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Nuclear and isotopic techniques application used in supporting nutritional studies in Latin America countries

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SUMMARY. The global nutrition community recognizes the usefulness of nuclear and isotopic techniques and especially stable isotopes for accurate measurements in key areas of human nutrition and health. Although progress has been made in many Latin America countries in reducing the absolute number of undernourished people, food policy and public health communities have to face the double burden on health. On one side they have to address the prevention of obesity and on the other side they are trying to reduce under-nutrition. However, to be successful in development of sustainable nutrition programs, a combination of relevant scientific knowledge and approaches that are practical is required to assure even a reasonable level of success. The objectives of this review are to highlight the role of isotopic techniques in nutritional studies and to review the role of the International Atomic Energy Agency in supporting nutrition interventions in Latin America countries.
Key words: Nutrition, stable isotopes, Latin America.

RESUMEN. Uso de técnicas nucleares y especialmente de isótopos estables en el soporte de estudios de nutrición humana en los países de América Latina. La comunidad global de la nutrición reconoce la utilidad de técnicas nucleares e isotópicas y especialmente de isótopos estables para las medidas exactas en las áreas dominantes de la nutrición humana y de la salud. Aunque se ha progresado en muchos países de América Latina en la reducción del número absoluto de desnutridos, la política alimentaria y las comunidades de la salud pública, tienen que hacer frente a la carga doble en la salud. Por un lado se tiene que tratar la prevención de la obesidad y, por otro lado, se está intentando reducir la malnutrición y la pobreza. Para ésto, el conocimiento científico relevante y el arte de la práctica son necesarios para ser acertados en el desarrollo de los programas sostenibles de la nutrición. Los objetivos de esta revisión son destacar el papel de técnicas isotópicas en estudios nutricionales y revisar el papel del Organismo Internacional de Energía Atómica (OIEA) en la intervención y soporte del estado de la nutrición en los países de América Latina.
Palabras clave: Nutrición, isótopos estables, América Latina.

INTRODUCTION

Latin America countries are experiencing an epidemiological overlap as part of the so-called nutrition epidemiological transition. Indeed, as shown in Table 1, in many countries of the region, a high incidence of nutritional deficiencies and infections coexist with obesity and non-communicable diseases. Stunting affects 13-24% of Latin American children while more then one-third of the adult population, mostly women, are experiencing overweight and obesity heath risks (1,2). Moreover, the WHO World Health Report (3) shows clearly (Table 2) that in developing countries with low mortality, such as most countries in Central and South America, under nutrition and obesity are among the five risk factors leading to disability and death (3).

Although progress has been made in many Latin America countries in reducing the absolute number of undernourished people, food policy and public health communities have to face the double burden on health. These countries have to address the prevention of obesity and simultaneously they need to reduce under nutrition.

TABLE 1
Percentage of children in malnutrition conditions and percentage of women overweight/obesity in some Latin America countries

Countries	% of under five children who are underweight	% of under five children who are stunted	Overweight and obesity level (%) in women 15-49 years
Bolivia	10	26	33.8
Brazil	6	11	35
Colombia	7	14	40.6
Dominican Rep.	5	6	48.1
Ecuador	15	27	-
Guatemala	24	46	34.2
Mexico	8	18	33.5
Peru	7	25	44.9
Chile	1	2	-

Source: (1,2)

The Bellagio Declaration (3) on the nutrition transition in the developing world stressed on the need for initiatives that provide technical support in the programme evaluation and cost effective assessments of existing and new programs and interventions to control malnutrition at national and regional levels.

TABLE 2
Leading 10 selected risk factors as percentage causes of Disease burden measured in DALYs in low mortality countries (e.g. Latin America countries)

Factors	DALYs in %
Alcohol	16.2
Blood pressure	5.0
Tobacco	4.0
Underweight	3.1
Overweight	2.7
Cholesterol	2.1
Low fruit & vegetable intake	3.9
Indoor smoke from solid fuels	1.9
Iron deficiency	1.8
Unsafe water, sanitation & hygiene	1.8

DALYs: Disability adjusted life in years. One DALY is equal to one healthy year of life lost. Source: (2)

However, to be successful in the development and implementation of sustainable nutrition programs, a combination of relevant scientific knowledge and practical approaches are required to assure a reasonable level of success. Reviewing and evaluating nutrition intervention thus need reliable and cost effective tools. These allow the policy makers to adopt sound sustainable strategies.

