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Cancer Control

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Office of Public Information
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International Atomic Energy Agency
Vienna International Centre
PO Box 100, 1400 Vienna, Austria
Phone: (43-1) 2600-0
iaeabulletin@iaea.org

Managing Editor: Nicole Jawerth
Editor: Miklos Gaspar
Design & Production: Ritu Kenn

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IAEA

The International Atomic Energy Agency's mission is to prevent the spread of nuclear weapons and to help all countries — especially in the developing world — benefit from the peaceful, safe and secure use of nuclear science and technology.

Established as an autonomous organization under the United Nations in 1957, the IAEA is the only organization within the UN system with expertise in nuclear technologies. The IAEA's unique specialist laboratories help transfer knowledge and expertise to IAEA Member States in areas such as human health, food, water, industry and the environment.

The IAEA also serves as the global platform for strengthening nuclear security. The IAEA has established the Nuclear Security Series of international consensus guidance publications on nuclear security. The IAEA's work also focuses on helping to minimize the risk of nuclear and other radioactive material falling into the hands of terrorists and criminals, or of nuclear facilities being subjected to malicious acts.

The IAEA safety standards provide a system of fundamental safety principles and reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from the harmful effects of ionizing radiation. The IAEA safety standards have been developed for all types of nuclear facilities and activities that serve peaceful purposes, as well as for protective actions to reduce existing radiation risks.

The IAEA also verifies through its inspection system that Member States comply with their commitments under the Nuclear Non-Proliferation Treaty and other non-proliferation agreements to use nuclear material and facilities only for peaceful purposes.

The IAEA's work is multi-faceted and engages a wide variety of partners at the national, regional and international levels. IAEA programmes and budgets are set through decisions of its policymaking bodies — the 35-member Board of Governors and the General Conference of all Member States.

The IAEA is headquartered at the Vienna International Centre. Field and liaison offices are located in Geneva, New York, Tokyo and Toronto. The IAEA operates scientific laboratories in Monaco, Seibersdorf and Vienna. In addition, the IAEA supports and provides funding to the Abdus Salam International Centre for Theoretical Physics, in Trieste, Italy.

A decade of action on cancer control

By Cornel Feruta, Acting Director General, IAEA

Cancer was responsible for the death of nearly 10 million people last year. The number of cancer-related deaths is on the rise, and developing countries are particularly hard hit.

For many years, the IAEA has worked to improve access to nuclear medicine — including diagnostic imaging — radiotherapy and dosimetry in developing countries. During the last ten years, under the leadership of late Director General Yukiya Amano, helping countries to tackle the cancer burden became one of the priority areas of the Agency. Supporting countries in offering comprehensive cancer care and improved radiotherapy services to an increasing number of patients became a key strategic goal of the IAEA.

While there are still close to 60 countries where less than a quarter of patients have access to radiotherapy, access has increased significantly in at least 20 developing countries over the last five years.

Some of these countries benefited from IAEA support. Our focus is on transferring knowledge and expertise. We provide training to radiation oncologists, medical physicists, radiologists and other professionals. We also help countries to acquire equipment.

The IAEA helps to ensure patient safety through quality control services. We have conducted over 13 500 dosimetry audits in the last 50 years, helping more than 2300 institutions around the world to ensure that patients receive exactly the right doses of radiation.

In 2015, world leaders adopted the United Nations Sustainable Development Goals, which include a key target to reduce the number of deaths from non-communicable diseases, like cancer, by one third by 2030. Nuclear science and technology can make a significant contribution to the achievement of this goal.

This edition of the *IAEA Bulletin* takes a closer look at radiation for cancer control throughout the world and the role of the IAEA. It provides an overview of cancer — its biology, diagnostics and treatment (page 4) — and highlights major recent advances such as image guided brachytherapy (page 10) and theranostics (page 8), including the production of new kinds of radiopharmaceuticals (page 6).

While radiation has been pivotal in how we control cancer, safety is of paramount importance to its effective use. A network of dosimetry laboratories coordinated by the IAEA and the World Health Organization is helping experts to ensure that radiation doses reliably meet international standards and are both safe and effective (page 27). IAEA safety standards play a central role in helping health authorities set up cancer care services (page 12). Innovative and cost-effective educational tools developed by the IAEA help countries to move beyond limitations of geography and funding to build up a highly trained national pool of specialists such as radiation oncologists and medical physicists (page 24).

Access to cancer care requires the establishment of effective national cancer control systems. Some countries work with the IAEA to adopt their laws and regulations (page 16), while others seek assistance with developing so-called ‘bankable documents’ that enable them to raise funding from lending institutions (page 18). Many countries also turn to the IAEA for training, equipment and expertise (page 22).

