IMPROVING CANCER CARE

INCREASED NEED FOR RADIOTHERAPY IN DEVELOPING COUNTRIES

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Cancer is not a modern phenomenon – a bone tumour has been observed in a 14-year-old pharaoh who succumbed and was mummified, only to be accurately diagnosed three millennia later. Chinese and Arabic medical writings also document clinical cases so well that some can clearly be identified today as cancer from the descriptions.

Cancer is a rapidly increasing problem in developing countries as statistics illustrate. Cases have risen from two million in 1985 to five million in 2000, and are projected to number 10 million in 2015. In developed countries, where there were five million cases in 1985 as well as in 2000, no increase is projected to 2015.

Despite the high rates of infectious diseases such as tuberculosis and malaria in developing countries, this rapid increase of cancer has spurred nations to recognize increasingly the need for guidance in clinical and medical physics aspects of radiation oncology to improve their standards of cancer care. No longer is cancer believed to be a disease of the affluent. The cancer rate in each age group, expressed as the number of cases in each 100,000 of that age group per year, is low in young persons, both affluent and poor.

The rapid rise of cancer in developing countries is attributable mainly to increasing life expectancy. This more aged population group is more likely to develop cancer. The likelihood of getting cancer does vary between developed and developing countries but the variation is far less than is commonly perceived. *(See graph, page 26.)*

What is observed is that the spectrum of cancers seen in the opulent differs from that seen in disadvantaged populations. Males in developing countries have liver and oesophagus tumours as the third and fourth most common cancers. These are relatively uncommon in developed countries, ranking lower than tenth. *(See table, page 26.)*

Similarly, in women, breast cancer is the most common in both population groups. However cervical cancer in disadvantaged women is almost as common -- accounting for 17% of all female cancers. In well-developed countries, cervical cancer accounts for only 4% of female cancers.

Differing patterns of cancer have a profound influence on the need for specific radiotherapy resources. These differences, coupled with the more advanced stages of cancer present in developing countries, place different demands on the selection and use of equipment for radiotherapy. The treatment protocols and equipment modelled on the best-developed countries seldom can be applied directly to developing countries owing to financial constraints and lack of qualified personnel.

A comprehensive national cancer control programme -- including preventative and early detection measures, coupled with a judicious mixture of treatment by surgery, radiotherapy and chemotherapy -- now results in the cure of 45% of all cancers in advanced countries. That is a target to which developing countries also aspire.

GLOBAL TRENDS & COOPERATION

The earliest applications of nuclear technology were diagnostic radiology and the treatment of cancer using radiation. The discovery of X-rays in November 1895 was followed by the first diagnostic "skiagrams" published in

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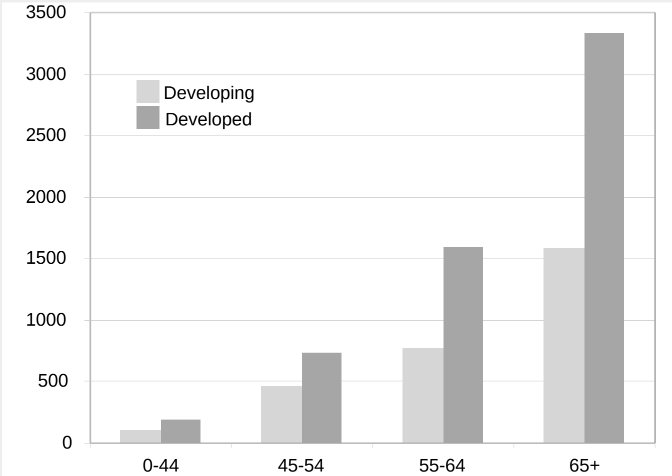
RATES OF CANCER IN DEVELOPING AND DEVELOPED COUNTRIES, BY AGE



THE MOST COMMON PRIMARY CANCERS IN MALES IN DEVELOPED AND DEVELOPING COUNTRIES

(RANKED BY FREQUENCY)

Cancer Primary	Developing	Developed
Lung	1	1
Stomach	2	4
Liver	3	>10
Oesophagus	4	>10
Colon/Rectum	5	3
Prostate	6	2
Oral cavity	7	9
Bladder	8	5

January 1896. Simultaneously, in January 1896, two patients, one with breast cancer, commenced treatment in Chicago; in February, a nasopharyngeal cancer was treated in Hamburg and a stomach cancer in July in Lyon. In November 1896, a 4 year-old child was the first patient treated in Vienna. What is more remarkable is that she was seen for clinical follow-up 70 years later - in excellent health.

