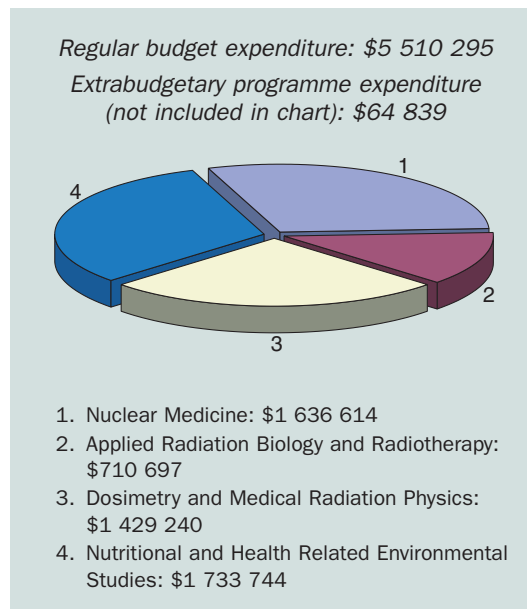


HUMAN HEALTH

PROGRAMME OBJECTIVE

To enhance the capabilities of developing Member States to address important health problems through the development and application of nuclear and related techniques in areas where they confer advantages in comparison with conventional techniques or by themselves constitute the conventional technique.



KEY ISSUES AND HIGHLIGHTS

- Medical services were developed to detect and manage infectious diseases through in vivo and in vitro nuclear medicine techniques.
- The initial phase of the first thematic CRP in nuclear medicine was completed.
- Analyses and projects were directed at the evaluation of the economics of the radiation therapy of cancer.
- A new instrumentation Code of Practice for dosimetry was developed and published.
- Stable isotope techniques for the prevention of degenerative disease were applied.

NUCLEAR MEDICINE

A priority during the year was the development of diagnostic methods and treatment procedures for coronary artery disease, liver cancer, thyroid cancer, bacterial infection, and infectious and childhood diseases. For example, a toxicology study of rhenium-188 Lipiodol for the treatment of liver cancer was completed after holding workshops in Colombia, Singapore and Viet Nam. The study formed the initial part of the Agency's first 'thematic CRP' in nuclear medicine, launched in 2000, on managing liver cancer using radionuclide methods with a special emphasis on trans-arterial radioconjugate therapy and internal dosimetry. The key feature of a thematic CRP is the pairing of an identical number of research agreement and research contract holders, with each pair supervising a research fellow working towards a doctorate or similar advanced degree in the same area as the CRP. The main benefit is to broaden the base of research in the area under study. Under this new CRP, ten researchers from ten developing countries are pursuing post-graduate training and education.

Tele-imaging and tele-maintenance via the Internet are innovative and cost effective methods of linking and repairing nuclear medicine imaging systems (such as gamma cameras and single photon emission computed tomography (SPECT) imaging) in developing countries. The first trial of the new technology was conducted with the linking of 38 gamma cameras and SPECT systems at various sites in Africa, and in Bolivia, Bulgaria, Hungary, Myanmar, Slovenia and Sri Lanka. Making full use of the expertise in these countries, this promising technology resulted in the repair of 12 gamma cameras and SPECT systems without the need for expert service missions, and a significant reduction in the downtime of these vital medical diagnostic instruments from several months to several days. This scheme has prompted WHO to seek the Agency's expertise for quality control and personnel training efforts, and for the coverage of medical instruments in general.