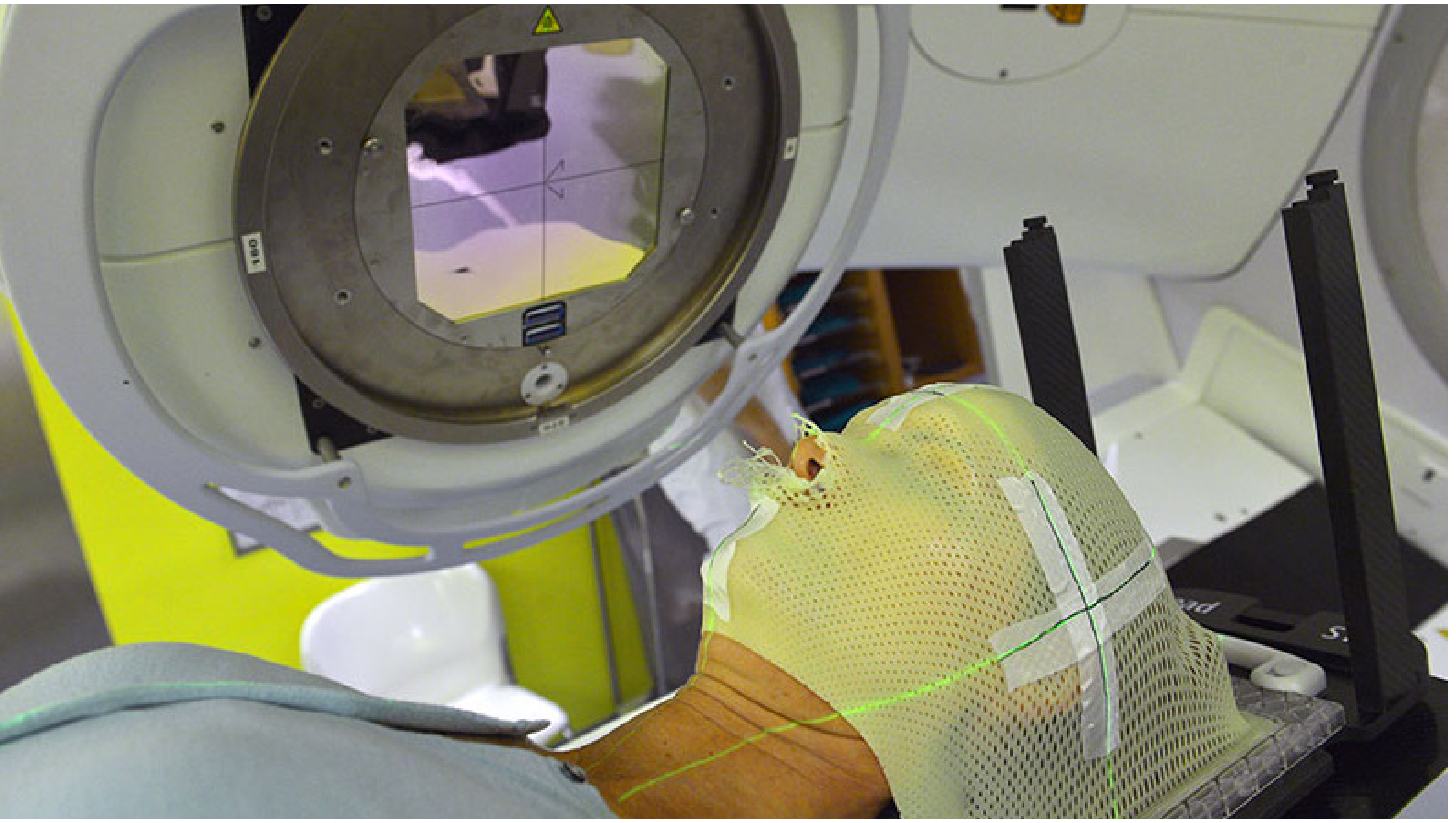
The 2019 Scientific Forum in September takes stock of the IAEA’s contribution to cancer control in the last decade. In four sessions over two days, leading scientists and experts from around the world, as well as IAEA experts, will review successes and challenges related to the setting up and delivery of nuclear and radiation medicine to fight a growing cancer burden. I invite you to follow the proceedings online: www.iaea.org/scientific-forum.

“Supporting countries in offering comprehensive cancer care and improved radiotherapy services to an increasing number of patients became a key strategic goal of the IAEA.”

—Cornel Feruta,
Acting Director General, IAEA

Cancer, nuclear medicine, radiation therapy and biology
An overview

By Nicole Jawerth



A radiotherapy mask keeps a patient's head still to ensure radiation consistently and accurately hits the precise target area during treatment.
(Photo: D. Calma/IAEA)

Cancers once considered unmanageable and fatal can now be diagnosed earlier and treated more effectively using nuclear medicine and radiation therapy, giving patients a better quality of life and, for many, a significant possibility of being cured. These developments can be attributed to advances in research and innovations in technology, which are becoming increasingly accessible.

But cancer remains a disease that is on the rise globally, having claimed the lives of 9.6 million people in 2018, a number that is expected to increase, with an estimated 16.3 million deaths predicted worldwide in 2040.

