IAEA BULLETIN

INTERNATIONAL ATOMIC ENERGY AGENCY

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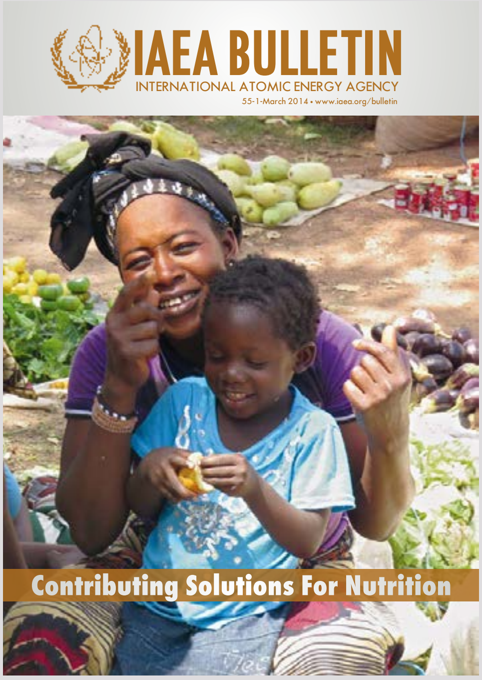
Contributing Solutions For Nutrition



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Cover Photo:
A mother and child in Burkina Faso.
(N. Mokhtar, IAEA)

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THE IAEA FOCUSES ON GLOBAL NUTRITIONAL NEEDS

For over fifty years, the IAEA has been helping its Member States to harness peaceful nuclear science and technology to bring demonstrable benefits to their people. Nutrition is one area in which the IAEA's partnership with Member States has steadily deepened.

Ensuring the right nutrition can have a profound impact on a child's ability to grow, learn, and emerge out of poverty.

Malnutrition remains one of the biggest killers of young children. Eradicating malnutrition and improving the nutrition of children worldwide are among the Millennium Development Goals, which the IAEA is committed to supporting. One out of ten children born in developing countries will die before their fifth birthday — that is more than 10 million children who die every year. For infants and children under the age of two, the consequences of undernutrition are particularly severe, often permanent. The first two years of a child's life are vital to shaping a healthy and prosperous future. During this period, children are especially vulnerable to poor nutrition and unsatisfactory hygienic conditions. Ensuring the right nutrition can have a profound impact on a child's ability to grow, learn, and emerge out of poverty. This, in turn, can make an important contribution to enhancing a society's long-term health, stability and prosperity.

The IAEA is playing a valuable role by encouraging the deployment of nuclear and isotope techniques to develop cost-effective nutritional interventions that can significantly improve children's health. For example, the IAEA contributes technical expertise in the use of stable isotope techniques to help determine whether children — and their mothers — are being properly nourished. Such techniques have been used as research tools in nutrition for many years. The IAEA helps Member States to use these techniques to evaluate their national nutrition programmes and improve public health policy.

The IAEA supports the Scaling Up Nutrition (SUN) Movement, through the United Nations System Network. The Sun Movement was launched at the United Nations General Assembly in September 2010 and is founded on the principle that all people have a right to food and good nutrition. It aims to significantly reduce malnutrition in participating countries.

This issue of the IAEA Bulletin focuses on the IAEA's work in nutrition. Topics include our initiatives to measure human milk intake in breastfed infants, lean body mass (muscle mass) in lactating mothers, and the bioavailability of iron in infants and young children. We also look at the paradox of the simultaneous occurrence of both undernutrition and overnutrition that is often found within communities, and even households, across the globe.

The IAEA is committed to doing everything it can to make peaceful nuclear technology available to help give all the children of the world a brighter future.

Yukiya Amano, IAEA Director General

IAEA NUTRITION PROGRAMMES FEED GLOBAL DEVELOPMENT

Najat Mokhtar, Head of the IAEA's Nutritional and Health-Related Environmental Studies Section, and her colleague Christine Slater, a nutrition specialist in the same Section, explain to writer Sasha Henriques why nutrition is such a critical issue for the Agency.

Q: Why is the IAEA involved in nutrition?

As an organization, the IAEA has a statutory requirement to "accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world."

Good nutrition is the cornerstone of good health and the development of nations. That's why the IAEA is involved in nutrition.

Nutrition is a holistic issue. Poor nutrition is one of the leading causes of disease and death. It affects brain development and the ability to learn, resulting in scholastic underperformance. Poor nutrition in infancy can lead to diseases like diabetes, hypertension, and cardiovascular disease in adulthood.

If we don't tackle nutrition from conception to two years of age, when the foundation is being set for the rest of a person's life, it's often impossible to make a difference later on.

Q: At first glance, nuclear and nutrition don't fit together. What's the connection?

The IAEA's Member States use nuclear methods to move their nutrition programmes forward. These nuclear techniques include the use of stable isotopes (which have no radioactivity) to better understand how nutrients are absorbed, utilized, or stored in the body. These very precise and powerful techniques can be safely and non-invasively used on everyone, from babies to the elderly, in order to determine nutritional status, and measure the effectiveness of nutrition programmes.

Nuclear techniques often provide answers that are not available by any other means.

By training Member States in the use of nuclear techniques for nutrition, the IAEA complements the work that these countries are doing with other international organizations and not-for-profit groups around the world to combat malnutrition in all its forms and to promote health.

Good nutrition in early life is essential for healthy growth. Mother and baby at a health centre in Burkina Faso.
(Photo: N. Mokhtar, IAEA)

Q: Nutrition can seem like a small, niche issue. Why do you think nutrition requires national and international attention?

Nutrition deserves global attention because it has a direct, proven impact on health and on the economic growth of nations. For a country to grow, it needs to have people who are healthy and capable of learning new skills. The population needs to be physically and mentally sound. Poor nutrition affects both the body and the brain.

In many countries in economic transition, obesity and related NCDs have reached epidemic proportions. IAEA is assisting the national authorities in Seychelles to build capacity for the evaluation of an intervention programme for the control and prevention of childhood obesity.
(Photo: N. Mokhtar, IAEA)

Nuclear science provides invaluable data that assist in the formulation of better nutrition intervention strategies.

For example, exclusive breastfeeding in the first six months of a baby's life is proven to be the best nutritional start a mother can give her child. But many mothers don't consider that giving their babies water or a little herbal tea for a stomach upset means that they aren't "exclusively breastfeeding".

Using conventional monitoring methods (like questionnaires), health professionals would be unable to catch such discrepancies. However, the use of stable isotope techniques provides unassailable data about the practice of exclusive breastfeeding, so that policymakers, doctors and nutritionists can change their approach accordingly.

In addition to measuring human milk intake in breastfed infants, nuclear and isotope techniques are also used to assess body composition and energy expenditure; to evaluate the bone health of the elderly; to track how the body takes in, uses, and retains important nutrients such as protein, carbohydrates, fat, vitamins, and minerals; to measure vitamin A reserves; and to measure how well iron and zinc from local foods and diets are utilized by the body.

Q: Does malnutrition go beyond not having enough to eat?

In more prosperous countries and countries in economic transition, an epidemic of overweight and obesity is emerging. This is a major public health challenge, and people of all ages and backgrounds face this form of malnutrition.

As a consequence, rates of diabetes, cardiovascular disease and other diet-related non-communicable diseases (NCDs) are escalating worldwide.

The costs of NCDs are increasingly a burden in low-income and middle-income countries, affecting people in the prime of their lives and putting more pressure on already over-stretched health systems and government and family budgets. Low-and middle-income countries bear 86% of the burden of premature deaths due to NCDs, resulting in huge economic losses and millions of people trapped in poverty. Most of these premature deaths from NCDs are largely preventable, but require a multisectoral approach to policies that influence risk factors such as unhealthy diet, lack of physical activity and inadequate access to health care.

Overweight and obesity often start early in childhood. Globally, about 43 million children under age five are overweight, according to the World Health Organization's (WHO) 2011 figures. These children are at increased risk of developing NCDs in later life.

Q: What are the global and political implications of focusing or failing to focus on nutrition?

Because malnutrition impedes individuals' ability to lead productive lives, failing to focus on nutrition perpetuates poverty in families, communities and nations.

According to the Scaling Up Nutrition (SUN) Movement, more than 30% of young children worldwide suffer from malnutrition with serious consequences for health, learning capacity, productivity, economic development and security. Investing in nutrition helps break the cycle of poverty by increasing a country's gross domestic product by at least 2–3% annually. Investing US $1 in nutrition can result in a return of up to US $30.