This X-ray technique developed into the radiotherapy discipline referred to as “teletherapy”. Significant improvement in clinical results was achieved with the introduction of high-energy teletherapy. Cobalt-60 teletherapy was first used in October 1951, almost 50 years ago. Megavoltage accelerators for the production of high energy X-rays became increasingly more reliable from the 1970s.

Radium was identified and isolated in 1898, but the first documented successful use for cancer treatment was in St. Petersburg in 1903. The application of radium evolved into the discipline of “brachytherapy” -- the application of sealed radioactive material directly adjacent to a tumour.

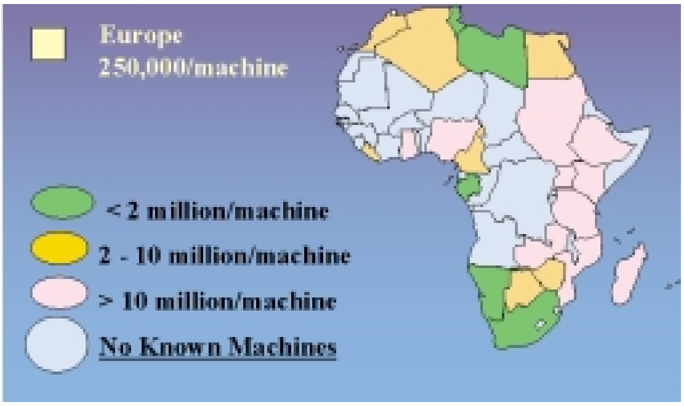
There has been rapid worldwide acceptance of radiotherapy as both a curative and palliative modality in the management of cancer. Many countries, designated as developing, initiated radiation therapy under general radiology in the early 1900s, but separated this growing discipline from diagnostic radiology in the 1950s.

However, there was a severe shortfall of facilities compared to the best developed countries. The last decade has seen an acceleration of the acquisition of equipment by developing countries. For example, the whole of Africa had 63 megavoltage teletherapy machines in 1991; this number rose to 155 machines by the end of 1998. *(See box, page 31.)*

During the past few years, there has been a corresponding increased demand from the IAEA’s Member States for assistance, including the provision of radiation sources and equipment, in establishing radiotherapy programmes for the treatment of cancer patients through technical cooperation projects. The activities have ranged from the initiation of radiation oncology in a country without any prior facilities to upgrading deficiencies in existing radiotherapy centres. The objective has been to nurture the radiotherapy technology until the internationally accepted standards for the centres of competence are achieved and sustained in those Member States where this technology is appropriate.

The IAEA has adopted a systematic approach for the provision of this assistance and equipment. The aim is to ensure that clinical, dosimetric, safety and maintenance aspects have been included, which otherwise could jeopardize the outcome of patient treatment, or contribute to accidents. All technical cooperation projects carried out with IAEA assistance have been implemented in compliance with *The International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS)*. The transfer of radiotherapy technology has been addressed through national and regional projects in Africa, Asia, Eastern Europe, and Latin America.

RADIOTHERAPY SERVICES IN AFRICA
(PEOPLE SERVED BY A SINGLE TELETHERAPY MACHINE)



AFRICA: GROWING NEED FOR SERVICES

Notwithstanding the success story of Ghana *(see box, pages 28-29)* Africa has a considerable shortfall of radiotherapy services for cost-effectively managing cancer. The European standard of 250,000 population served by a single teletherapy machine is not matched in any country in Africa. *(See map.)*

The establishment of a *new radiotherapy department* is a major task representing a significant capital outlay and requiring experience of the technology used. The accomplishment of this task, without any previous experience in a country, requires international expertise.

The IAEA has supported a number of countries in establishing their first radiotherapy centres. Initially, a feasibility study is undertaken in response to a request to the IAEA. It is important that the Health Ministry be involved from the outset as they have the long-term responsibility of supporting the service to be developed. Medical counterparts are identified and estimates made of the patient numbers likely to benefit from these services. This initial evaluation provides estimates for staff training, equipment and expertise required. Moreover, a layout of the buildings required on the hospital site is produced.