Cancer occurs when cells in the body grow and divide abnormally and uncontrollably, often forming clusters called tumours. Tumours can be diagnosed using small amounts of radiation and then treated with higher doses. Confirmation of the type of tumour, as well as of its size, location and extent of spread, is essential to selecting the appropriate treatment approach, such as surgery, radiotherapy, chemotherapy or immunotherapy, that is used either alone or in combination. When radiotherapy is appropriate, it is necessary to select the dose required carefully and to deliver it to the tumour with accurately calibrated equipment to maximize the effectiveness of the process while minimizing harm. The science of measuring, calculating and assessing absorbed doses of radiation is called dosimetry (see page 14).

Nuclear medicine

Nuclear medicine is a branch of medicine that involves the use of radiopharmaceuticals to diagnose and, in some cases, treat diseases such as cancer.

Radiopharmaceuticals are selected based on the location and type of cancer to be evaluated, and whether they are to be used for diagnosis, treatment or both. The radiopharmaceutical is then injected, inhaled or ingested into a patient’s body. Once inside the body, it seeks out and then gathers near or inside the cancer cells, allowing for the evaluation of the tumour location or the delivery of the targeted radiation. Over a known period of time, the radiopharmaceutical loses its radioactivity.

For diagnosis, a radiopharmaceutical with very small amounts of radioactive material, termed a ‘tracer,’ is introduced into the body. Once it has collected in or near the cancer cells, a specialized camera is used to detect the radiation that is released, which is then used to create precise images of what is happening in the patient’s body. These images help the healthcare team to understand the patient’s condition and plan treatment. Images may be taken throughout the cancer care process to monitor the disease and adjust care accordingly.

For treatment, radiopharmaceuticals with higher amounts of radioactive material are selected. The tracer accumulates and delivers the radiation to the cancer cells, where the radiation damages and kills them.

In some cases, radiopharmaceuticals are used for both diagnosis and treatment. This is called theranostics and is one of the latest advances in cancer diagnosis and treatment (see page 8).

Radiation therapy

Radiation therapy, or radiotherapy, is carried out by a team of experts in radiation oncology, medical physics and radiation therapy technology who are trained to target ionizing radiation at cancer cells. Depending on the type and location of the cancer, the team may use external sources of radiation, such as cobalt-60, from a machine that emits radiation, or a linear accelerator that delivers photon radiation using electricity. They may also place radiation sources directly next to or inside of the tumour, which is known as brachytherapy. One of the latest advances in radiotherapy is image guided brachytherapy (see page 10).

Radiotherapy involves carefully selecting doses of radiation that are strong enough to effectively damage DNA in the cancer cells, while minimizing harm to healthy cells. Cancer cells often cannot repair damage to their DNA after small doses of radiation as efficiently as any normal healthy cells that are in the treatment area. To take advantage of this biological difference between cancerous and healthy cells, a course of radiotherapy may be divided into multiple small doses over several weeks, giving the best chance of destroying the tumour with the fewest side effects. Understanding the parameters for determining the best treatment regimen in individual situations is part of the science called radiobiology.

Over 14 million people worldwide are diagnosed with cancer each year. Around half of all cancer patients receive radiotherapy at some point during their treatment, and it is often used in combination with other methods, such as surgery and chemotherapy.

The IAEA has worked for over 60 years to promote the use of and advances in radiation medicine in controlling cancer. It supports countries worldwide in developing and maintaining their national cancer care services by training and educating professionals, equipping facilities and facilitating the transfer of scientific know-how between experts (see page 22). The IAEA also assists with planning, setting up and reviewing national cancer control plans, including resource mobilization for projects (see page 18).

Radiopharmaceuticals are medical drugs containing radioactive material and can be used for diagnosis or treatment purposes.
(Photo: S. Slavchev/IAEA)

Cancer-treating radiopharmaceuticals gain ground in Asia thanks to IAEA

By Miklos Gaspar

A specialist at INMOL in Lahore, Pakistan checks the quality of radiopharmaceuticals before they are used on patients.
(Photo: INMOL)

Radiopharmaceuticals — medical drugs containing radioactive materials — used for treating cancer have taken root in healthcare systems in many parts of the world, but they are only now beginning to gain ground in developing countries. Thanks in part to an IAEA technical cooperation project, these drugs, which can increase patients' life expectancy, are reaching more countries in Asia. This includes lutetium-177 (Lu-177)-DOTATATE — a radiopharmaceutical for treating neuroendocrine tumours, which are deadly gastrointestinal cancers. The drug has been successfully produced and is now in clinical use, through the project, in Iran, Jordan, Pakistan and Thailand.

As part of the three-year project on radiopharmaceutical production, which ended in December 2018, the IAEA provided support to radiochemists, radiopharmacists and technologists from 20 countries. They received training in the development, quality control and use of therapeutic radiopharmaceuticals. Of the participating countries, 4 are already using these radiopharmaceuticals in clinical practice, and over 100 patients have received treatment.