A SMALL PART CAN REVEAL THE WHOLE: HOW ISOTOPE TECHNIQUES HELP NUTRITION

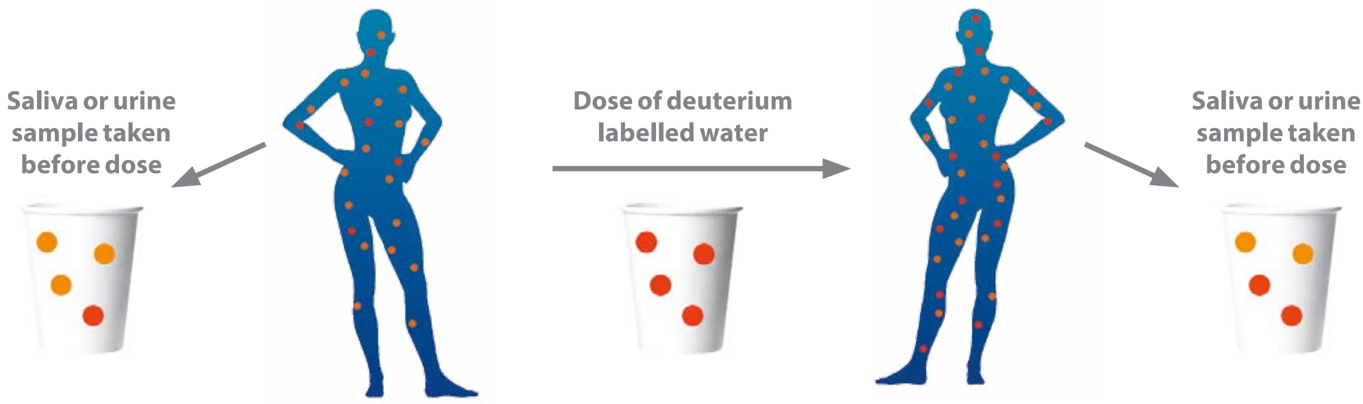


Fig. 1: Determining the amount of fat in the human body by measuring total body water (TBW) with isotopes.

Stable isotopes can be used to measure the amount of water or other nutrients in the body or the amount of an ingested nutrient that is absorbed and metabolized or excreted. They can be also used to measure the rate of absorption, utilization or synthesis of proteins, fats or carbohydrates.

Stable isotopes of carbon, hydrogen, oxygen, nitrogen, iron and zinc can be used in studies assessing nutritional status, energy expenditure, breastfeeding practices, micronutrient status and the absorption of nutrients from the foods we eat.

Commonly used stable isotopes include deuterium (hydrogen-2), oxygen-18, carbon-13 and nitrogen-15. Isotopes of iron include iron-57 and iron-58, and isotopes of zinc include zinc-67, zinc-68 and zinc-70. All stable isotopes occur naturally, but elements or compounds can be synthesized that are enriched compared to the naturally occurring amount. These isotopes or isotope labelled compounds are metabolized by the body in the same manner as the natural kind, but with the added benefit of being trackable. Stable isotopes are not radioactive and are therefore risk-free for people of all ages.

Water is composed of isotopes of hydrogen and oxygen. Natural water is composed mainly of ^{1}H and ^{16}O, but contains a very small amount of ^{2}H (deuterium) and ^{18}O. However, water can be made to contain a much higher proportion of deuterium or oxygen-18 compared to natural water. We say that this water is enriched. Deuterium oxide (D_2O) is enriched water in which 99.8% of the hydrogen atoms are in the form of hydrogen-2.

Assessment of Body Composition

Determining the amount of fat in the human body can be done by measuring total body water (TBW) with isotopes. The human body can be thought of as being composed of two categories: fat mass, and fat-free mass. There is no water in fat mass, whereas 73–80% of fat-free mass consists of water. The fat-free mass of a newborn baby contains 80% water, and this gradually decreases to 73% in adults. This means fat-free mass can be determined by measuring TBW and then using an appropriate hydration factor. Fat mass is the difference between body weight and fat-free mass. Sometimes the results are expressed as a percentage of total body weight.

The deuterium dilution technique (Fig. 1) involves measuring a person's saliva and/or urine just before they consume a dose of deuterium labelled water and repeating the process 3 to 5 hours later. The increased level of deuterium shows in the person's saliva and urine samples.

Urine or saliva samples gathered from the test subject after isotope equilibration show increased levels of deuterium. The deuterium is evenly distributed throughout the body after 3 to 5 hours.

The person's pre-dose samples of urine or saliva are compared with the post-dose samples to calculate TBW, fat-free mass and ultimately the amount of fat in the body. Body composition is a good indication of health. Too much fat or too little fat-free mass raises the risk of serious health conditions.

Assessment of Breastfeeding Practices

Nutrition plays a vital role in early child development. Isotope techniques can help determine if a baby is exclusively breastfed or not, as well as how much human milk the baby consumes. Conventional methods to determine the quantity of milk consumed by a baby can be time-consuming. They can also disturb a baby's feeding pattern, as these methods require that the baby is weighed before and after each feed. A more accurate and very informative alternative technique is known as the deuterium oxide dose-to-mother technique. This is the only way to determine whether a baby is exclusively breastfed or not.

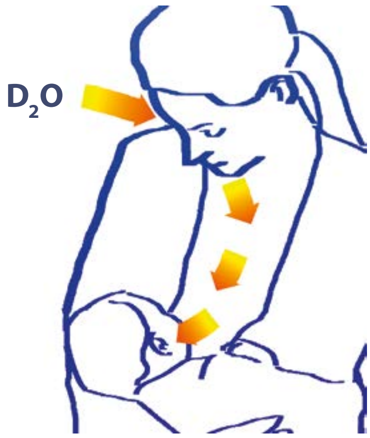


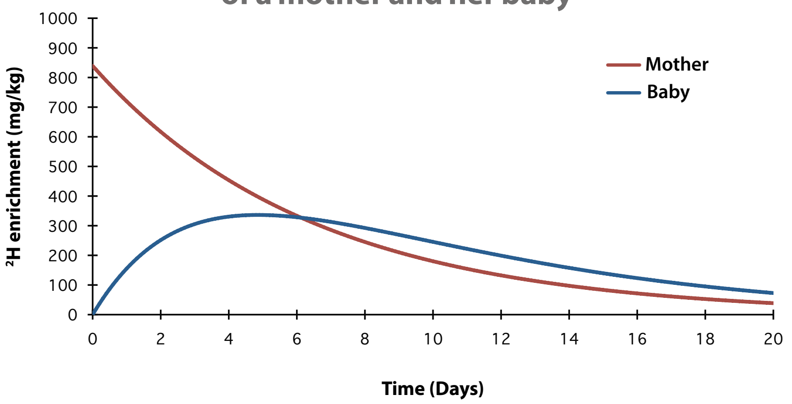
Fig. 2: Dose to Mother Technique

The mother consumes deuterium oxide. The deuterium mixes with water in her body including the milk the baby drinks. The saliva of both the mother and child is enriched with deuterium. This can be measured with sensitive equipment.

A lactating mother drinks a dose of deuterium oxide that is distributed throughout her body and is incorporated into her milk (Fig. 2). Over a period of 14 days, samples of saliva or urine are collected from the mother and child, revealing the changes in isotope concentration. This gives insight into the baby's intake of human milk and whether the baby has consumed water from other sources, as well as the body composition of the mother.

After the mother has taken the dose of deuterium oxide, the deuterium gradually disappears from her body and appears in the body of the baby (Fig. 3). Deuterium in the baby's body comes only from the milk consumed during breastfeeding. As the deuterium is eliminated from the mother's body, the enrichment in her milk declines and therefore the enrichment in the baby's body also falls. A mathematical model is used to determine how much of the deuterium given to the mother appears in the baby's saliva. This is related to the amount of human milk consumed by the baby. The model also gives an estimate of the amount of water from sources other than its mother's milk, and therefore whether the baby is exclusively breastfed or not.

Fig. 3: Deuterium enrichment in the body water of a mother and her baby



Assessment of Total Energy Expenditure

When determining how much food a person needs, it is important first to deduce how much energy they expend. If water labelled with hydrogen-2 (deuterium oxide) is mixed with water labelled with oxygen-18, the mixture is known as the doubly labelled water (DLW). Researchers can use DLW to get an estimate of total daily energy expenditure (Fig. 4). Total energy expenditure is also used to determine a person's physical activity level.