All these items allow the partners – the Member State and the IAEA -- to determine the commitments required. An IAEA technical document (TECDOC-1040, *Design and Implementation of a Radiotherapy Programme: Clinical, Medical Physics, Radiation Protection and Safety Aspects*) was developed as a joint activity of medical physicists, clinical and radiation-safety personnel. It provides a framework and guidance for a consistent comprehensive approach to initiating or expanding radiation oncology services.

During the past seven years, modern radiation therapy has successfully commenced in Ethiopia, Ghana, Mongolia, Namibia and Uganda and the IAEA is involved in a new project in Yemen.

The start of a *second radiotherapy centre* in a country is only slightly less complex. Local counterparts have a clearer idea of what they are undertaking and there is the possibility of giving some local training before sending trainees to other countries to acquire their full training and degrees. Gezira in Sudan and Zaria in Nigeria are examples of second centres commissioned during the past few years with IAEA support.

Under the African Regional Agreement (AFRA), a project on the improvement of clinical radiotherapy has brought together 18 countries. The focus has been on providing regional training courses and expertise, as well as small equipment items.

EUROPE: UPGRADING RADIOTHERAPY

While generally accepted estimates show that cancer is curable in about 45% of cases, this standard cannot be achieved unless a high degree of accuracy and reliability of radiotherapy services are maintained. Both clinical aspects (diagnosis, decision-making, indication for treatment, follow-up) as well as procedures related to the physical and technical aspects

SUSTAINING MODERN RADIOTHERAPY IN ACCRA, GHANA

Photo: The front entry to the radiotherapy department at Korle-Bu Hospital, Accra immediately after completion in 1996, before the grass, flower beds, large lizards and patients arrived.

In 1993, the IAEA launched a project for radiotherapy services in Ghana, a country of 14 million people. No cancer registry existed in Ghana; published cancer data were scanty. However, using population based figures -- with the cooperation of the WHO Geneva and Lyon offices -- Ghana was estimated to have over 10,000 cases of cancer occurring annually. Furthermore, the neighbouring countries, Cote d'Ivoire, Burkino Faso and Togo have no treatment facilities. The project had the strong support of the wife of the president, Mrs. Rawlings, and thus also of the Health Ministry, Ministry of Foreign Affairs and the Atomic Energy Authorities. The Korle-Bu Hospital of the University of Ghana Medical School was selected as the site for development.

The first IAEA challenge was to find training institutions. Radiotherapy training of a medical graduate is usually of four years duration in order to reach standards where the radiotherapist can treat without supervision. Among the considerations is the need for similarity of clinical material and of treatment equipment so that the training is directly applicable to the clinical situations on the trainees' return. Furthermore, the Ghanaian medical degree had to be recognized by the host country Medical Council or the trainee could not touch a patient - a bit like learning to drive a 10-ton truck by sitting in the passenger seat. A University in South Africa satisfied these criteria and was selected. Five medical doctors were sent for training commencing in 1995. Physicists for medical physics training were sent to South Africa and the UK. In addition, diagnostic radiographers were sent for two years to South Africa, China and the USA for training as radiotherapy technologists -- technicians who operate the therapy machines. Training in the UK was provided for four oncology nurses to study aspects of nursing cancer patients.

Simultaneously in 1994, experts scrutinized the layout drawings. Significant deficiencies were seen and rectified. Structural drawings were requested to review the radiation protection provided. With repeated expert visits regarding the details of construction, a well functional and fully air-conditioned building was far advanced in 1995 and ready to receive equipment in 1996.

While the type of equipment had been selected as generic items, considerable further impetus was given to the project by a generous donation by the Government of China at the end of 1994. Decisions regarding the machines could be finalized and an engineer was sent to China to study the construction and maintenance of the cobalt machine and simulator as both of these major items were provided by that country.

The period from 1996 to the end of 1997 was hectic; equipment arrived from many countries, all requiring installation, acceptance testing and commissioning. Comprehensive dose measuring

of patient treatment must be subjected to careful control and planning. It has long been recognized that the physical aspects of quality assurance in radiotherapy are vital. It is now increasingly acknowledged that a systematic approach is necessary for all the stages within clinical and technical aspects of a radiotherapy programme to achieve safe and effective treatment.