"This project has had a great impact on improving the management of cancer patients by introducing new treatment options that had not been available previously, particularly given the absence or limited value of other treatment modalities like chemotherapy and radiotherapy in certain cases," said Amer Al-Hourani, radiopharmacist at the Jordanian Royal Medical Services institute, where ten patients have so far been treated with the radiopharmaceuticals.

"This project has had a great impact on improving the management of cancer patients by introducing new treatment options that had not been available previously."

—Amer Al-Hourani, radiopharmacist, Jordanian Royal Medical Services Institute

Targeted therapeutic radiopharmaceuticals

Radiopharmaceuticals are medical drugs made with radioisotopes usually linked to biological molecules that can target specific organs, tissues or cells within the human body. Since the early 1950s, radiopharmaceuticals have become more commonly used in the diagnosis of various diseases and, to a lesser extent, in the treatment. With recent advances in nuclear medicine research, new radionuclides and radiopharmaceuticals have been developed with greater targeting potential, which is expanding the range of possibilities for customizing and combining radiopharmaceutical diagnostic and treatment options.

The main therapeutic drug that the project participants learned to develop and use is Lu-177-DOTATATE. Targeted therapeutic radiopharmaceuticals, like

Lu-177-DOTATATE, mostly consist of biomolecules such as peptides (amino acids linked in a certain order), antibodies and proteins that are chemically radiolabelled with beta emitting radionuclides, such as Lu-177.

Lu-177 is the radioisotope of choice because, after it is manufactured in a research reactor, it survives long enough to be linked, or labelled, to the right biological molecule, taken to the hospital and then injected into the patient.

Once inside the body, the biological molecule carries the Lu-177 quickly and directly to the tumour, where it concentrates and then bombards the tumour with radiation. Since the molecule targets only the cancer cells, and Lu-177 has a limited lifespan, this technique maximizes treatment of the cancer while minimizing harm to healthy cells in the body. It is most commonly used to treat tumours in the stomach, intestine, prostate and pancreas.

The targeting ability of certain radiopharmaceuticals, like Lu-177-DOTATATE, makes them a useful treatment option for cancers that have spread to several organs through the lymphatic system or the bloodstream. In such cases, removal of the original tumour site with surgery is insufficient, and radiotherapy would require exposing substantial parts of the body to radiation, putting the patient at risk. They are also one of the preferred treatment methods for patients whose immune systems are too weak for chemotherapy, which is a treatment type that affects the patient's whole body.

Treating patients, extending life expectancy

Along with developing and adopting Lu-177-DOTATATE cancer care services, several countries involved in the project have also been expanding their theranostics capacities. Theranostics is a cancer care method that combines the use of radiopharmaceuticals for diagnosis and treatment (learn more on page 8).

In Pakistan, for example, 15 doctors have been trained and equipped, in part through the IAEA, to help set up the country's theranostic radiopharmaceutical services. Each year, there are more than 170 000 new cancer cases in Pakistan.

"The launching of theranostic facilities at INMOL, for the very first time in Pakistan, is a landmark achievement," said Irfan Ullah Khan, Deputy Chief Scientist at the Institute of Nuclear Medicine and Oncology Lahore (INMOL) in Pakistan. "Although the [IAEA] project has ended, we [now] have the technology in Pakistan, so we are continuing the successful treatment of patients. This has really changed patients' lives."

A three-year follow-up IAEA project, launched in early 2019 as a second phase of support, assists the countries involved in the original project in continuing and completing licensing applications and the full operationalization of the method, said Mykola Kurylchyk, the Project Management Officer at the IAEA in charge of this initiative.

"Any country with a research reactor can, in principle, produce these isotopes, and the IAEA is committed to making the technology available to all interested countries," Kurylchyk said.

From beta to alpha

The IAEA project also aims to help countries lay the foundation for the use of alpha emitters as radiopharmaceuticals.

Radiopharmaceuticals using radioactive material undergoing alpha decay — emitting a helium-4 isotope of two protons and two neutrons — rather than beta decay are more effective for cancer treatment but harder to produce. Alpha particles have higher levels of energy transfer and a shorter range. They can therefore better penetrate cancer cells and are up to ten times more effective in destroying these cells than beta particles.

"After countries have learned to produce and administer beta emitters, the production and use of alpha emitters is one of the next steps for even more effective and targeted treatment," said Amir Jalilian, a chemist specializing in radioisotopes and radiopharmaceuticals at the IAEA.

The IAEA has helped experts from Kuwait and Thailand to acquire this more advanced technique, and two hospitals, one in each of these countries, are now using it for treatment. Specialists in some of the other participating countries aim to start the production and use of alpha emitters by 2021, thanks to the follow-up technical cooperation project.