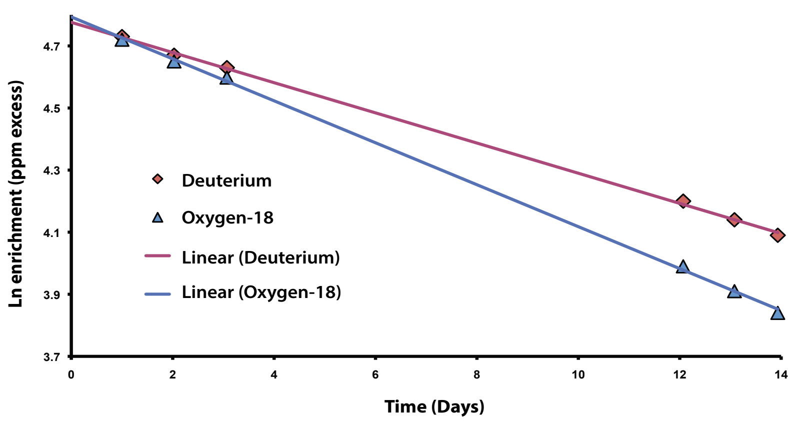
The participant drinks a dose of DLW, which gets distributed throughout the body water. Every time the person breathes or exercises,

Fig. 4: Doubly Labelled Water Method

After drinking a dose of DLW, the body water is enriched with deuterium and oxygen-18. As time progresses, the deuterium (orange dots) and oxygen-18 (red dots) leave the body and this rate of decline is a direct indication of energy expenditure.

some of the labelled oxygen and hydrogen is lost in their urine, sweat and breath. Deuterium is lost only in water, whereas oxygen-18 is lost in both water and carbon dioxide. The difference in the elimination rates of deuterium and oxygen-18 is a measure of carbon dioxide production rate, from which energy expenditure can be calculated (Fig. 5). Urine samples over a 14 day period reveal the decline in the introduced isotopes. A very slow decline indicates little energy expenditure, while a sharper, faster decline indicates high energy expenditure. The DLW technique is ideal for measuring total daily energy expenditure in normal, daily living conditions, and is being used by the IAEA in projects designed to address childhood obesity and quality of life in the elderly.

Fig. 5: Rate of elimination of deuterium and oxygen-18 from the body



The gradients of the lines in the graph above are a measure of the rate of elimination of deuterium and oxygen-18 from the body. Oxygen is lost faster than deuterium, because oxygen is lost in water and carbon dioxide, whereas deuterium is lost only in water. The difference in the gradients of the lines is therefore a derived estimate of carbon dioxide production rate.

Assessment of Vitamin A Body Stores

The stable isotope dilution technique is used in studies to determine the change in body vitamin A during an intervention (e.g. vitamin A fortification, supplementation or food-based approaches that encourage consumption of a wide variety of nutritious foods). Stable isotope methods (Fig. 6) are the only non-invasive way to establish that the levels of vitamin A are too high. This can occur when vitamin A supplements and fortification programmes are implemented in the same communities.

Stable isotopes of hydrogen (^{2}H) and carbon (^{13}C) can be used to label vitamin A.

Assessment of the Bioavailability of Iron and Zinc

Assessing the bioavailability (absorption and utilization) of nutrients from food is important because people usually eat more than one type of food at a time, and some might contain enhancers or inhibitors of absorption. Bioavailability studies of iron and zinc in foods using stable isotopes can reveal large differences in absorption between different food combinations. Iron and zinc stable isotopes are used to determine the bioavailability of the mineral from a test food that has been fortified or biofortified or that is consumed in the same meal as a potential inhibitor (e.g. phytic acid in unrefined grains, nuts, seeds and legumes) or as an enhancer (e.g. vitamin C) of mineral absorption. The stable isotopes of iron and zinc can be added to a test food.

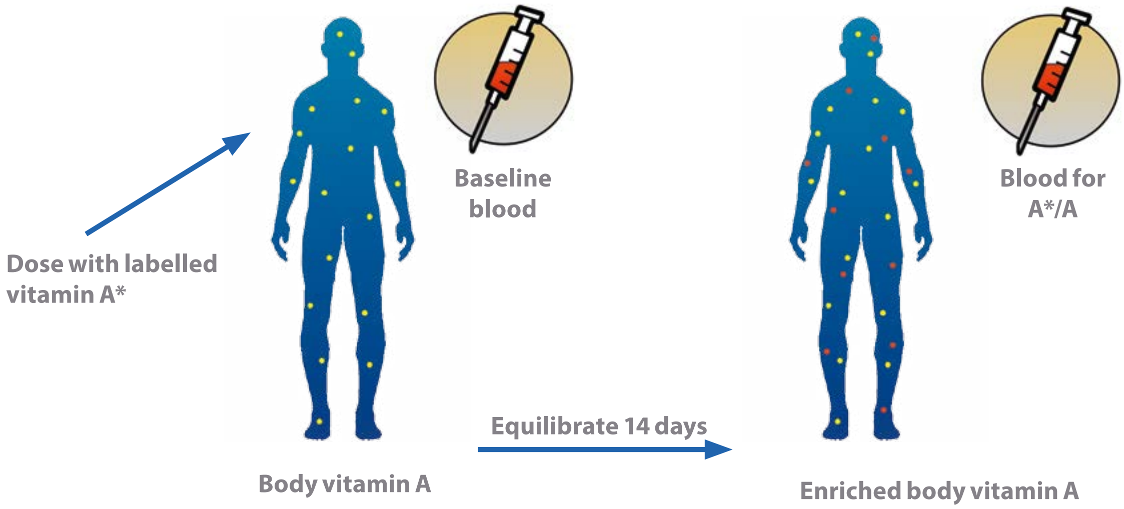


Fig. 6: Assessment of vitamin A status

For assessment of vitamin A status, a dose of vitamin A labelled with a stable isotope is administered after a baseline blood sample has been collected. A period of equilibration of the dose with the vitamin A body pool is necessary before the follow-up blood sample is taken for analysis by mass spectrometry. From the dilution of the precisely measured dose of isotope labelled vitamin A, it is possible to calculate the total quantity of exchangeable vitamin A in the body. This is the most sensitive way to non-invasively estimate vitamin A status over the whole range, from deficient to normal to excessive.

Fig. 7 depicts a study design to assess iron incorporation into red blood cells after consumption of a cereal based meal and the same meal with an orange, which contains vitamin C — an enhancer of iron absorption.

A baseline blood sample is collected and a test meal (A), containing a known amount of a stable isotope of iron (^{57}Fe), is consumed. On the following day, a test meal (B) is consumed that contains a known amount of a second stable isotope of iron (^{58}Fe) and a potential enhancer or inhibitor of iron absorption. Half of the study participants receive the test meals in the reverse order.

A second blood sample is collected two weeks later. After processing of the blood samples, the iron isotopes are analysed with an appropriate mass spectrometer. The ratios of stable iron isotopes before and after consumption of the test meals are used to determine the amount of iron absorbed from the meals and incorporated into the red blood cells, thus revealing the effect of enhancers or inhibitors present in the meal.

By Michael Amdi Madsen, IAEA Office of Information and Communication

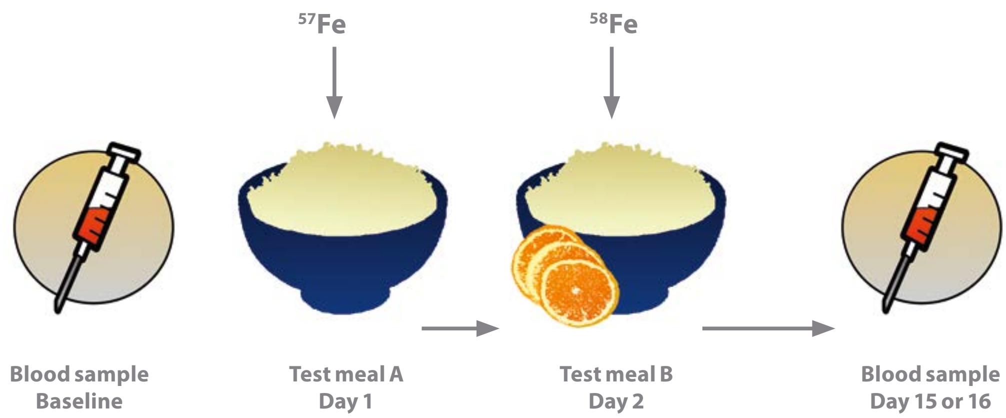


Fig. 7: Assessment of iron absorption

ISOTOPES HELP DESIGN BETTER NUTRITION PROGRAMMES

Good nutrition is essential for good health. To ensure proper nutrition, energy-dense fat, protein and carbohydrates need to be accompanied by vitamins and minerals. Malnutrition is the result of too much food or too little food and a lack of variety in the kinds of food eaten. More than 30% of young children suffer from some form of malnutrition with devastating consequences for health, learning, future earning potential, economic development, resilience and security. Undernutrition in early life, when accompanied by excessive weight gain later in childhood, increases the risk of chronic diseases in adulthood. Obesity has reached epidemic proportions globally, with at least 2.8 million adults dying each year from diseases related to overweight or obesity such as cardiovascular diseases, diabetes and some forms of cancer.

Stable isotope techniques play an important role in the development and monitoring of interventions against malnutrition. Compared to other conventional techniques, these methods, which do not involve radiation, offer much more sensitive and specific measurements. They can be used to establish the ratio of lean tissue to fat in body composition; to estimate the number of calories spent each day; to determine whether breastfed babies are exclusively breastfed according to the recommendations issued by the World Health Organization (WHO); to assess a person's vitamin A reserves; and to establish how well iron and zinc are utilized from local foods and diets. This provides Member States with information to help them design or improve their national health and nutrition programmes.