The global nutrition community recognizes the usefulness of nuclear and isotopic techniques and especially stable isotopes for accurate measurements in key areas of human nutrition and health: assessment of nutritional status, nutrient uptake and bioavailability, nutrients requirements, micronutrient malnutrition, food analysis, *etc.* (4).

The objectives of this review are to highlight the role of isotopic techniques in nutritional studies in general and to review the role of the International Atomic Energy Agency in supporting nutrition interventions in Latin America in particular.

Nuclear and isotopic techniques applied to human nutrition: A brief overview

Stable isotopes do not emit radiation and hence can be safely utilized in human studies and are particularly useful in human nutrition. There are two forms of isotopic tracers: radioactive and stable.

Radioactive isotopes can be detected via radiation they emit. They have many important applications, such as measurements of body composition, uptake and bioavailability of nutrients and with ^{14}C-urea breath test to examine bacterial colonization by *Helicobacter pylori*. However, the risk of radiation related health effects overtime has dampened the use of radiotracers in human subjects.

Stable isotopes on the other hand are invaluable since there are virtually no health risks associated with their use. Therefore they are preferred for work in humans, especially in infants, children and pregnant women. Many naturally occurring elements exist as a mixture of two or more stable non-radioactive isotopic forms. There are the heavy stable isotopes (*e.g.* ^{54}Fe, ^{56}Fe, ^{57}Fe, ^{58}Fe, ^{64}Zn, ^{66}Zn, ^{68}Zn, ^{70}Zn) and light stable isotopes (*e.g.* ^{1}H, ^{2}H, ^{13}C, ^{12}C, ^{15}N, ^{14}N, ^{16}O, ^{17}O, ^{18}O).

The main advantages and disadvantages of these two forms of isotopic tracers are summarized in Table 3.

TABLE 3
Advantages and disadvantages radioactive and stable isotopes

Isotopes Utility	Radioisotopes	Enriched Stable Isotopes
Advantages	- authentic tracers - easily detectable - generally inexpensive - sample preparation minimal - whole body measurement, retention can be determined	- minimal health risk, can be used in infants, pregnant and lactating women - multi-elements procedure - tracers may be followed for longer periods - samples can be stored without loss of tracers - reanalysis possible
Disadvantages	- safety concerns, some risk through exposure to radiation - unsuitable for infants and children, pregnant and lactating women - decay time - only one radioactive element can be studied - sample analysis must be timed based on half-life - expensive waste problem	- not true tracers, larger amount needed - expensive - extensive sample preparation - still complex and costly analysis - direct determination of retention not possible

Source: (5).

Some examples of the application of stable isotope applications in human nutritional studies are as follow:

Estimation of total energy expenditure

Energy expenditure data can be used to strengthen the

base for public health policy. The doubly labeled water (DLW) method determines the caloric expenditure of people in their normal environment. It is accurate and can be applied under field conditions. After administration of a sample dose of double-labeled water $^{2}H_{2}$ ^{18}O both isotopes equilibrate with total body water and are eliminated differentially in body fluids over a period of days. Deuterium (^{2}H) leaves the body as water and ^{18}O leaves it as water and CO_2. Thus, the difference rate of loss of the two isotopes ^{2}H and ^{18}O is used to calculate CO_2 production of the subject, which is in turn, is used to calculate energy expenditure (6).