Seeing cancer cells, killing cancer cells
Theranostics for diagnostics and treatment

By Elisa Mattar and Nicole Jawerth

Using molecules to safely carry radioactive materials inside the human body is helping physicians get more accurate images of tumours and more effectively eliminate cancer cells. This method of combining therapeutic and diagnostic uses of radiopharmaceuticals is called theranostics. It's one of the latest advances in cancer care and one of several methods the IAEA is helping to bring to patients in countries worldwide through technology transfer and capacity building.

"Theranostics has the potential to change the idea of cancer treatment. It is a very efficient approach that allows you to see what you treat and treat what you see."

—Mohamad Haidar, Associate Professor of Clinical Radiology, American University of Beirut Medical Center, Lebanon

"Theranostics has the potential to change the idea of cancer treatment," said Mohamad Haidar, Associate Professor of Clinical Radiology in the Department of Radiology at the American University of Beirut Medical Center in Lebanon. "It is a very efficient approach that allows you to see what you treat and treat what you see. The result is a better quality of life, improved life expectancy and minimal side effects compared to other treatments, like chemotherapy."

While it has been used for more than 70 years for a few specific diseases, such as thyroid cancer, theranostics has only started to take off in the last few decades; advances in medicine and technology have led to the development of new radiopharmaceuticals and medical equipment, opening the door for theranostics to be used for fighting cancers of the prostate, liver, gastrointestinal system and nervous system, among others. This includes treatment of neuroendocrine tumours using a radiopharmaceutical called lutetium-177 (Lu-177)-DOTATATE (learn more about this on page 6).

Although theranostics offers the possibility to improve patient outcomes, it is not yet widely available; the method requires different skills and facilities from those readily available for other cancer care methods, such as radiotherapy, chemotherapy and surgery.

"Through IAEA support, countries across the world are setting up facilities and receiving training in nuclear medicine and radiotherapy and, when ready, safely transitioning to personalized medicine and advanced methods such as theranostics and stereotactic body radiation therapy (SBRT)," said May Abdel-Wahab, Director of the IAEA's Division of Human Health.

How theranostics works

In some ways, theranostics works like other medical drugs by interacting with protein molecules, which are called receptors, on the walls of cells. These receptors can bind with outside molecules, such as hormones and drugs, which activate the receptors and generate a biochemical or electric signal that tells the cell what to do, such as to stop producing the chemicals that signal pain to the brain.

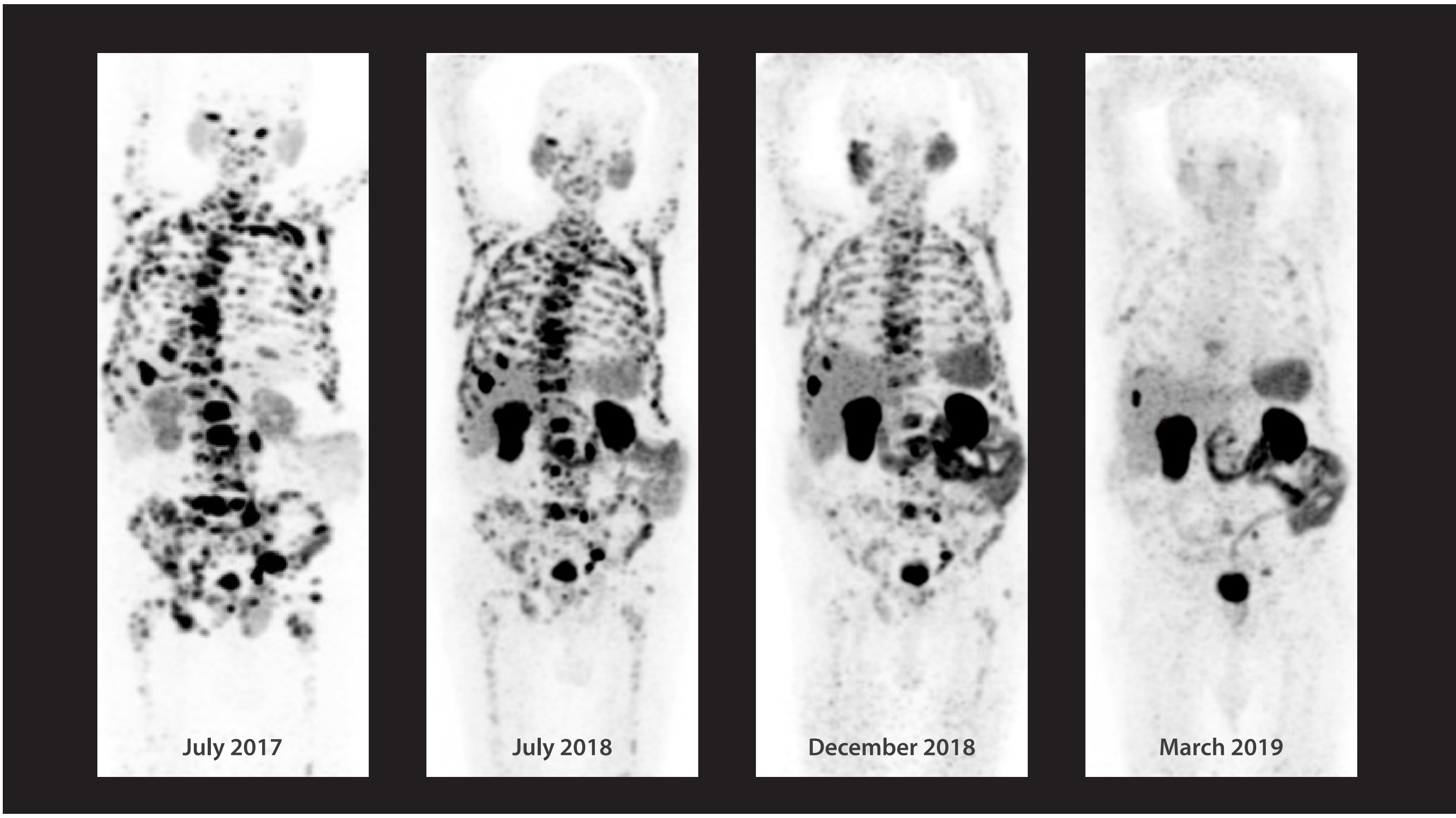
Different molecules are attracted to different types of receptors. By knowing which molecules go with which receptors, medicines can be created that link the right molecules with, for example, pain-blocking chemicals that the molecules then carry to the right cell receptors to, say, stop a headache.