The IAEA works with Member States through national and regional technical cooperation projects, and coordinated research projects to develop and monitor sustainable interventions aimed at managing malnutrition.

Malnutrition has risen to the top of the global health agenda because of its long-term consequences. Together with other United Nations organization and agencies, the IAEA is part of the Scaling Up Nutrition (SUN) Movement, which was launched by the United Nations General Assembly in September 2010. The Movement is founded on the principle that all people have the right to food and good nutrition, and aims at significantly reducing malnutrition in participating countries. IAEA experts have so far supported 16 SUN participating countries in building their capacity to use isotope techniques to better manage and improve nutrition among their populations.

The epidemic proportions of the rise in chronic diseases around the world have resulted in the development of WHO's Global Action Plan for the Prevention and Control of Noncommunicable Diseases. The IAEA participates in the newly formed United Nations Interagency Task Force on the Prevention and Control of NCDs, which will coordinate the activities of the United Nations organizations in the implementation of the Action Plan that includes targets related to the prevention of obesity and increased physical activity.

The IAEA is also a member of the International Malnutrition Task Force, which is an inter-agency advisory and advocacy group on the management of acute malnutrition involving collaboration between WHO, the United Nations Children Fund (UNICEF), the IAEA, the International Paediatric Association and the International Union of Nutritional Science.

In May 2014, the IAEA will host an International Symposium on Understanding Moderate Malnutrition in Children for Effective Interventions. Moderate malnutrition is associated with more nutrition-related deaths than severe malnutrition, because it affects a greater number of children. The four-day event will review, among other topics, the current level of knowledge, knowledge gaps, and the further research that is needed in this area. It will bring together public health nutritionists, health professionals, health and nutrition policymakers, and partners like the SUN Movement, WHO, the World Food Programme and UNICEF.

I hope that the Symposium will help to strengthen cooperation between experts and policymakers, and to create opportunities for further research and application of various approaches to help alleviate malnutrition and contribute to better health for everyone.

Daud Mohamad, IAEA Deputy Director General and Head of the Department of Nuclear Sciences and Applications

Daud Mohamad

A WAY FORWARD TO IMPROVE NUTRITION WITH STABLE ISOTOPES

1 People need food and water to survive, but nutritious food is central to healthy living. Energy-dense fat, protein and carbohydrates need to be accompanied by vitamins and minerals (micronutrients) to ensure proper nutrition. Malnutrition, an inappropriate balance of nutrients, can occur with too much or too little of food.
(Photo: A. S. Gorisek, IAEA)

2 The IAEA works with other agencies to evaluate interventions in Member States that are designed to address the problem of malnutrition. Stable isotope techniques can be used to validate the information collected through the use of questionnaires and simple measurements. Capacity building through training and the provision of equipment enables nutritionists worldwide to use these methods in community settings as they are safe, non-invasive and can be used with adults and children of all ages. (Photo: H. Aguenaou, Morocco)

3 Compared to other conventional techniques, these stable isotope methods, which do not involve radiation, offer much more sensitive and specific measurements to evaluate nutritional and lifestyle interventions, for example food fortification, healthy eating and physical activity programmes.
(Photo: E. Aguilar Lema, Ecuador)

4 Stable isotope techniques help scientists to determine whether the right amounts of micronutrients are received, utilized and retained by the body; to establish the amount of lean tissue and fat in body composition; and to estimate the number of calories spent each day. They can also tell whether breastfed babies are exclusively breastfed according to the WHO's recommendations, and how much milk they take in. This provides Member States with information to help them design or improve their national health and nutrition programmes.
(Photo: M.E. Valencia Juillerat, Mexico)

Text by Aleksandra Sasa Gorisek, IAEA Department of Nuclear Sciences and Applications

ASSESSING INTERVENTIONS: IAEA TECHNICAL COOPERATION ENHANCES NUTRITION PROGRAMMES

Malnutrition — in all its forms — is a significant development challenge, affecting childhood health, workplace productivity, and national health programmes in countries around the world. While the effects of undernutrition are well recognized, there is less recognition of the fact that the long term impact of obesity or inappropriate nutrition can also be very damaging to health and to national economies. Increasingly, countries around the world are taking action to implement nutritional or physical activity interventions designed to improve the future health of children, as well as the health of their populations in general. Such interventions may include the promotion of exclusive breastfeeding, school breakfast or lunch programmes, nutrition awareness campaigns, food fortification, and investment in sports activities and facilities.

The IAEA, through its Technical Cooperation (TC) programme, is working with its Member States to help them to assess the efficiency and effectiveness of such intervention programmes, in order to ensure that government efforts are having the desired effect, and that resources are being well applied. For such assessments, reliable data are essential, and it is here that nuclear science and technology come into play.

Nuclear techniques can be used to collect a range of important nutrition-related data to: assess body composition, measure the total daily energy expenditure of persons, monitor the efficacy of breastfeeding programmes, determine bone mineral density and measure micronutrient bioavailability from foods. Nuclear techniques can also be used to assess vitamin A status. The data gathered using these techniques allow governments to make evidence-based decisions about nutrition programmes, promotion of sports in schools and food fortification, and support the development of effective national nutritional programmes.

IAEA TC projects around the world have contributed to developing and evaluating interventions to curb the dramatic increase in childhood obesity in the Middle East and to building capacities in the Asia and the Pacific region. The projects have also played a role in the design and improvement of interventions aimed at preventing and controlling obesity and related health risks in Africa and Latin America. TC projects have built capacity in using nuclear techniques to assess body composition in 17 countries in Latin America and the Caribbean, 23 in Africa and 10 in the Asia and the Pacific region.

Kwaku Aning, IAEA Deputy Director General and Head of the Department of Technical Cooperation

Kwaku Aning

Beneficiaries of the IAEA Technical Cooperation Programme.
(Photo: R. Quevenco, IAEA)

THE IAEA ESTABLISHES PARTNERSHIPS WITH INTERNATIONAL ORGANIZATIONS TO PREVENT MALNUTRITION IN CHILDREN AND OLDER PEOPLE

Regional technical cooperation with stakeholders from Member States in Latin America.

(Photo: E. Cody, IAEA)

The period from conception to 2 years of age — the first thousand days of a child's life — represents a critical window of opportunity for avoiding health risks later in life. The assessment of growth during this crucial period of early vulnerability has traditionally been largely based on anthropometric measurements such as body weight and length, with less attention to the quality of growth and the relative partitioning of nutrients to fat-free mass or fat mass. However, now, the amount and distribution of body fat and the amount and composition of lean mass are understood to be very important for the long term health prospects of infants and children.

Isotope techniques can be used to measure body composition with a high degree of accuracy. This provides governments with key data to enable them to make decisions about national nutrition interventions on the basis of evidence.

The IAEA is working in partnership with international organizations around the world to reduce malnutrition, and, consequently, to alleviate the multitude of preventable diseases caused by poor nutrition.

For example, the IAEA and WHO are working together to develop body composition reference standards from birth to 2 years of age. These standards will help Member States to evaluate their strategies to reduce infant and child undernutrition.

In addition, as part of its efforts to promote better nutrition for infants and children, the IAEA is participating in the Scaling Up Nutrition (SUN) Movement. The IAEA is also part of the International Malnutrition Task Force, which contributes to building capacity in developing countries to fight malnutrition in all its forms.

WHO recommends that infants should be exclusively breastfed for the first six months of their lives, in order to achieve optimal growth, development and health, and that children should continue breastfeeding with nutritious complementary foods up to the age of two years or beyond. The IAEA and WHO Regional Office for Africa are working together through a regional technical cooperation project involving more than 13 countries to use stable isotope methods to evaluate interventions aimed at promoting exclusive breastfeeding.

The IAEA is collaborating with the Consultative Group on International Agricultural Research through HarvestPlus to use stable isotope techniques to assess the efficacy of biofortification (improving the nutritional content of staple foods) to improve the micronutrient status of populations and contribute to eliminating the hidden hunger of micronutrient deficiency.

At the other end of the age scale, the IAEA and the Pan-American Health Organization (PAHO)/WHO are collaborating in a regional IAEA technical cooperation project to help Member States in Latin America to use stable isotope techniques for the early diagnosis of sarcopenia in the elderly. Sarcopenia refers to the loss of muscle mass and strength that affects the aged.

By bringing together diverse agencies and institutions that share the same goal — promoting nutrition for better health – inter-agency partnerships will continue to prove effective in minimizing the many health problems caused by malnutrition.

