 1986; 21 : 715-7.
51. Sharma RD, Rukmini C. Hypocholesterolemic activity of unsaponifiable matter of rice bran oil. *Indian J Med Res* 1987; 85 : 278-81.

52. Ghafoorunissa. Fat and fatty acid contents of cereals and pulses and their relevance to Indian diets. *Eur J Clin Nutr* 1989; 43 : 275-83.
53. Ghafoorunissa, Krishnaswamy K. *Diet and heart disease*. Hyderabad: National Institute of Nutrition; 1994.
54. Ghafoorunissa. Impact of quality of dietary fat on serum cholesterol and coronary heart disease: Focus on plant sterols and other non-glyceride components. *Natl Med J India* 2009; 22 : 126-32.
55. Patwardhan VN. The nutritive value of hydrogenated oils (vanaspati). *J Sci Ind Res* 1948; 7 : 253.
56. Patwardhan VN. Investigations on hydrogenated oils. *J Sci Ind Res* 1951; 10A : 18-21.
57. Food Safety Standards Authority of India. *Food safety and standards amendment to regulation act. The gazette of India, 4th August, 2015*. New Delhi: Controller of Publications, Ministry of Health and Family Welfare, Government of India; 2015. Available from: old.fssai.gov.in/Portals/0/Pdf/Gazette_Notification_TFA_28_08_2015.pdf, accessed on November 17, 2018.
58. Krishnaswamy K, Prasad MP, Krishna TP, Pasricha S. A case control study of selenium in cancer. *Indian J Med Res* 1993; 98 : 124-8.
59. Krishnaswamy K, Polasa K. Diet, nutrition & cancer - The Indian scenario. *Indian J Med Res* 1995; 102 : 200-9.
60. Krishnaswamy K, Prasad MP, Krishna TP, Annapurna VV, Reddy GA. A case study of nutrient intervention of oral precancerous lesions in India. *Eur J Cancer B Oral Oncol* 1995; 31B : 41-8.
61. Krishnaswamy K, Goud VK, Sesikeran B, Mukundan MA, Krishna TP. Retardation of experimental tumorigenesis and reduction in DNA adducts by turmeric and curcumin. *Nutr Cancer* 1998; 30 : 163-6.
62. Nirmala K, Prasanna Krishna T, Polasa K. *In vivo* antimutagenic potential of ginger on formation and excretion of urinary mutagens in rats. *Int J Cancer Res* 2007; 3 : 134-42.
63. Kota N, Krishna P, Polasa K. Alterations in antioxidant status of rats following intake of ginger through diet. *Food Chem* 2008; 106 : 991-6.
64. Vijayapushpam T, Subba Rao GM, Antony GM, Rao DR. Nutrition education for student community volunteers: A comparative study of two different communication methods. *Food Nutr Bull* 2008; 29 : 108-12.
65. Vijayapushpam T, Antony GM, Rao GM, Rao DR. Nutrition and health education intervention for student volunteers: Topic-wise assessment of impact using a non-parametric test. *Public Health Nutr* 2010; 13 : 131-6.
66. Rao DR, Vijayapushpam T, Subba Rao GM, Antony GM, Sarma KV. Dietary habits and effect of two different educational tools on nutrition knowledge of school going adolescent girls in Hyderabad, India. *Eur J Clin Nutr* 2007; 61 : 1081-5.
67. SubbaRao GM. Nutrition communication thus far and further - A critical examination of research and practice. *Indian J Sci Commun* 2009; 8 : 3-13.
68. SubbaRao GM, Vijayapushpam T. Nutrition education for student-volunteers using televised folkdance form. *J Nutr Educ Behav* 2009; 41 : 436-7.
69. Gavaravarapu SM. Group quiz: A tool for nutrition education and self-assessment. *J Nutr Educ Behav* 2013; 45 : 380-2.
70. Nalam A, Gavaravarapu SM, Kodali V, Dharmapuri RR. Pictorial learning and visual imagery-based activity methods in nutrition education for primary schoolchildren in India. *J Nutr Educ Behav* 2017; 49 : 264-70.
71. Saha S, Vemula SR, Mendu VVV, Gavaravarapu SM. Knowledge and practices of using food label information among adolescents attending schools in Kolkata, India. *J Nutr Educ Behav* 2013; 45 : 773-9.
72. Vemula SR, Gavaravarapu SM, Rao MVV, Mathur P, Laxmaiah A. Knowledge and practices of using food label information among adolescents attending schools in Kolkata, India. *Public Health Nutr* 2013; 45 : 773-9.
73. Gavaravarapu SM, Saha S, Vemula SR, Mendu VV. Read-B4-U-eat: A multi-component communication module to promote food label reading skills among adolescents in India. *J Nutr Educ Behav* 2016; 48 : 586.
74. Narasinga Rao BS. Control of anaemia through iron fortified salt - A critical appraisal of its implications. *ICMR Bull* 1982; 12 : 47-52.
75. Nair KM, Brahmam GN, Ranganathan S, Vijayaraghavan K, Sivakumar B, Krishnaswamy K, et al. Impact evaluation of iron & iodine fortified salt. *Indian J Med Res* 1998; 108 : 203-11.
76. Sivakumar B, Brahmam GN, Madhavan Nair K, Ranganathan S, Vishnuvardhan Rao M, Vijayaraghavan K, et al. Prospects of fortification of salt with iron and iodine. *Br J Nutr* 2001; 85 (Suppl 2) : S167-73.
77. Ministry of Women and Child Development. *National use of double fortified salt (DFS) in national programs, No 5-4/2011, ND/Tech (date 21 June, 2011)*. New Delhi: Ministry of Women and Child Development, Government of India; 2011. Available from: <http://www.wcd.nic.in/sites/default/files/icdsdtd22022012.pdf>, accessed on November 9, 2018.
78. NITI Aayog, Government of India. *Nourishing India - National Nutrition Strategy*, Available from: http://niti.gov.in/writereaddata/files/document_publication/Nutrition_Strategy_Booklet.pdf, accessed on November 17, 2018.
79. Ministry of Women and Child Development, Government of India. *About POSHAN Abhiyaan*. Available from: https://www.icds-wcd.nic.in/nnm/NNM-Web-Contents/UPPER-MENU/AboutNNM/PIB_release_NationalNutritionMission.pdf, accessed November 17, 2018.