Improved quality control in radiation oncology has the potential for increasing cancer survival. As stated by the Cancer Research Working Party of the Commission of the European Communities (1991), "it is estimated that in Western Europe a significant increase in cancer survival (five percent) could be obtained by increasing the level of quality of radiotherapy. For Eastern European countries, this increase could even be as high as fifteen percent."

The cancer spectrum in east and southeast European countries, including newly independent countries, is equipment had to be provided and then used to commission the treatment machines. This data, in turn, was loaded onto the treatment planning system which then had to be commissioned. Numerous experts were sent to assist the resident medical physics personnel who had returned from training.

October 1997 saw the first radiotherapist, Dr. Francis Durosinmi-Etti, who had been the first radiation oncologist on the IAEA staff, take up duties. He initiated the paper systems; treatment sheets, machine log books; and educated the local hospital medical staff on the role of radiotherapy and treatment of the resulting influx of patients. Between then and the end of December, 70 patients were treated. In the first week in 1998, Prof. Wu Jin Dong of China, took over as acting director as the Ghanaian fellows had not yet completed their studies and examinations. He accelerated the pace of patient accrual and, in the following six months, treated a further 320 patients, predominantly female (72%), with breast and cervix cancers in approximately equal numbers accounting for 50% of all patients. Since then, three qualified Ghanaian radiation oncologists have returned to keep up the momentum.

Photo: President Rawlings (centre) at the cobalt treatment machine with a patient being treated by Dr.Wu Jin Dong (right) at the official opening in Ghana.

A training course for AFRA participants was held at the radiotherapy centre in April of 1998. The subject, most appropriately, was quality assurance (QA) in radiation oncology. Three internationally renowned medical physicists, three radiation oncologists, two IAEA staff members and groups of students descended on the fledgling department. Everything that could operate was poked, prodded, measured or otherwise examined to assist in developing the best QA systems possible. At the end, the department was commended in achieving a level comparable with the best standards of Africa.

The official opening was held on 26 May 1998 under the chairmanship of Mr. Afful, the Minister for Environment, Science and Technology. An address was given by the President of Ghana with his first lady, as the Patron of the National Radiotherapy and Nuclear Medicine Committee, in attendance. Also present were Dr. Brookman-Amissal, the Minister of Health and Prof. Allotey, the Chairman of the Ghana Atomic Energy Commission.

Assistance continues to this department. An orthovoltage machine to treat shallow tumours, anticipated in the initial plan, is being installed -- not only to cope with the special requirements of some treatments, but also to alleviate the load of patients on the single cobalt machine which now exceeds its capacity. Together with the International Agency for Research on Cancer (IARC), the IAEA is also involved in developing the national cancer registry which will provide the information required to expand these services rationally.

much as it is in Western Europe, and so is the frequency of cases. Even though the basic radiotherapy infrastructure and trained personnel exist in these countries, the effect of economic difficulties and conflicts is evident in the therapy facilities and equipment available.

Extensive but focused assistance was recently provided by the IAEA to a number of countries in east and southeastern Europe under two closely linked regional projects. They aim to upgrade radiotherapy and to improve skills in medical physics.

These projects helped with the upgrading of seven oncology centres with radiotherapy equipment and instrumentation, by sharing costs with the governments of Albania, Armenia, Bosnia & Herzegovina, Croatia, the Former Yugoslav Republic of Macedonia, Georgia and Moldova. An important result of these projects was the provision of high quality

IAEA SUPPORT FOR UPGRADING RADIOTHERAPY IN SARAJEVO

The medical institutions in Bosnia and Herzegovina had deteriorated. Buildings and equipment had been destroyed during the conflict of 1992-95. Before 1992 the radiotherapy department of the Institute of Oncology in Sarajevo was a small provincial hospital serving the local population with approximately 1200 cancer patients treated per year. The staff has a proud record of having continued treatment through the war years even though at most critical times only about 100 patients per year had been able to avail themselves of this facility. The department emerged from the war with only one 17-year-old cobalt-60 machine with a nine year-old radiation source and a damaged brachytherapy machine. There was no adequate dosimetry equipment nor computerized treatment planning systems.

There is no national cancer incidence data available at present as the National Cancer Registry is only now being established in Bosnia and Herzegovina. However, the estimated figures indicate that about 5000 cancer patients will require radiation therapy in the foreseeable future.