Estimation of lean body mass (body composition)

There is a growing consensus among global nutrition experts that evaluating body composition in children and adults will help in designing strategies to improve national health profiles, which is an important step in targeting health and nutrition intervention. A trace dose of water labeled with ^{2}H or ^{18}O is administrated and allowed to equilibrate for 4-6 hours. Isotope enrichment in urine or saliva samples is measured to calculate body water volume. Total body water is used to quantify fat-free mass. Body composition is calculated from measured body water and the hydration coefficient of fat-free mass. The amount of fat (adipose) tissue is calculated as the difference between total body weight and lean body mass (7). Exact measurements of lean mass and fat mass are very useful to assess under nutrition and obesity in populations at risk. In addition, lean body mass can be considered a valuable indicator to monitor body wasting in HIV/AIDS patient, which shows a decrease in lean body mass. An increased in energy expenditure also is seen when compared to HIV negative subjects (8).

Measurement of breast milk intake

Measurement of breast milk intake is fundamental for infant nutrition in developing countries since it is well known that early introduction of weaning foods is an important cause of child malnutrition. The isotope dilution method does not interfere with feeding behavior and is therefore suitable for nutritional studies in developing countries. The mother given dose of ^{2}H or ^{18}O labeled water, which mixes with the body water pool and is transferred to the baby via breast milk. By collecting samples of the mother's saliva or milk and the baby's saliva or urine, the breast milk intake of the baby can be calculated (9).

Trace element bioavailability

The uptake and metabolism of labeled micronutrients can be traced in vivo. In fact, stable isotopes provide the most acceptable way of measuring the uptake and bioavailability of trace elements in humans (10).

Analysis of food

Neutron activation analysis (NAA) is a highly sensitive method for the accurate determination of up to 60 elemental concentrations in material. Sensitivities are sufficient to measure certain elements at the nanogram level and below. The NAA method is based on the detection and measurement of characteristic gamma rays emitted from radioactive isotopes produced in the sample upon irradiation with neutrons. The technique requires only small amounts of sample material - 100 to 200 milligrams and it is also not necessary to do any sample preparation other than size reduction and (in some cases) drying, making the technique non-destructive. Application of NAA-related methods is particularly attractive for developing countries since many research reactors are available to provide the needed neutron source (11). Inductively Coupled Plasma Mass Spectrometry (ICP-MS) also offers multi-element determinations.

Osteoporosis

Measuring bone mass is essential to diagnosing and managing osteoporosis and related issues of bone metabolism. DEXA (Dual Energy X-ray Absorptiometry) is now the standard technique for measuring bone mass density. Low energy X-rays are passed through the bones to measure the mineral particularly calcium content of the bones. The precision of DEXA is very high and the data can be standardized for age, weight, height and ethnic status (12).

Detection of infection

The use of the stable isotope in ^{13}C-urea breath test, instead of ^{14}C-urea, has recently been applied to detect *Helicobacter pylori* infection in humans. Breath is collected for a base value before a ^{13}C labeled urea is administered. The enzyme urease of *H. pylori* breaks down the urea into ammonium and labeled bicarbonate. The latter compound will be metabolized by the person into carbon dioxide and expired. After 20-30 minutes a second breath sample is collected and measured for ^{13}C (13).

The role of the IAEA in supporting nutritional studies using nuclear and related techniques

The International Atomic Energy Agency (IAEA), as an independent intergovernmental, science and technology-based organization in the United Nations family, provides assistance in the use of nuclear science and technology for peaceful applications and facilitates the transfer of nuclear technology and knowledge in a sustainable manner to its Member States. One of its programmes focuses on human health, specifically for the use of isotopes or nuclear related

techniques to evaluate human nutritional status and the nutritional quality of foods. Through this programme, the IAEA offers technical support via coordinated research projects (CRPs) and technical cooperation projects (TCP) (14) to evaluate the efficacy of fortified food supplementation initiatives and other interventions aimed at fighting many forms of malnutrition. It is a partner in addressing nutrition and health problems in more than 50 countries in collaboration with Member States, other United Nations organizations and donors.

Coordinated Research Projects (CRPs)

A Coordinated Research Project (CRP) is a mechanism by which group of countries are brought together to work on a well-defined research topic for an average duration of 3 years. Modest annual funding is made available to developing countries mainly for sample collection and analysis. As a crucial part of a CRP, collaboration between scientists from developing and developed countries is stimulated and exchanges of information are encouraged through participation at the research coordination meetings (RCM) funded by the IAEA.