A critical part of the Agency's human health programme is the *application* of nuclear and

related techniques in the treatment of cancer and infectious diseases. A regional technical co-operation project successfully applied an immunoradiometric assay of the hepatitis C antibody in Latin America that resulted in the screening of 18 691 subjects and the detection of 270 positive cases. Another project produced indigenous, high quality antibodies to alpha-feto protein for the detection of liver cancer. This project was carried out in co-operation with Algeria, Argentina, Brazil, Egypt, India, Indonesia, Malaysia and Mongolia. And a project involving a regional screening network for neonatal hypothyroidism in East Asia resulted in the rescue of 360 babies from mental retardation out of a total of 1.3 million babies that were screened. To sustain local expertise in the application of radioimmunoassay to neonatal screening, interactive multimedia teaching software was developed. In Africa, 77 682 tests for the detection of tumour markers were carried out in 17 countries. The number of cancer cases detected/monitored was significant, ranging from 24 to 50% of the patients investigated. The project also contributed to the training of 20 clinical laboratory science graduates in tumour marker assays.

The Agency seeks to maximize the impact of its activities by working with other international organizations working in the same area. One instance involved WHO and the transfer of molecular isotope based tests to Member States. For example, tests for the detection of drug resistant malaria and tuberculosis (TB) were validated. With these tests results can be obtained in two to three days as opposed to conventional methods that take 28 days for malaria and a minimum of five weeks for TB. Practical use was made of this technology in Mali where, during an epidemic, results were quickly provided to the control programme manager showing 75% resistance to the anti-malarial drug chloroquine and none to Fansidar. The latter was used for effective control of the epidemic. In Latin America, similar technology was used to establish less invasive diagnosis of tegumentary leishmaniasis. An antibody based test suitable for screening for Chagas' disease in blood banks using an optimal mixture of recombinant antigens resulted in improved diagnostic accuracy as compared with conventional serology.

APPLIED RADIATION BIOLOGY AND RADIOTHERAPY

Several analyses and projects were directed at the evaluation of the economics of radiation therapy of cancer. It became evident that high dose rate brachytherapy technology has expanded rapidly in Member States, with a concomitant reduction in low dose rate for most applications.

Models to derive the cost of cancer treatment using brachytherapy and cobalt and Linac teletherapy in different countries were developed and implemented. These take into account the utilization of the equipment, the salaries of all personnel, building costs and the duration of a working day to derive a cost per treatment using any of these modalities.

A randomized clinical trial of the treatment of cervical cancer using a new radiation sensitizer versus radiotherapy alone was concluded involving 333 patients from four countries. The study demonstrated a significant improvement in the control rate and survival in patients who received the hypoxic cell sensitizer at the same time as radiotherapy. This is the first positive result reported with this group of sensitizers.

DOSIMETRY AND MEDICAL RADIATION PHYSICS

The Agency is the only organization that provides for developing Member States a link to international standards for measuring radiation and the quality assurance techniques necessary for the calibration of radiation therapy machines and industrial radiation facilities (see Box 1).

With regard to international standards for radiation measurements, the Code of Practice (CoP) for dosimetry based on direct calibration using standards of absorbed dose to water, developed and published by the Agency in 2000 as Technical Reports Series No. 398, was endorsed by WHO, PAHO and ESTRO. In addition, several countries adopted it as the basis for their determination of absorbed dose to water, making it the only internationally accepted CoP. Previously, codes for dosimetry were based on standards of air kerma, which introduced a layer of complication that became unnecessary when Primary Standards Dosimetry Laboratories began disseminating radiation measurement standards of absorbed dose to water determined calorimetrically. Secondary Standards Dosimetry Laboratories in Member States will

BOX 1. HELPING MEMBER STATES TO MAINTAIN QUALITY ASSURANCE IN RADIATION TREATMENT PLANNING SYSTEMS

Medical physicists from the Agency participated in the investigation of two serious incidents involving the overexposure of patients undergoing radiation treatment for cancer. In the first incident, in Panama, the system used to plan radiotherapy treatments gave an incorrect value of the calculated exposure time which was not checked by manual calculation. Of the 28 overexposed patients, 12 subsequently died. In order to assist Member States with the commissioning and quality assurance of their treatment planning systems, a meeting utilizing the services of consultants was convened to establish guidelines for the use of Agency experts conducting on-site review visits for such systems. In the second incident, which occurred in Poland, an electrical power outage appears to have precipitated multiple failures of a linear accelerator involving both its beam output monitor and its safety interlock system. Unfortunately, the resulting large increase in beam output was not detected prior to resuming patient therapy. This resulted in the overexposure of five patients. The Agency's role was to investigate the cause of such incidents in order to inform users of similar equipment of the inherent dangers involved. ■

benefit by having access to a system of dosimetry that is inherently simpler than earlier ones.