This is the same with radiopharmaceuticals; radioactive materials are linked to molecules that have been selected based on how they interact with the body when certain cancers are present. The molecules then carry the radioactive materials to the target tumour for diagnostic imaging or treatment. As the healthy cells do not have the same receptors as the target cells, the radiopharmaceuticals bypass them and do not damage them.

"With an approach that focuses on the specific needs of each patient, theranostics provides a transition from conventional medicine to personalized and precision medicine; the result is the selection of the right therapy for the right patient," said Diana Paez, Head of the IAEA's Nuclear Medicine and Diagnostic Imaging Section.

First you see, then you treat

For diagnostic imaging, radiopharmaceuticals with small amounts of radioactive material are either injected, ingested or inhaled, and



Progress of theranostics on an 82-year-old patient with prostate cancer that spread to lymph nodes and bones. Condition at beginning of theranostics (very left) to near complete remission (very right).

(Photo: American University of Beirut Medical Center)

then transported through the body to the target area. Once the drug gathers around or inside the target cells, the tiny amount of radiation emitted by the radiopharmaceutical is scanned and detected by a special camera. This then produces images of that area of the body.

Following the results of diagnostic imaging, the physician determines which course of treatment is best for the patient. If theranostics is suitable, a radiopharmaceutical is selected for that patient, and the exact amount of radiation needed for treatment is determined — the dose depends on the type and size of the tumour, as well as the patient's age and gender, the severity of the case and the organ targeted. Once the radiopharmaceutical collects around or inside the cancer cells, the radiation it emits damages and kills the cancer cells, while harm to the surrounding healthy cells is minimized. Patients usually have several treatment sessions, and further diagnostic images are taken to monitor progress.

"We have seen responses to theranostic treatment that were nearly impossible with other kinds of treatment," Haidar said. While for now they are only treating a handful of patients each year, Haidar and his team of 15 specialists in Lebanon have already begun seeing significant results.