Recently, the T-CRP (Thematic CRP or Doctorate CRP) a new type of CRP has been introduced that is dedicated to the support of PhD students. This increases the scope of a normal CRP for capacity building in developing countries. Pairs of countries (developed and developing countries) are stimulated to work together. The program promotes postgraduate training in the student's country of origin and supports the possibility of short training in a developed country. The T-CRP has a longer duration up to 4-5 years, and has an increased level of funding through traditional CRPs.

The Technical Cooperation Programme (TCP)

The Technical Cooperation Programme (TCP) support socio-economic goals to Member States based on their respective national development priorities and relevant nuclear applications. It promotes the transfer of known technology that has been used in the Agency and addresses priority problems identified by Member States and ensure its support through the TC programme is strategically planned for maximal impact generation. Unlike CRPs that focus on research for development of tools and techniques, the TCP covers projects relevant to proven nuclear techniques that are ready for practical applications and can contribute to the solutions of field or development problems.

The TCP responds to project requests received from Members States by applying of appropriate criteria for project formulation and appraisal according to the TC strategy and Management Principles and by securing formal approval by the IAEA Board of Governors. These criteria include strong government support and patronage priority areas for national development. Requests must be linked directly to end-users, which in the case of nutrition projects are usually public health institutes that can implement recommendations that result from funded projects and use project results to modify interventions as needed. The TCP comprises of national, regional or inter-regional technical cooperation projects that are implemented for 2 to 4 years by one or more institutes in a country or various countries in a region.

As sources of technical co-operation, in kind contributions towards manpower development via training, fellowships, expert missions or scientific visits and equipment are provided to recipient Member States. Existing facilities relevant to the achievement of funded projects' objectives are supplemented with an end of sustaining the capabilities of Member States after project completion.

IAEA-supported nutrition studies in Latin America

Participation of the Latin America countries in the regular budget programme (CRPs)

Since early 1980's, Latin America countries have been involved actively in almost all IAEA's CRPs (Table 4). These have included studies on trace elements, amino acid and protein metabolism, osteoporosis, vitamin A, growth monitoring, osteoporosis and *H. Pylori* infection. Brazil, Jamaica, Mexico, Uruguay, Chile, Guatemala, Peru, Argentina and Venezuela have been among the participating countries.

The main outcomes of these CRPs and of the Latin America projects are described in the Nutrition and Health Related Environmental Studies (NAHRES) reports as indicated in (Table 5). In the last 20 years the total amount of the Agency' support to CRPs is about US$ 2.6 million, of which US$600,000 has been allocated to researches in Latin America countries.

Participation of Latin America countries in the Technical Cooperation Programme (TCP)

In the late 90s, the IAEA began its involvement in the evaluation of nutritional intervention programmes through the application of stable isotopes, primarily through initiatives of Member States with the support for national Technical Co-operation projects. By the decades end, Peru and Chile implemented and completed national TC Project in 1994 and 1997, respectively (Table 6).