In the area of industrial applications, 20% of the 50 cobalt-60 beam audits that were performed for Member States through the International Dose Assurance Service (IDAS) exceeded the acceptance limit of 5%, indicating the importance of this service. At the request of FAO, eight cobalt-60 beam calibrations were checked using IDAS dosimeters for participants of a CRP on the quality assurance of mass produced and released fruit flies. This assistance in dosimetric measurements will help the participants to standardize their irradiation technique.

The IAEA/WHO thermoluminescence dosimetry (TLD) postal dose audit service monitored the calibration of more than 400 radiotherapy beams at hospitals worldwide. The dosimeter return rate exceeded 95%, indicating a significant commitment to the service, but 20% of the results exceeded the 5% acceptance limit. Historically, it has been observed that as laboratories participate in the service, their overall performance improves, pointing to the value of this service for Member States.

NUTRITIONAL AND HEALTH RELATED ENVIRONMENTAL STUDIES

The first thematic CRP on nutrition on isotopic and complementary tools for the study of micronutrient status and interactions in developing country populations exposed to multiple nutritional deficiencies was launched. The aim is to devise approaches for a sustainable focus on micronutrient malnutrition in chronically malnourished populations by evaluating micronutrient interactions, and to support capacity building in the area of food and nutrition in developing countries. Eight doctoral fellows will be able to acquire higher level degrees in food and nutrition as a result of this CRP.

A CRP that ended in 2001 studied the use of stable isotopic techniques in the prevention of degenerative diseases (obesity and 'non-insulin dependent diabetes') in developing countries.

Important results of this CRP were the establishment of standard protocols for body composition and physical activity measurements, and the suggestion to use total body fat distribution patterns as predictors of the evolution of insulin resistance syndrome.

The doubly labelled water technique for investigating human body composition was further refined in a CRP that studied measurements of dietary energy intakes in women and men. The results of this CRP, together with those obtained from a regional Latin American technical co-operation project, contributed to the formulation of new recommendations by the Joint WHO-FAO-United Nations University Expert Consultation on Energy in Human Nutrition. These recommendations are, for the first time, based on measured data on energy metabolism in children and adult populations from developing countries.

A technical co-operation project provided guidance to Senegal, for its national nutrition plan campaign, on the use of isotopic methods to quantify the transfer of breast milk from the mother to the baby. The results are being used to optimize planning for food supplements for the baby that is being weaned. In another technical co-operation project, measurement of the effectiveness of multivitamin supplementation was undertaken in several Asian countries. Regional training courses, group training and a workshop for policy makers were key activities in this project. In particular, the results from studies on wheat flour (in Indonesia) helped policy makers and industry to choose the best fortificant(s) for greater effectiveness of national programmes.

In the area of environmental health, a CRP assessed the levels and health effects of airborne particulate matter (APM) in the mining, metal refining and metal working industries using nuclear and related analytical techniques. As a result, strategies and techniques were developed for sampling work place APM and human tissues and/or fluids. In related work, a regional technical co-operation project for Latin America generated reliable compositional data sets for the PM₁₀ (particulate matter of 10 micrometre diameter) and PM_{2.5} fractions of APM in Buenos Aires, São Paulo, Santiago de Chile and Mexico

City, all of which suffer from high levels of air pollution. The levels of toxic heavy metals were accurately determined during critical (cold, hot, dry and humid) periods of the year.

The Agency's database on Natural Matrix Reference Materials (<http://www.iaea.org/programmes/nahunet/e4/nmrm/index.htm>) was updated and now contains over 26 000 values (mass fraction or concentration) for 750 different measurements and 2163 reference materials produced by 59 producers from 22 countries. In 2001, the database was extended to include organic constituents, in particular organic macro- and micronutrients.