In 1996, a comprehensive programme was undertaken, with the support of the Ministry of Health, to re-establish the Institute of Oncology in Sarajevo, which is the only radiotherapy centre in the country. The counterpart took the opportunity to build an entirely new, bright department with sufficient provisions for future installations.

The first IAEA imperative was to provide a comprehensive set of properly calibrated dosimetry equipment, before refurbishment of the old machine and acquiring a new cobalt-60 machine with its ancillary equipment. The brachytherapy equipment was repaired. A new linear accelerator and a simulator were purchased under national funds and the IAEA provided an expert for their commissioning. The quality of treatment has been enhanced by implementation of computerized treatment planning. Two treatment planning systems were acquired and experts fielded to assist the local staff to measure radiation dose distributions of the cobalt-60 beam, high energy photon and electron beams of the linear accelerator and to enter these into the treatment planning system. Also, the IAEA supported intensive training of professionals from the team of eleven radiation oncologists, three medical physicists and ten radiographers working at the department. The official opening of the radiotherapy department at the Institute of Oncology in Sarajevo took place in May 1999.

A mission completed in March 2001 by IAEA staff revealed a phoenix risen from the ashes. In a short time, the institute has grown into a well-organized radiotherapy department with adequate installations in a spacious building, having modern therapy machines, immobilization and imaging equipment operated by a well qualified, dedicated radiotherapy team. The department treats at present 1100 patients. This has not yet met the country's needs for radiation therapy. Professor Mirza Musanovic, the director of the institute, Dr Nermina Obralic, the chief radiation oncologist and Mr. Advan Drljevic, the chief medical physicist, are considering making provision for further developments and additional equipment to meet the national need of approximately 5000 cancer patients that will require radiotherapy among the 4.1 million population.

training to radiotherapy clinicians and medical physicists through a generous package of fellowships and training courses.

An agreement with the European Society for Therapeutic Radiology and Oncology (ESTRO) allowed the IAEA-supported participants to join the regular ESTRO teaching courses including one training course annually with simultaneous Russian translation. This enabled the IAEA to train several hundred professionals in Europe in the field of radiation oncology and medical radiation physics. Despite this progress, technical and infrastructure inadequacies exist which affect the level of safety, efficiency and effectiveness of radiotherapy treatment.

The present regional project in Europe seeks to address some of these issues through the consolidation of potential centres of competence already identified at the planning stage. The project predominantly provides training to clinicians, medical physicists and radiation technologists in these radiotherapy centres to ensure that all stages of radiotherapy treatment can be accomplished adequately and safely.

A major requirement in the future is to introduce quality audits more widely in radiotherapy departments to qualify them eventually as centres of competence. For this, the radiotherapy centre itself must implement internal quality assurance and control programmes. It also must conduct regular reviews of progress through audits and verifications by external reference bodies. Both national and international bodies are needed to ensure accurate dosimetry and treatment delivery.

Training is accomplished through selected ESTRO courses supplemented by IAEA training in specific well-defined topics. Minor equipment provision focuses on dosimetry and patient positioning reproducibility.

DIRAC: DIRECTORY OF RADIOTHERAPY CENTRES

In 1959, the IAEA started compiling a register of hospitals and clinical institutions that offered radiation therapy with radionuclide or high-energy teletherapy equipment. The first edition of the Directory of High-Energy Radiotherapy Centres was published in 1968 and the last update of the directory was released in 1976. Since 1995, the IAEA has worked to build a computerized international registry of radiation sources that was given the name of DIRAC, for Directory of Radiotherapy Centres. The project since has been joined by the World Health Organization (WHO).

DIRAC encompasses data collected in 1995-2000 on teletherapy machines, devices and sources used in brachytherapy, and equipment for dosimetry, patient dose calculation and quality assurance. The numbers of staff at the installations (radiation oncologists, medical physicists, technicians, etc.) are included as well. In the present edition, DIRAC includes more than 5300 radiotherapy centres in over 160 countries with approximately 6300 radiotherapy machines and 2500 brachytherapy units installed. However, it is still an incomplete description of the present status of radiotherapy in the world. The electronic version of DIRAC is being continuously updated, based on replies to the questionnaires circulated.