Omar Yusuf, IAEA Office of Public Information and Communication

TRACKING NUTRITIONAL PROGRESS: IAEA CAPACITY BUILDING PROGRAMMES

1 **Kuwait:** The IAEA has helped to establish a body composition assessment suite at the Kuwait Institute for Scientific Research. Facilities include an isotope ratio mass spectrometer for analysis of deuterium and oxygen-18 enrichment, and dual energy X ray absorptiometry for assessment of bone mineral content. In collaboration with the Nutrition Department at the Ministry of Health, the equipment is being used to assess body composition and energy expenditure in Kuwaiti schoolchildren as part of the evaluation of a programme designed to curb the rise in childhood obesity in Kuwait. (Photo: C. Slater, IAEA)

2 **Botswana:** The IAEA has helped to establish facilities for analysis of deuterium enrichment by Fourier transform infrared (FTIR) spectrometry at the National Food Technology Research Centre (NFTRC). The NFRTC is a regional designated centre in the field of deuterium dilution techniques in human nutrition, and has hosted numerous regional training courses in this area. The facility has been used to evaluate a food supplementation programme in adults living with HIV and to assess breastfeeding practices of women in the region. (Photo: M.E. Valencia Juillerat, Mexico)

3 **Ecuador:** Through national and regional technical cooperation projects, the IAEA has helped to establish facilities for analysis of deuterium enrichment by FTIR spectrometry in 17 Latin American countries, including Ecuador. These facilities are used to evaluate national programmes designed to combat the double burden of malnutrition in the region, where micronutrient deficiencies and obesity exist side by side. (Photo: E. Aguilar Lema, Ecuador)

4 **Costa Rica:** With the help of the IAEA, the University of Costa Rica has established a laboratory for the assessment of body composition using deuterium dilution techniques. The procurement of an FTIR spectrometer enabled the local counterpart to obtain funds for refurbishment of the laboratory and installation of air conditioning. This facility was used to assess the impact of national programmes to decrease the prevalence of micronutrient deficiencies, obesity and non-communicable diseases in school age children. (Photo: E. Quintana Guzmán, Costa Rica)

Text : Christine Slater, IAEA Nutritional and Health-Related Environmental Studies Section

EVALUATING FOOD-BASED APPROACHES TO PREVENT MICRONUTRIENT MALNUTRITION USING ISOTOPE TECHNIQUES

Fruit and vegetables are one of our main sources of vitamins and minerals – market in Cotonou, Benin.

(Photo: C. U. Loechl, IAEA)

Good nutrition needs more than just carbohydrates, protein and fat. Humans may eat enough calories to live, but may have a diet that fails to provide sufficient levels of crucial vitamins and minerals that allow them to be mentally and physically healthy. A lack of these essential vitamins and minerals often results in what is termed as 'hidden hunger', where the signs of undernutrition are less visible and people may not even be aware of it. Hidden hunger has been estimated to affect as many as 2 billion people globally. Vitamin and mineral deficiencies account for an estimated 7.3% of the global disease burden, with iron and vitamin A deficiencies ranking among the top 15 leading causes of the global disease burden. Hidden hunger impairs the mental and physical development of children and adolescents and can result in lower IQ, stunting, and blindness; women and children in low-income countries are especially vulnerable. Hidden hunger also reduces the productivity of adult men and women due to increased risk of illness and reduced work capacity.

Micronutrients are substances needed in amounts of less than 100 mg (less than the weight of two grains of salt!) per day for good health, growth and development. They include all vitamins, as well as some minerals such as zinc, iron, chromium, copper, manganese and iodine. Micronutrients play important roles in nutrition, including ensuring healthy growth and development, resistance to infection, and specific functions such as good vision, bone strength, or oxygen-carrying in red blood cells. Many micronutrients are limited in human diets, largely due to high intakes of energy-dense, nutrient-poor staple foods. In developing countries, many individuals do not have the resources to purchase or cannot access a wide range of nutritious foods such as meat, eggs and fish, as well as fruit and vegetables in order to meet their nutritional requirements.

Current strategies to address hidden hunger include individual supplementation, staple food fortification, biofortification of crops and improved dietary diversification.

Micronutrient supplementation provides one or more micronutrients daily or periodically in liquid, tablet or capsule form. For example, high dose vitamin A supplements are given every 6 months to children between 6 and 59 months to prevent mortality in areas where vitamin A deficiency is prevalent.

Food fortification can be achieved by adding micronutrients to staple foods that are regularly eaten by the population, so that the micronutrient is consumed frequently in amounts chosen to prevent deficiencies, while avoiding the likelihood that excessive amounts, which are also unhealthy, will be consumed. This provides an efficient distribution system for staple foods that are processed at just a few sites and distributed widely, for example large grain mills or the principal producers of cooking oils.

Biofortification is the process by which the nutritional quality of staple crops is enhanced. Biofortified crops accumulate higher levels of minerals and vitamins in their seeds and roots during growth. Biofortification is intended to be a self-sustaining agricultural approach to food fortification that involves the breeding, selection and promotion of stable food crops based on their nutrient content to meet human nutritional requirements, in addition to other agricultural attributes such as crop yield and disease resistance.

Another essential strategy is the promotion of dietary diversification or consumption of a wide variety of foods across nutritionally distinct food groups. Dietary diversification or modification strategies at the community or household level aim to enhance the availability, access, and utilization of foods with a high content and bioavailability of micronutrients throughout the year. This approach involves changes in food production practices, food selection patterns, and traditional household methods for preparing and processing indigenous foods.

The IAEA provides support for the use of stable isotope techniques to investigate absorption and retention of iron or zinc from fortified or biofortified foods fed to adults or children, from mixed diets that contain enhancers and inhibitors of absorption or from modified dietary practices, for example using traditional household methods, such as fermentation, germination and soaking to reduce phytic acid. In addition, stable isotope techniques can be used to quantify how much human milk is consumed by infants. When this information is combined with the micronutrient content (e.g. vitamin A) of human milk, the infants' micronutrient intake can be estimated.

The IAEA is currently concluding a coordinated research project on food fortification and biofortification to improve micronutrient status during early life. Three examples from this research project show the importance of stable isotope techniques in the evaluation of the bioavailability of iron or zinc from biofortified crops. In Rwanda, investigators used iron stable isotopes to study iron absorption from beans to determine which chemicals in beans should be the focus of crop breeding programmes to improve the absorption of iron from beans. Beans have two components known to reduce iron absorption, phytic acid and polyphenols. Phytic acid (which also occurs in whole grains and seeds) binds minerals such as iron, calcium and zinc, thereby substantially

IAEA SUPPORTS RESEARCH ON NUTRITION-SENSITIVE AGRI-FOOD SYSTEMS

As a continuation of its biofortification research, the IAEA is starting a new five-year coordinated research project on the use of nuclear techniques to assess the role of nutrition-sensitive agri-food systems in improving the diet, health and nutritional status of vulnerable populations. This research project will generate important information about the role of body composition in understanding the link between agriculture and nutrition and in strengthening the evidence in support of nutrition-sensitive agricultural policies and practices. Compared to total body weight, body composition provides a more sensitive means of assessing changes in nutritional status in response to nutrition-sensitive agricultural interventions and changes in consumption.

The deuterium dilution stable isotope technique, one of the most accurate techniques for assessing body composition, will be used in this research project. Studies, which have been accepted so far from Bangladesh, Cuba, Haiti, Myanmar, Peru, Senegal and Tanzania, will evaluate different nutrition-sensitive agricultural interventions, such as household or community level gardens with nutritious crops, diversification of crops and dairy promotion in combination with nutrition education.

Market in Burkina Faso.
(Photo: N. Mokhtar, IAEA)

reducing mineral absorption. Polyphenols, compounds associated with the pigments of coloured beans, also reduce iron absorption. The study in Rwanda found that the phytic acid in beans inhibited iron absorption by women so substantially that there would be little or no benefit in increasing iron or decreasing the polyphenol content of beans without also decreasing the phytic acid content. These findings, published in 2012, provide information to agricultural scientists about the best strategies for developing iron-biofortified bean crops.

A zinc absorption study in Bangladesh showed that, zinc-biofortified rice contained more zinc, but it was less efficiently absorbed, so did not substantially improve the total amount of zinc retained by children compared with control rice. This 2013 study indicated that the zinc content of the biofortified rice needed to be further increased to have a meaningful effect on the children's zinc nutrition. In India, iron and zinc from biofortified pearl millet, a staple food, were well absorbed in amounts that meet the requirements for young children. Children under the age of three could meet their full daily iron needs from just 100 grams of the biofortified pearl millet flour. This 2013 finding that biofortified pearl millet could improve children's nutrition demonstrates that it would be useful to further disseminate this crop, which is now being cultivated by more than 30 000 farmers in Maharashtra, India, and that it will also be useful to do so in arid and semi-arid regions of Africa.

Another study in Morocco is investigating the impact of the daily consumption of vitamin A fortified oil and vitamin A supplementation on the vitamin A content in human milk in lactating women during the first 6 months postpartum. Vitamin A in human milk and human milk intake is measured in infants at 3 and 6 months of age.