TABLE 4.
CRP list of IAEA Nutrition Studies during 1983 – 2004

Co-ordinated Research Projects (CRP) Completed:	Project No:	Country	Starting Year
Dietary intake of trace elements	E4.30.01	Turkey, Spain, Brazil, Iraq, Sudan, Thailand, China, Italy, Sweden, USA, Canada, Yugoslavia, Australia, Finland	1983
Toxic elements in foodstuffs (RCA)	E4.30.02	Jamaica, Bangladesh, Thailand, Pakistan, Australia, China, Malaysia, India, Japan, Indonesia, Netherlands	1985
Applications of stable isotope tracers	E4.30.03	China, Germany, Ghana, Papua New Guinea, Romania, Australia, India, Malaysia, Mexico, Uruguay, Guatemala, Italy, Senegal, Nigeria, UK, US	1988
Bioavailability of Fe & Zn	E4.30.04	Chile, India, Myanmar, Pakistan, Peru, Philippines, Poland, Sri Lanka, Venezuela, UK, US	1990
Amino Acids, Protein & Energy Metabolism	E4.30.05	Bangladesh, Bolivia, Guatemala, India, Pakistan, Philippines, Jamaica, Peru	1992
Osteoporosis	E4.30.06	Brazil, Canada, Chile, China, Croatia, Hungary, Philippines, Russia, Singapore, S. Africa, Turkey	1994
Vitamin A	E4.30.07	China, India, Israel, Peru, Philippines, S. Africa, Thailand	1995
Reference Asian Man	E4.30.08	Bangladesh, China, India, Indonesia, Japan, Korea, Malaysia, Pakistan, Philippines, Vietnam	1995
Prevention of Stunting	E4.30.09	Argentina, Brazil, Chile, Mexico, Pakistan, Peru, Venezuela	1996
Infant Growth Monitoring (Collaboration with WHO)	E4.30.10	Bangladesh, Brazil, Chile, Pakistan, UK, USA	1999
Prevention of Degenerative Diseases (Obesity, Non-insulin Dependent Diabetes and Coronary Heart Disease) in Ageing	E4.30.11	Brazil, Chile, China, Cuba, India, Jamaica, Mexico, Nigeria	1999
Active:			
H. Pylori Infection Prevalence in Early Childhood	E4.30.12	Argentina, Bangladesh, Belgium, Benin, Chile, India, Indonesia, Mexico, Pakistan, Senegal	1999
Nutrition-Pollution Interactions and their Impact	E4.30.14	Bangladesh, Brazil, Chile, China, India, Kenya, Korea, Morocco, Peru, Sweden, Vietnam	2001
Application of isotopic and nuclear techniques to (IUGR) intrauterine growth restriction in developing countries	E4. 30.15	Bangladesh, Brazil, Cameroon, India, Morocco, Pakistan, South Africa, Sudan, USA,	2003
Assessment of total energy expenditure and body composition for older adult subjects with different lifestyles	E4.30.16	Brazil, China, Guatemala, India, Mexico, Morocco, New Zealand, Philippines, South Africa, Senegal, USA	2004
Thematic Co-ordinated Research Projects (T-CRPs) for capacity development in Developing Countries			
Micronutrient Status and Interaction	E4.30.13	Bangladesh, Brazil, Ghana, India, Indonesia, Mexico, Pakistan, Sri Lanka, Thailand	2001

TABLE 5
List of NAHRES Reports from the CRP Projects during 1983-2004
(These reports are available upon request, free of cost)

CRP	NAHRES Report No.
Dietary intake of trace elements	2, 8, 10
Toxic elements in foodstuffs	3, 23
Applications of stable isotope tracers	4, 5, 7
Bioavailability of Fe & Zn	11, 20, 34
Amino Acids, Protein & Energy Metabolism	15, 21, 30, 41
Osteoporosis	14, 28, 31, 39, 40, 51, 67
Vitamin A	25, 32
Reference Asian Man	38, 54
Prevention of Stunting	44, 48
Infant Growth Monitoring	55, 79
Prevention of Degenerative Diseases	47, 70, 76
H. Pylori Infection Prevalence in Early Childhood	56, 78
Nutrition-Pollution Interactions	71, 80
Micronutrient Status and Interaction	72
Intrauterine growth restriction (IUGR)	73, 81
Total energy expenditure and body composition for older adult subjects with different lifestyles	74

TABLE 6
List of IAEA supported National TC Projects on Nutrition Studies during 1994-2003