In addition to identifying individual institutions with radiotherapy machines, DIRAC provides a global estimate of current and future needs for radiotherapy facilities. Even though developing countries represent about 85% of the world population, the developed countries (North America, Western Europe, Australasia and Japan) have two-thirds of all radiotherapy facilities; 85% of all electron accelerators and over 30% of all cobalt units. Only about 2100 teletherapy machines, mainly cobalt-60 units, are installed in developing countries, which is far from being sufficient to serve the current population. Of the current 5 million new cancer cases per year, 50% require radiotherapy. If it is assumed that one machine is required for 500 new cancer cases treated, then the current need is for a total of 5000 machines. By the year 2015, a total of 10,000 machines will be needed to provide treatment for the estimated 10 million new cancer cases per year in developing countries.

The DIRAC data are subject to change due to the continuous updating. The database will soon be available on the Internet at http://www.iaea.org/programmes/nahunet/.

THE PATH AHEAD

Radiotherapy is a multidisciplinary speciality that uses complex equipment and radiation sources for delivery of treatment. It is estimated that over 2100 megavoltage teletherapy machines are currently installed in developing countries. This figure is significantly below the estimated current needs of almost 5000 machines. A conservative estimate points to a need for about 10,000 machines by the year 2015. Although this figure might appear difficult to achieve, the number of treatment units in developing countries has increased considerably as have the number of brachytherapy devices.

With this perspective, in addition to the enormous need for qualified professionals (including radiation oncologists, medical physicists, radiotherapy technicians, radiation protection officers, and maintenance engineers) capable of operating new radiotherapy equipment, the development of the medical infrastructure for cancer treatment appears to be a substantial undertaking over forthcoming years. Moreover, this nuclear technology enjoys broad public acceptance and thus extraneous factors are unlikely to inhibit growth.

The IAEA's support in establishing, together with its Member States, a single radiotherapy centre in Namibia and Ethiopia has resulted in both countries receiving the same level of transfer of technology. However, in Ethiopia, with a population of 40 million, this hardly scratches the surface of the need for treatment facilities. In Namibia, with only 1.5 million people, the work represents starting from nothing and going directly to the best service achieved in Africa.

The IAEA has a role in the transfer of this medical technology and its safe usage. It is not within the means, nor an objective of the IAEA to undertake the national responsibility for general availability of these services. A competent department within a country will serve as a model on which future development can be based.

A few countries have not yet adopted this technology which will be recognized as a priority as cancer numbers increase over the next decade.

A continued strong programme in radiation oncology and medical physics, providing both tools and guidance for improving standards of radiation therapy, will offer an incentive for better practice. An important result will be that developing countries will advance to reach the standard of cancer care achieved in the developed world. ❐

RADIOLOGICAL SAFETY

The IAEA's recent response to a radiation emergency at a radiotherapy centre in Panama underscored the importance of applying established safety standards in medical care involving ionizing radiation. The emergency affected 28 cancer patients, eight of whom had died as of June 2001. Panama's national authorities informed the IAEA about the event on 22 May 2001, and requested assistance under the Convention on Assistance in the Case of Nuclear Accident or Radiological Emergency. An IAEA team of six international experts, including professionals in radiology, radiotherapy, radiopathology, radiation dosimetry, and radiation protection, visited the country in late May to early June.

Based on advisory information from the expert team, the mission confirmed that the cause of the patient overdose lay with the entering of data into the computerized treatment planning system which is used at Panama's National Oncology Institute. Shielding blocks are used to protect healthy tissue of patients undergoing radiotherapy there, as is the normal practice. Data on the shielding blocks are entered into the computer, which calculates the dose distributions in patients and the treatment times. For the 28 patients who were affected, data were entered in a batch for several shielding blocks at once. However, this approach apparently caused the treatment planning system to calculate incorrect radiation doses, and consequently incorrect treatment times.

The IAEA team briefed Panama's authorities on the mission's findings, and the government agreed that these should be shared with the international community. Particularly emphasized by the expert team was the need to follow written quality assurance procedures. This includes ensuring that the procedures require manual checks of the doses to the prescription points as calculated by computer, for each individual patient, before the first treatment; and performing verification measurements using a phantom for new procedures, especially in complicated treatments, for which manual calculations may not be practical. Drawing upon the expert team's mission, the IAEA is planning to publish a detailed report on the emergency and lessons learned.