The IAEA is also sponsoring ongoing research on dietary modifications that enhance the nutrient intake from plant-based local complementary foods and human milk to prevent micronutrient deficiencies in infants and young children in developing countries. Examples include:

- Addition of phytase (an enzyme that splits phytic acid, which reduces iron and zinc absorption) and fish to plant-based traditional complementary foods in Bangladesh to enhance zinc absorption;

- Addition of amaranth grain (a pseudo-cereal) (20%) to traditional white maize tortillas to enhance zinc absorption in young Guatemalan children;

- Addition of a whey-protein based nutritional supplement to a plant-based diet in young children in Mexico to improve iron and zinc absorption;

- Food supplementation (leaf powder) for pregnant women until one month postpartum to increase infants' vitamin A intake from human milk.

The results of the IAEA supported research will help to establish effective and sustainable strategies and interventions based on locally available foods to prevent and combat micronutrient deficiencies.

Cornelia U. Loechl, IAEA Nutritional and Health-Related Environmental Studies Section

STABLE ISOTOPES: THE METHOD OF CHOICE TO ASSESS VITAMIN A INTERVENTIONS

Testing a child for vitamin A nutrition using the VALID technique in northern Thailand.

(Photo: T. Pongcharoen, Thailand)

The tragic consequences of vitamin A deficiency (blindness, illness, and premature death) have stimulated extensive efforts to prevent this deficiency. Perhaps most notable in scope and influence is the WHO's recommendation since 1998 that high-potency supplements should be given every 4–6 months to children 6 to 59 months old who live in the affected regions of the world. The WHO estimates that 1.25 million deaths in 40 countries have been averted by this programme.

Many of these countries have also addressed the problem by fortifying commonly consumed foods, such as cooking oil or sugar. Agricultural programmes have developed both biofortified and genetically modified foods with increased vitamin A content.

Unfortunately, it is very difficult to assess the impact of vitamin A supplementation because, although blood vitamin A is reduced in cases of deficiency, it is also reduced with infections even if there are adequate amounts of vitamin A stored in the liver. Blood vitamin A is reduced with moderate deficiency, but does not show if a person has borderline deficient, healthy, or excessively high vitamin A nutrition (which also may be unhealthy). Public health officials have not had sensitive techniques available for evaluating whether vitamin A supplementation or food fortification programmes are effective, and they have had to make do with extremely non-specific techniques, such as counting the number of children receiving supplements or fortified foods, and the number of childhood deaths.

Fortunately, there is a stable isotope technique that provides a sensitive and accessible assessment of vitamin A in the whole body. This technique measures blood samples to determine the dilution of an oral dose of isotope labelled vitamin A after it mixes with the (unlabelled) vitamin A already in the body. This is the vitamin A labelled isotope dilution (VALID) technique. The VALID technique can be used to assess vitamin A status, the success of vitamin A supplementation or fortification, the amounts of vitamin A that humans require, and how well the pro-vitamin A compounds, such as carotene from local plant foods, are

Preparing doses of labelled *Moringa oleifera* leaves in Mexico to assess the vitamin A value.
(Photo: V. López Teros, Mexico)

converted to useful vitamin A in the body. With this method, body vitamin A can be measured using only blood samples, yielding information that would not otherwise be available without biopsies of the liver, where the body stores vitamin A. Work in this area has been developed and validated through experiments with animals and humans since the 1970s, including comparisons with liver vitamin A measured in patients undergoing routine surgery in Bangladesh and the United States of America.

In collaboration with other agencies, the IAEA has sponsored publications on the detailed application of this stable isotope method that can be found on the IAEA Human Health Campus at nucleus.iaea.org/HHW/Nutrition/VitaminA/RefsVitaminA/index.html#publ. The IAEA has also supported use of the method in studies by international investigators in developing countries.

The value of the VALID technique is demonstrated by two recent examples. Because rice is an important dietary staple in northern Thailand, this food was selected for fortification with iron, zinc, and vitamin A. Schoolchildren consumed the fortified rice or unfortified control rice as part of their school lunch for five months. Although blood measurements of iron and zinc nutrition improved, blood vitamin A did not change in the group given fortified rice. However, a follow-up study using the VALID technique revealed that children consuming the fortified rice had an increase in body vitamin A stores, despite no difference in blood vitamin A. This verified the benefit of rice fortification with vitamin A for these children, which would not have been detected with other methods.

In another fortification study with Mexican preschool children, application of the VALID technique showed that milk drinks fortified with vitamin A increased their body vitamin A stores, compared to their initial values, or to those of other children that did not receive the fortified milk. Blood vitamin A increased slightly in the children who received the fortified milk, and decreased in the control group, providing a complementary, but much less clearly interpretable result.

The IAEA is sponsoring additional studies in very young children (1–2 years old) with the VALID technique to assess the vitamin A value of consuming *Moringa oleifera* leaves in Mexico, of kale cooked in peanut butter (compared with kale cooked in lard) in Zimbabwe, and of maize biofortified with vitamin A in Zambia. A 2013 meeting with our collaborative nutrition research centre, the St. John's Research Institute (SJRI), in Bangalore, India, fostered interaction among international investigators who provided an update on progress in the development and application of the VALID technique and made recommendations for it to be used to help evaluate public health interventions.

Further plans are under way to use the VALID technique to verify that nutrition programmes are helping children meet their nutritional need for vitamin A, without accruing excessive body vitamin A stores that could have long-term adverse effects on the liver, the nervous system, and several other organ systems.

Janet R. Hunt, IAEA Nutritional and Health-Related Environmental Studies Section

USING NUCLEAR TECHNIQUES TO DETECT *HELICOBACTER PYLORI* INFECTION

Breath is sampled by blowing through a straw into a glass tube, and then putting the cap on the tube to seal it, or by blowing into a bag, depending on which method will be used to analyse the samples (tubes for analysis by isotope ratio mass spectrometry; bags for analysis by non-dispersive infrared spectroscopy).

(Photo: T. Ahmad, Pakistan)

Helicobacter pylori (H. pylori) is present in all countries the world over. More than 50% of the world's population harbour *H. pylori* in their upper gastrointestinal tract. It can negatively influence nutrition by affecting the uptake of iron and zinc and by increasing susceptibility to diarrhoeal disease. Beyond that, *H. pylori* is also a major cause of stomach diseases like chronic gastritis, and elevates the risk of developing stomach cancer.

The carbon-13 urea breath test is a quick and non-invasive diagnostic test to detect the presence of *H. pylori*. The patient drinks urea labelled with stable carbon isotopes (^{13}C) that is dissolved in orange juice or citric acid to make sure it coats the entire surface of the stomach, thereby improving the test's accuracy. If *H. pylori* is present, it metabolizes the urea and, after 30 minutes, produces carbon dioxide labelled with the stable carbon isotope ($^{13}CO_2$), which can be detected in the breath analysis (Fig. 8).

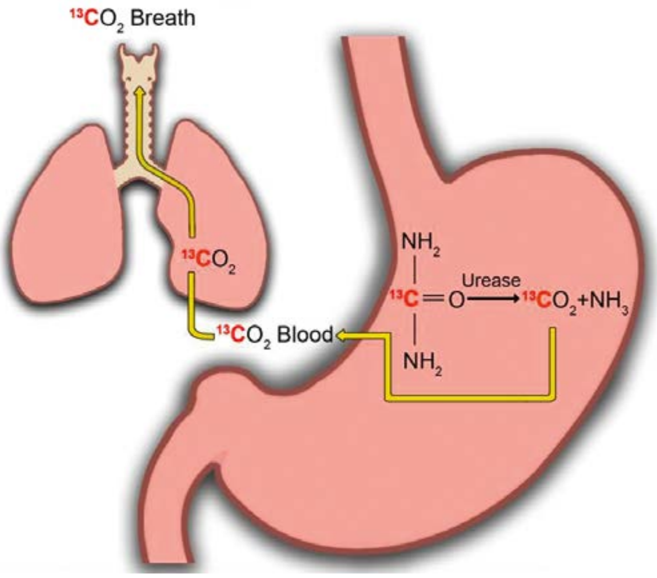


Fig. 8: The principle of the carbon-13 urea breath test

The bacterium *Helicobacter pylori* can survive in the acid conditions of the stomach, because it produces large amounts of the enzyme urease. When urea labelled with ^{13}C reaches the acid environment of the stomach, urease hydrolyses the urea to produce ^{13}C -labelled carbon dioxide ($^{13}CO_2$) and ammonia. The ammonia helps to neutralise the acid. The labelled CO_2 quickly enters the blood and is carried to the lungs, where it is excreted in the breath. The enrichment of ^{13}C in breath CO_2 within 30 minutes is an indication of the presence of *H. pylori* in the stomach.

The IAEA has been undertaking research into *H. pylori* and its consequences for nutrition since 1999, and over the last 15 years, has worked with 25 low- and middle-income Member States to utilize and implement the carbon-13 urea breath test.