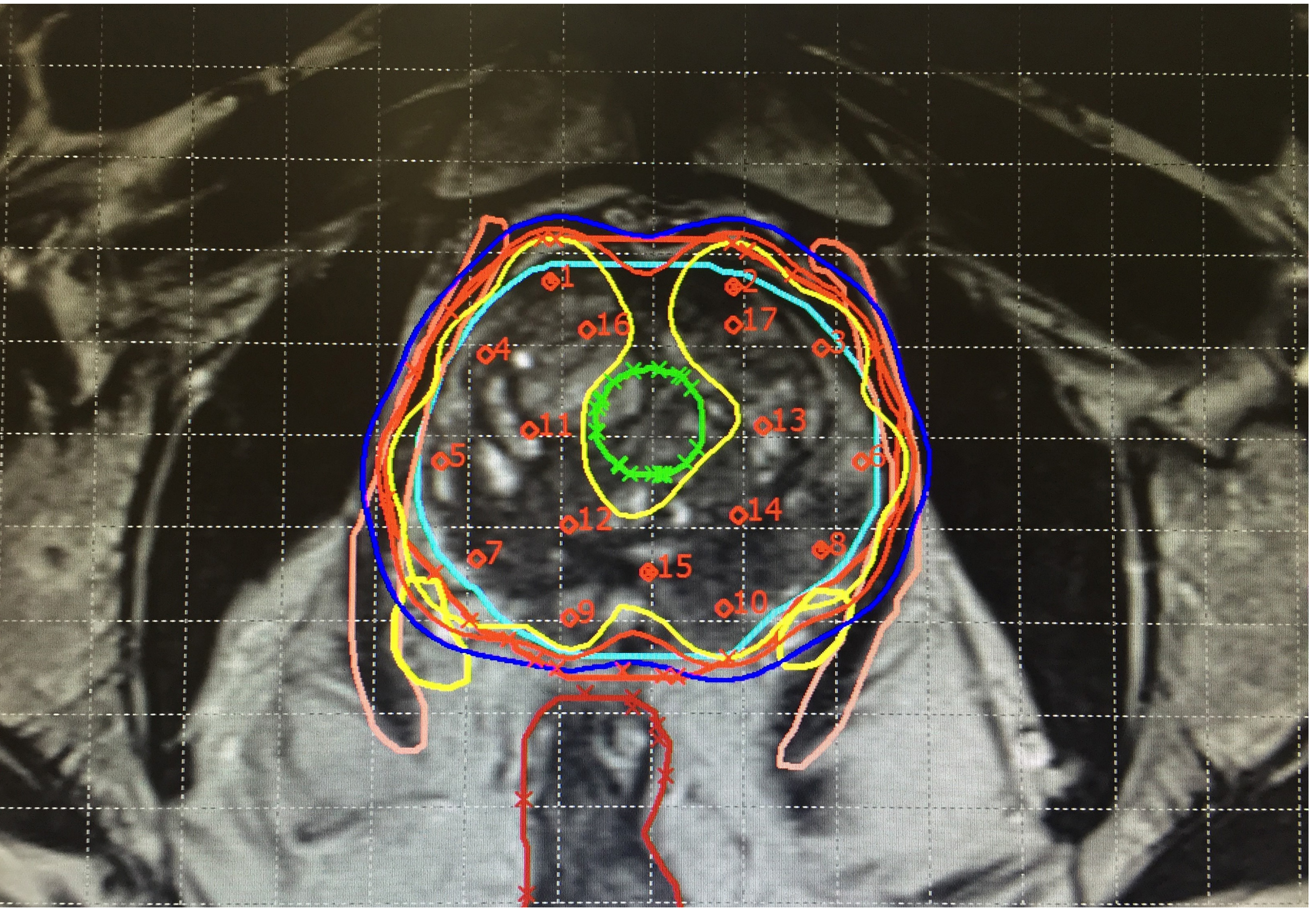
"For example, I had an 82-year-old patient with prostate cancer that had spread to the lymph nodes and bones, and after failed treatment using other methods, we switched to theranostics," he said. "After two doses with lutetium-177 prostate-specific membrane antigen (PSMA), we saw a significant drop in tumour lesions, and then, after an additional dose with another radiopharmaceutical, actitium-255 PSMA, near complete remission."

These are just preliminary findings, explained Haidar, and there is still much work to be done in the field of thearonstics to more fully understand its impact and potential scope. He and his team plan to continue their work with the IAEA to advance their research, refine their skills and help train others in the region. The IAEA, through its technical cooperation programme, has provided training and donated equipment to Lebanon to support the development of its cancer care services.

"In the future, we could see an expansion of theranostics into use for breast and lung cancers," he said. "If we can find a molecule that works specifically for these very common cancers, it could have a big impact on cancer survival rates and quality of life."

A new vision for cancer treatment: image guided brachytherapy

By Elisa Mattar



Detailed medical images help health professionals distinguish between tumours, healthy tissue and organs to ensure radiation sources are correctly targeted.
(Photo: Auna Oncosalud)

Advances in technology have helped to pave the way for techniques like image guided brachytherapy (IGBT) that are leading to better outcomes and offering a better quality of life for patients.

"IGBT is a highly personalized and fine-tuned method for treating cancer that can help improve survival rates in many types of cancer, while lowering the risk of complications," said Gustavo Sarria Bardales, Medical Director of the Radiation Therapy Department at Auna Oncosalud hospital in Peru. "With the rise in cancer cases worldwide, the use of IGBT offers safe, effective and quality treatment against some prevalent cancers, such as breast, prostate and cervical cancers. Further developing and implementing this technology is a great opportunity to expand access for more patients and provide them with effective care."

While brachytherapy — a form of internal radiation treatment using radioactive sources — has been a common treatment for many cancers for more than 100 years, IGBT has only in the last 15 years been possible thanks to advances in medical imaging, treatment planning and dose delivery.

IGBT is designed to maximize the radiation dose to kill cancer cells while minimizing the exposure of the surrounding healthy cells. It uses detailed 3D medical images to capture organ volume changes in order to tailor and optimize brachytherapy for patients' needs.

The images show the exact size and location of a tumour and relevant organs in order for the healthcare team to precisely plan and safely place radioactive sources directly next to or inside a tumour for treatment. This placement can either be temporary, using a removable applicator containing the sources, or permanent, using sources called seeds that remain indefinitely inside the body; over time, the seeds lose their radioactivity and become harmless.