National Projects Completed:	Project No.	Country	Starting year
Isotopes in nutrition studies	CHI/7/007	Chile	1997
Micromineral interaction in vulnerable groups	CHI/7/008	Chile	1999
Evaluating supplementary infant eeding practices	ETH/7/004	Ethiopia	1999
Improve child nutrition	PER/7/003	Peru	1994
Dietary studies in Portugal	POR/7/002	Portugal	1994
Isotope evaluation of community nutrition program	SEN/7/002	Senegal	1999
Evaluation of community programme	SEN/7/003	Senegal	2003
Investigating micronutrient deficiency	SIL/7/002	Sierra Leone	1995
Improvement of nutrition & diagnosis	SRL/7/004	Sri Lanka	2001
Active:			
Evaluating Zn, Vitamin A as supplements in treatment of Malaria	BKF/7/002	Burkina Fasso	2003
Evaluate impact of multinutrient supplements on pregnancy outcomes	EGY/7/003	Egypt	2003
Breast Milk Trace element composition and Infant Growth	GHA/6/011	Ghana	1999
Evaluation of Complementary Feeding Program	GHA/7/003	Ghana	2003
Improving nutritional status of children and women	MAG/7/003	Madagascar	2003
Trace element methods for studies workplace monitoring	NIR/7/003	Nigeria	1999
Monitoring food fortification program	SAF/7/003	South Africa	2003
Food Supplementation strategy for women in rural areas	SEN/7/004	Senegal	2003
Monitoring food fortification program in Morocco	MOR7002	Morocco	2003

The IAEA recognized the value of regional co-operation in facilitating transfer of know-how and capabilities, as well as integration of valuable results that provide regional if not global perspectives in dealing with common issues related to nutrition in some Latin America countries. Subsequently, some Latin American countries have become more involved in regional TC projects (Table 7). Through this realisation, a three-year regional Technical Co-operation project was initiated in 1999 on "Using Isotopes to Evaluate Nutrition Intervention Programmes (RLA/7/008)". This initially involved Argentina, Chile, Cuba, Brazil and Mexico but was completed in the latter four countries.

The regional nutrition project supported the evaluation of the effectiveness of some large nutrition supplementation programmes in place by the Latin America governments. These programs amounted US$ 300 million in Chile, US $ 2 billion per year in Mexico, US $ 56 million in Brazil and US$ 80 million per year in Cuba. These programs benefit millions of children and adults in those countries. The IAEA funded the application of isotopes activities through the Technical Co-operation Hard Core fund that subsequently was complemented by the U.S. extra-budgetary fund.

Implementation strategies

Investigations and measurements in the TC projects were carried-out on specific study areas. In keeping with the principle of Technical Cooperation in Developing Countries (TCDC) that recognizes diverse capabilities within regions, measurements of isotopes were made when possible in one of the participating institutes, *e.g.* in Chile when need laboratory capabilities are not available in another participating country. Each participating institute is expected to provide scientific, service or data to the other project participants. A Principal Co-coordinating Counterpart with expertise that is recognized globally provides advisory

assistance that ensures adequate co-ordination of national and regional activities, and the integration of results in respective national plans and policy-making efforts. Scientific guidance provided through the implementation of national activities ensures moving towards the attainment of the objectives of regional initiatives.

TABLE 7
List of IAEA supported Regional TC Projects on Nutrition Studies during 1994-2003

Regional Projects Completed:	Project No:	Country	Starting Yr.
Measuring the Effectiveness of Multinutrient Supplementation	RAS/7/010	China, Indonesia, Malaysia, Pakistan, Philippines, Thailand, Vietnam	1999
Active:			
Evaluate Nutrition Intervention Programs	RLA/7/008	Chile, Cuba, Brazil, Mexico	2000
Early Diagnosis of *Helicobacter pylori* Infection (ARCAL LIV)	RLA/6/042	Argentina, Bolivia, Brazil, Chile, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Mexico, Panama, Peru, Venezuela	2001
Diagnosing Osteoporosis (RCA)	RAS/7/012	India, China (Hong Kong), Singapore, Thailand, Viet Nam, Philippine	2003
Monitoring Food ortification Program	RAS/7/014	China, Indonesia, Pakistan Thailand, Vietnam	2003
Assess nutrition intervention related to HIV/AIDS in Africa	RAF/7/006	Ghana, Senegal, South Africa,	2003

The TC regional projects in Latin America likewise have supported the regional co-ordination of activities that result in the exchange of scientific results and assess progress and future directions. Transfer of know-how has been facilitated through workshops and training courses conducted for young scientists from each participating country.