The IAEA is also continuing its research into the effect of *H. pylori* infection on gastric acid secretion and on iron and zinc absorption in asymptomatic individuals from developing countries. Gastric acid is essential for the conversion and absorption of micronutrients such as iron and zinc. The IAEA is also testing a new non-invasive way to measure gastric acid secretion using stable isotopes.

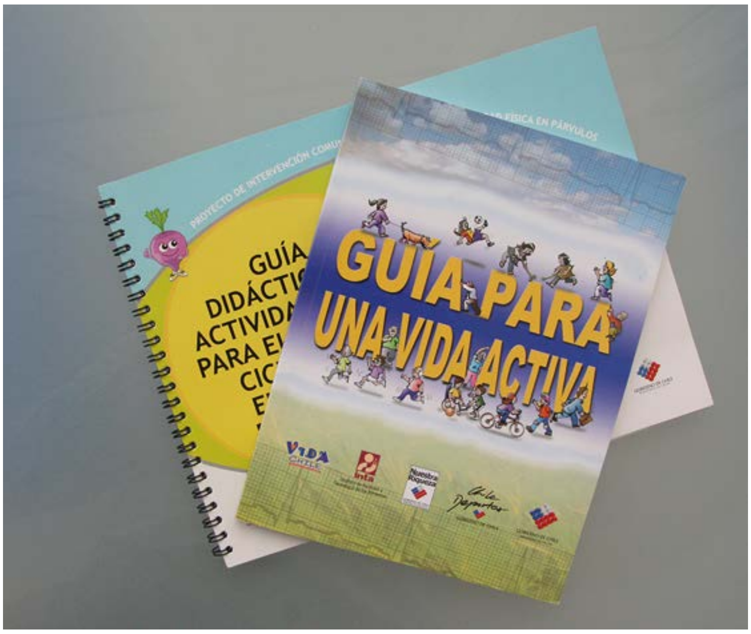
Christine Slater, IAEA Nutritional and Health-Related Environmental Studies Section

CHILE SUCCESSFULLY HALTS I

1 The increasing prevalence of childhood obesity in Latin America has become a cause for concern. The IAEA has worked closely with the Institute of Nutrition and Food Technology (INTA) at the University of Chile since 1997 to address the problem of malnutrition in the country. (Photo: A.S. Gorisek, IAEA)

2 In Santiago, the Laboratory of Energy Metabolism and Stable Isotopes was established in 1998 with the help of the IAEA to provide an isotope ratio mass spectrometer and training in the use of stable isotope techniques to assess body composition, infant feeding practices and total daily energy expenditure. (Photo: A.S. Gorisek, IAEA)

3 Stable isotope techniques play an important role in the development and monitoring of interventions against malnutrition. These techniques are more accurate than conventional techniques and are often able to provide specific details that are not available by any other means. (Photo: C. Slater, IAEA)



4 Close links between the INTA, the Ministries of Health and Education, the National Board of Day Care Centres (JUNJI), the National Council for School Assistance and Scholarships (JUNAEB), and the National Sports Council have ensured that the information collected from IAEA projects has been used as a basis for policy decisions relating to school feeding programmes and physical activity in schools. (Photo: B.T. Gebka, IAEA)

RISE IN CHILDHOOD OBESITY

5 In Chile, the JUNAEB plans and provides food for schools and day care centres, targeting vulnerable families. To avoid an unintended increase in childhood obesity as a result of the feeding programmes, the programmes are combined with scheduled physical activity. (Photo: A.S. Gorisek, IAEA)

6 The pilot phase of the programme was evaluated with support from the IAEA's technical cooperation programme. As the evaluation was positive, the improved programme was adopted by the Chilean national authorities and between 2006 and 2010 this programme was extended to 75% of Chile's preschool children. There are plans to roll it out in the rest of the country. (Photo: A.S. Gorisek, IAEA)

7 Chile is the only country in Latin America that has successfully halted the rise in childhood obesity in preschool children. The latest statistics show that between 2000 and 2010, the rate of obesity in children attending day care centres dropped from 10.4% to 8.4%. (Photo: A.S. Gorisek, IAEA)

8 The IAEA and the Government of Chile continue to work closely to address and solve the problems arising from unhealthy eating habits and lack of physical activity through the peaceful uses of nuclear sciences and applications. (Photo: A.S. Gorisek, IAEA)

Text: by Alexandra Sasa Gorisek, IAEA Department of Nuclear Sciences and Applications

ASSESSING BREASTFEEDIN

1 Children who receive only human milk for the first 6 months of their lives are more resistant to disease and infection and less likely than children fed with formula milk to develop diabetes, cardiovascular disease, and cancer in adulthood.

2 With the IAEA's guidance, nuclear techniques are being used to test the effectiveness of breastfeeding promotion strategies. Researchers use non-radioactive stable isotopes of hydrogen (^2H) in water (^2H_2O) to measure the movement of liquid from mother to child.

3 How much ^2H they find is directly proportional to how much human milk the baby has ingested. The technique also shows whether the baby has eaten anything other than human milk over a two-week period.

4 Morocco, along with dozens of countries around the world, has experienced an alarming reduction in the frequency and consistency of exclusive breastfeeding.

G USING NUCLEAR SCIENCE

5 In Morocco's case, the decline (first noticed in the 1980s) was attributed to the growth of the formula milk industry, the increasing number of working mothers, and poorly trained health care workers. The country's exclusive breastfeeding rate dropped from 62% in 1992, to 15% in 2006.

6 So Morocco's Ministry of Health developed training courses for health professionals and awareness programmes for mothers. They evaluated their success by using deuterium dilution technique to assess the exclusivity of breastfeeding. The results were alarming.

7 Instead of the 27% exclusive breastfeeding that was reported by questionnaire surveys, and by periodically weighing babies, the use of stable isotopes showed that only 13% of infants were actually being breastfed exclusively for the first 6 months.

8 The IAEA helps 34 Member States use nuclear techniques in the promotion of exclusive breastfeeding because of the undeniable individual, societal and economic benefits of proper nutrition in early life.

Photos and text by Sasha Henriques, IAEA Office of Public Information and Communication

THE IAEA SUPPORTS MEMBER STATES' NUTRITION PROGRAMMES: WHAT THEY HAVE TO SAY

Top: Breastfeeding practices during the first six months are evaluated under IAEA nutrition projects.

Right: A mother and child involved in the body composition assessment study.

(Photos: N. Mokhtar, IAEA)

IAEA Capacity Building in Burkina Faso

"Under the IAEA's Technical Cooperation programme, Burkina Faso's Institute of Research in Health Sciences (IRSS) has received support to help build the capacity to evaluate human nutrition programmes using stable isotope techniques, and assess public health actions to improve maternal and young child nutrition.

Various nutrition projects were supported by the IAEA and implemented by the IRSS to assess the impact of double supplementation with vitamin A and zinc on the reduction of malaria incidence; the body composition of young children and their mothers; and the human milk intake of breastfed babies. They also provided key information on exclusive breastfeeding during the first six months of life to the national programme coordinators.

These projects have established sustainable research capacity for the assessment of micronutrient nutrition, specifically for analysing the level of zinc in plasma using atomic absorption spectrometry, and for measuring vitamin A using high performance liquid chromatography (HPLC). Stable isotope techniques have been used to determine the body composition of lactating mothers and the human milk intake of breastfed babies. In addition, the IRSS is now providing training in these techniques and is engaged in regional and international collaboration with scientists and research institutes specializing in these fields of study."

— By Jean-Bosco Ouedraogo, IRSS, Burkina Faso

Building the Capacity to Evaluate Vitamin A Supplementation Programmes in Cameroon

"Vitamin A deficiency affects 190 million children under five years old worldwide, occurring most frequently in Africa and South East Asia. Cameroon, which is one of the countries facing this challenge, established a WHO-recommended high-potency vitamin A supplementation programme in 2002, following a national survey of serum vitamin A that showed that 39% of children under five were suffering from vitamin A deficiency. To support the Cameroon Government in enhancing its expertise and evaluation techniques to monitor the effectiveness of the vitamin A supplementation programme, the IAEA has provided Cameroon with equipment and the

Meeting with participants for the first Cameroon study of vitamin A reserves in children.

(Photo: G. Medoua, Cameroon)

necessary training. A stable isotope technique can sensitively detect whether human vitamin A reserves are deficient, adequate, or excessive (for more details please see article on Stable Isotopes: The Method of Choice to Assess Vitamin A Intervention). Cameroon is the first country in Africa to establish national capacity for the implementation of this method, and has provided leadership in planning a new regional project in Africa on the use of stable isotope techniques to monitor and assess the vitamin A status of children susceptible to infection."

— By Gabriel Medoua, Centre for Food and Nutrition Research, Yaoundé, Cameroon

Isotope Studies in Cuba Influence the National Nutrition Recommendations

"Over the past few years, Cuba has acquired in-depth knowledge about the connection between nutrition and health using nuclear science and techniques. With the support of IAEA projects, Cuban researchers are using sensitive methods to evaluate national nutrition programmes. These methods are based on the use of stable isotopes of oxygen and hydrogen to assess body composition and daily energy expenditure in children and adults.