Attention has recently been focused on the consequences of the military use of depleted uranium (DU) on the environment and local civilian populations. In addition to participation in 2000 in a UNEP sampling mission to evaluate the situation with respect to DU in Kosovo, the Agency's Laboratories at Seibersdorf provided analytical results for total and isotopic uranium analysis (i.e. verification of the origin of the uranium). The Agency organized a scientific seminar and training course in September — in co-operation with UNEP and WHO, and with financial support from Germany, Italy and Switzerland — on 'Depleted Uranium in the Environment'. The seminar and course provided up to date information on the detection, measurement, assessment of risks and potential health effects from the use of DU armour piercing ammunition or by its use in civilian applications (e.g. radiation shielding or as aircraft counterweights). The training course was held jointly at the Agency's Laboratories at Seibersdorf and at the Karlsruhe Training Centre, Germany, and also involved the Institute for

Radiation Protection in Neuherberg, which provided assistance on environmental modelling and radioecological aspects of DU, Wismut GmbH, which reported on decontamination issues and site restoration technologies, and the German Army, which supported the field studies.

The Agency was requested by Kuwait to assist in an assessment of the post-Gulf War contamination of the environment by DU and to verify Kuwaiti national results. The Seibersdorf Laboratories analysed 30 samples containing air filters, water, DU (armour piercing) penetrators and soil from various regions of Kuwait. A report summarizing the results is being prepared. Further field sampling is to take place in 2002.

The Agency's Network of Analytical Laboratories Monitoring Environmental Radioactivity (ALMERA) network was established to provide accurate and precise environmental radioactivity measurements in the event of a nuclear incident. Member States nominate laboratories which are required to demonstrate their analytical competence by participation in regular Agency proficiency tests (Table I). The first such test of the ALMERA network was completed in May and a report summarizing the results is in preparation.

Human health and environmental monitoring data are completely dependent on the quality of the primary analytical measurements. As part of its ongoing task to assist laboratories in Member States to evaluate and develop their analytical capabilities for environmental radioactivity monitoring, a phosphogypsum candidate reference material was characterized

TABLE I. PARTICIPATION IN ALMERA PROFICIENCY TESTS

Target laboratories	Matrix	No. of sets dispatched	No. of results reported
$\alpha + \beta$ spectroscopy	Soil	56	44
γ spectroscopy	Soil	74	49

for its primordial radionuclide content (uranium, thorium, radium-226 and lead/polonium-210). The Agency's Laboratories at Seibersdorf collected approximately 600 kg of the material, which is now available for preparation as a candidate reference material. Similarly, a total of 13 water samples were prepared as part of a proficiency test on the determination of radium-226/-228 and uranium-234/-235/-238 in natural waters. Samples from five natural water sources were collected in Austria and Poland. The remaining eight sample waters were prepared by spiking de-ionized water with known levels of these primordial radionuclides to simulate a range of low and high salinity waters. In this way, the Agency was able to evaluate the effectiveness of participants' procedures in dealing with a range of water types, from groundwaters to waste waters, within the framework of the proficiency test.

Neutron activation analysis is a versatile tool that can be used for the direct analysis of the trace element content of solid samples. The Agency's Laboratories at Seibersdorf was involved in establishing a neutron activation analysis facility at the KFKI reactor in Budapest to replace the irradiation facility after the Austrian ASTRA reactor was closed in July 1999. In addition, discussions took place concerning modifications to the KFKI reactor to enable it to accept the installation of a fast pneumatic transfer system supplied by the Agency. Such a system permits the analysis of a range of analytes (activation products) that have short half-lives, and permits short irradiation times which can enhance the capabilities of the technique. Based on test irradiations, it was decided that the installation of the Agency's fast pneumatic system should proceed, with funding allocated in 2002.