Main outcomes from the regional project on nutrition in Latin America RLA/7/008

Prior to the regional project on nutrition (RLA/7/008), worldwide data on energy expenditures were based on surveys in developed countries. No data existed from Latin America to provide a scientific basis to formulate food programmes suited to local conditions. A comparison of recently obtained project data indicates that existing references values overestimate energy needs of children below 7 years old (14). Results from the Cuban study designed to evaluate the Cuban nutrition program's capacity to cover the energy requirements of children were obtained by applying the doubly labeled water technique. This study concluded that the energy requirement of well-nourished children is 8.6% lower than the 1985 FAO/WHO/UNU recommendations.

Through the initiatives under the regional project, Chile carried out a national effort to investigate energy balance, physical activity pattern, dietary intake and body composition in preschool children. As a result, the Chilean government recognized the necessity to reduce the energy intake of children to prevent obesity, an increasing problem in countries considered to be in "nutrition transition" (15). Scientific papers were published and presented during the International Congress on Nutrition (16).

In addition, other specific results also had other significant impacts on national programmes. Policies related to food fortified with iron and zinc in pre-school food programmes of the National Supplementary Feeding Programme (coverage of ~1.3 million) of Chile were modified based on this projects scientific results. As a result, anemia has been reduced from 28.8% to less than 8% within a year in a sample of 300 children after the program increase its foods fortified with use of iron and zinc. This generates impact on the enhancement of educational performance and decrease infections among children.

In Mexico the Social Security System in recognition of the importance of isotopic studies to their nutrition programme purchased two mass spectrometers to sustain the assessment of the effect of food supplementation to pregnant and lactating mothers and to monitor the effect of iron and zinc fortification.

In Brazil, US $40,000 equivalent was allocated by the government for the first large-scale epidemiological study employing isotopes to measure the body composition of 200 under-nourished children after 6 months of participation in a specific intervention.

The results of investigations of energy expenditure of young children in Cuba and Chile based on doubly labeled water (14,15) were used for the first time by the FAO/WHO/UNU expert committee convened in 2001 to establish new energy recommendations. The IAEA has the opportunity to partner with other UN agencies in promoting isotope based research relevant to energy and protein requirements, mainly in developing countries.

Financial resources in support of NAHRES nutritional projects

In the last 20 years, the IAEA invested about US $2.6 million for research activities through CRPs. Over 20% of the financing was allocated for Latin American countries. In the ten-year period, regional and national TC projects

amounted to over US$ 7.6 million, more than double of what was invested in research in the previous 20 years. About 40% of this total amount was invested in TC projects supporting the use of isotopic techniques in nutrition research programmes in Latin American countries, and enhancing capabilities and laboratory facilities relevant to those studies. It is notable that Latin American countries are more active in TC projects than in work through the CRPs. This reflects the region's interest in applications of techniques that can yield information relevant to existing socio-development programmes.

CONCLUSION

Since the 90s Latin America countries have developed and planned designed to meet nutritional priorities in each country. However, the rate of progress of nutrition programs effectiveness remains slow in many Latin America countries. To reach millennium goals, countries must build cost effective by strategies using accurate tools for evaluation and monitoring.

It is clear that through their participation to the IAEA program in nutrition, Latin America countries have recognized the significance of nuclear and stable isotopic techniques to help secure accurate assessments of nutritional status of population and the effectiveness nutrition interventions in improving health. Indeed, some countries such as Chile, Mexico and Cuba focused nutrition intervention programmes according to local population needs that were informed by results enabled by isotopic investigations.

Although Latin America countries are represented in all the IAEA nutrition activities (CRPs and TC projects), some countries in the region have yet to incorporate isotopic techniques in tackling nutritional issues.

In addition, good technical capabilities and scientific infrastructures are now available in some countries in the region *e.g.* Chile and Mexico. These can be used as regional expertise centers and serve to build capacities in the region.

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