Since 1999, the Cuban Institute of Nutrition and Food Hygiene of the Ministry of Public Health has been using stable isotope techniques in human nutrition research. Four Latin American regional projects and four coordinated research projects (CRPs) have helped to improve understanding of how the health of people of all ages is related to body composition and daily total energy expenditure, and the relationship of anaemia and *Helicobacter pylori* (*H. pylori*) infection to absorption of iron from foods.

The equipment, materials and training provided by the IAEA in this field have helped to improve Cuban nutrition programmes for children and the elderly, to establish new nutritional recommendations, and to improve investigations of obesity and risk factors for non-communicable diseases and national intervention programmes for the prevention of childhood micronutrient deficiencies.

With the IAEA's support, the Cuban Institute of Nutrition and Food Hygiene has established a new Stable Isotope Laboratory, which is able to measure ^{13}C and deuterium. This allows for body composition and *H. pylori* infection to be measured by non-invasive methods. A total of six researchers have been trained in stable isotope techniques and ten workshops and training courses related to the use of isotopes in human nutrition research have been held in Cuba. New projects planned for 2014–2016 will use these techniques to evaluate agriculture programmes to provide nutritious food for schoolchildren and the effect of muscle wasting on the quality of life of the elderly."

— By Manuel Hernandez Triana, Institute of Nutrition and Food Hygiene, Havana, Cuba

Cuban children travelling to school.

(Photo: M. Hernandez Triana, Cuba)

St John's Research Institute, Bangalore, India.

(Photo: St John's Research Institute, India)

The IAEA's Collaborating Centre in Nutrition in Bangalore, India

"St John's Research Institute (SJRI) in Bangalore, India, has been an IAEA collaborating centre for nuclear techniques in nutrition for four years, and has been a nodal point for training in the application of stable isotope approaches to nutrition. The Centre has excellent facilities for conducting research in human nutrition and health, including a calorimetry facility for measuring energy expenditure and the full range of facilities for applying reference techniques to assess body composition, including dual energy X ray absorptiometry to measure bone mineral content; air displacement plethysmography to assess body fat; and stable isotope dilution to measure total body water.

The collaborating centre is also building a whole body potassium counter to measure body cell mass in infants and pregnant women. It has state-of-the-art mass spectrometry facilities that are required for measuring stable isotope enrichment, including facilities for isotope ratio mass spectrometry, gas chromatography-mass spectrometry, liquid chromatography–mass spectrometry, and thermal ionization mass spectrometry.

Technology transfer has been one of the successful outcomes of technical cooperation (TC) projects and of coordinated research projects (CRPs). The IAEA identifies cutting edge technologies that can be used in resource poor areas and international experts to facilitate technology transfer. The collaborating centre in nutrition supports the IAEA's TC programme by providing experts and hosting fellowships and scientific visits to provide training in the assessment of body composition, energy metabolism, breastfeeding practices and iron absorption.

Trainees have come from a number of countries, including Afghanistan, Bangladesh, Botswana, Cambodia, Ghana, Madagascar, Malaysia, Mauritius, Myanmar, Nepal, South Africa, Senegal, Sri Lanka, the Syrian Arab Republic, Tanzania, Thailand and Uganda. The collaborating centre also participates in and supports the IAEA's CRPs, which provide a launch pad for young investigators from developing countries to study nutrition and enhance their skills in, and understanding of, the use of nuclear sciences and applications to improve nutrition in a collaborative and thematic context.

TC projects and CRPs generate data for national policy decisions. While the studies are necessarily small, they provide useful data to substantiate evidence for national and regional policy decisions and recommendations.

CRPs help to harmonize methods. For example, by developing a standardized method for measuring body composition in infants and young children, it was possible to systematically evaluate changes in body composition in malnourished children following refeeding programmes at different sites in various countries. Similarly, harmonized body composition and energy expenditure protocols have led to integrated reports across countries that have defined body fat and physical activity levels. Harmonized protocols to measure lactation performance, infant growth and maternal nutrition are also currently being developed. These coordinating efforts will help to define nutritional requirements for mothers and babies, as well as the benefits of exclusive breastfeeding. The numerous methodology manuals on stable isotope techniques in nutrition that have been published by the IAEA and distributed freely are a great capacity building resource, and the collaborating centre is pleased to have contributed to these achievements."

The manuals can be downloaded from the IAEA Human Health Campus nutrition pages at: nucleus.iaea.org/HHW/Nutrition/index.html

— By Anura Kurpad, St John's Research Institute, Bangalore, India

Promoting Good Nutrition through Isotope Techniques in Morocco

"Morocco is undergoing a nutrition transition characterized by problems related to undernutrition being replaced by problems related to overweight and obesity, which can exist together with micronutrient deficiencies if a high calorie diet is consumed that does not contain enough fruit and vegetables.

Rates of exclusive breastfeeding, which is the cornerstone of good, early nutrition, continue to decline, with a drop from 32% in 2004 to 15% in 2006.

In children under five years, 15% are stunted and more than 30% are suffering from micronutrient deficiencies, including iron, vitamin A, folic acid and iodine deficiencies. A third of pregnant women and women of childbearing age are anaemic, compared to only 18% of men, and the prevalence of folic acid deficiency in women of childbearing age is 25%. Obesity and overweight, caused by changes in lifestyle, diet and levels of physical activity, are prevalent in more than 40% of adults.

To overcome these challenges, the government, with local and international partners, developed the National Strategy for Nutrition 2011–2019, to promote healthy lifestyles, to strengthen professional capacities and coordination between partners, and to develop research work in the area of nutrition.

Children drinking a dose of deuterium-enriched water.

(Photo: S. Henriques, IAEA)

Morocco uses nuclear techniques to study the role of body fat as an indicator of health risk in obese children and adolescents; to determine the relationship between maternal body fat and birth weight; to evaluate interventions aimed at promoting vitamin A supplement-ation and oil fortification for nursing mothers; and to assess the nutritional status of the elderly.

The doubly labelled water technique is used to evaluate total energy expenditure for children and adolescents, and to estimate physical activity so that interventions that are aimed at promoting healthy life styles can be assessed."

— By Professor Hassan Aguenaou and Dr Imane Elmanchawy of the Joint Unit for Nutrition and Food Research at Ibn Tofaïl University, National Centre for Nuclear Energy, Sciences and Technology (CNESTEN), Morocco

Improving Nutrition in Thailand

"Support from the IAEA through its national and regional technical cooperation activities, as well as various CRPs, has enabled Thailand to generate evidence that is useful when developing nutrition policy and programmes. The IAEA has assisted Thailand in establishing capacity in the use of stable isotope

Thai children enjoying lunch that includes rice fortified with vitamin A, iron and zinc. An IAEA study using stable isotopes demonstrated that there was an increase in vitamin A stored in children eating fortified rice.

(Photo: T. Pongcharoen, Bangkok)

techniques to improve micronutrient nutrition by evaluating strategies to enhance the bioavailability and efficacy of foods fortified with micronutrients, and in establishing reliable instrumentation and facilities to assess body composition, energy expenditure and breastfeeding practices, with a view to preventing and controlling non-communicable diseases. These increased capacities are useful in order to evaluate the impact and effectiveness of nutrition interventions, especially among vulnerable population groups such as children and women. The IAEA's support has also strengthened collaboration with internationally renowned scientists and reference laboratories to ensure the quality of research in the application of stable isotope techniques to evaluate nutrition programmes. The capacity developed in Thailand can be extended to neighbouring countries through training, expert visits and appropriate technical assistance aiming at alleviating malnutrition in South East Asia."

— By Pattanee Winichagoon, Mahidol University, Bangkok, Thailand

IAEA-Supported Studies Influence Nutrition Supplementation Policy in Senegal

"In Senegal, the IAEA has helped build technical capacity in the use of nuclear techniques to evaluate national nutrition programmes targeting vulnerable populations such as women and children. For example, through a national TC project, the benefit of a food supplementation programme for pregnant and lactating mothers was evaluated. This provided key information to government policymakers on the food quality needed for an optimal pregnancy outcome and for infant and child growth and the results were taken into account in the national policy on micronutrient supplementation.

In addition to providing training, the IAEA has also contributed to the upgrading of the infrastructure of the Nutrition Unit at the Cheikh Anta Diop University, Dakar, that includes providing support for an isotope ratio mass spectrometry facility that will provide training and analytical services to the region.

The Nutrition Unit is now part of the national committee on nutrition and provides advice, services and expertise in order to improve nutrition in Senegal."

— By Salimata Wade, Cheikh Anta Diop University, Dakar, Senegal

Facilities for measuring micronutrients in blood at the Cheikh Anta Diop University, Dakar, Senegal.

(Photo: N. Mokhtar, IAEA)

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