For certain cancer types, such as cervical cancer, IGBT is combined with external beam radiotherapy, while, for others, such as breast and prostate cancers, it can be used as an exclusive treatment. With IGBT, higher doses of radiation can be used for targeting a tumour directly, meaning healthy tissues receive a lower dose of radiation, as the sources are placed directly in or next to a tumour.

However, placing the sources inside a patient's body requires expertise in various disciplines, such as surgery, imaging and contouring, and treatment planning, explained Alfredo Polo Rubio, a radiation oncologist at the IAEA. "It is not a 'one-size-fits-all' procedure, since each patient's body and each tumour is different, and brachytherapy is a kind of personalized treatment. Combining brachytherapy with imaging gives the healthcare team a clearer view of the tumour and the surrounding organs and facilitates the placement of the radiation sources, assessment of tumour response and more accurate adjustment of radiation doses."

Although IGBT is considered cost-effective thanks to its high success rate, it remains costly. The technique requires expensive software and hardware to complete the personalized treatment plan, as well as a highly qualified team of specialists, from oncologists to dosimetrists and radiation therapists, and, in some cases, surgeons, to assist with the placement of applicators in the patient's body.

Many countries worldwide are working with the IAEA to develop their cancer treatment services and, when they are ready, to adopt innovative methods, such as IGBT. Through IAEA technical cooperation and coordinated research projects, experts receive training and equipment, as well as access to professional networks to boost their expertise. The IAEA has also produced guidelines and technical documents to support the implementation of IGBT and to guide professionals in the transition from simple to more complex techniques.

Some countries, such as Peru, are now moving towards IGBT to help manage the growing burden of cancer.

"Cancer is quickly becoming the first cause of death among Peruvians and is continuing to increase," said Sarria Bardales. Around 66 000 people in Peru are diagnosed with cancer each year. "The health system is not prepared for such an epidemiological transition, so new solutions like IGBT need to be adopted."

Peru has worked with the IAEA for more than 30 years to build up its cancer care services. In the last five years, this collaboration has included building Peru's human resources capacity in IGBT and connecting Peruvian professionals with international networks and experts in this particular area.

"We used to be limited to conventional 2D and 3D brachytherapy. Now we have begun using IGBT and are waiting to see the full impact of its use," Sarria Bardales said. "We expect that, in the next decade, IGBT will become a more standard treatment for cancer patients, as it's a more personalized approach and has a higher rate of success, making it a more cost-effective and adequate treatment method for various types of cancer."

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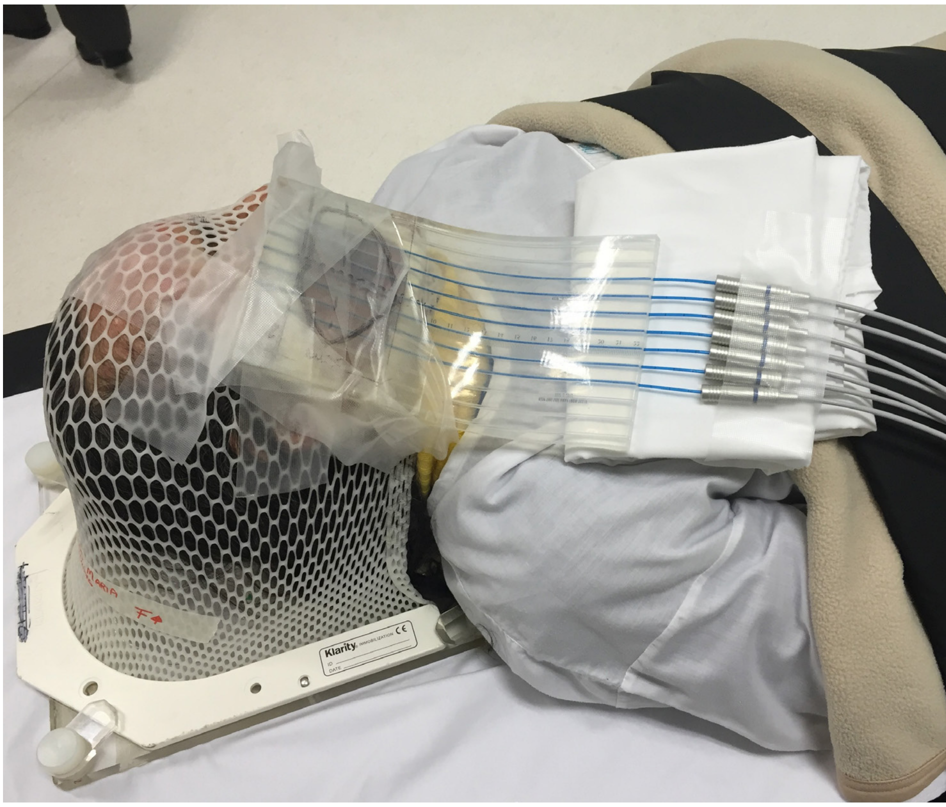
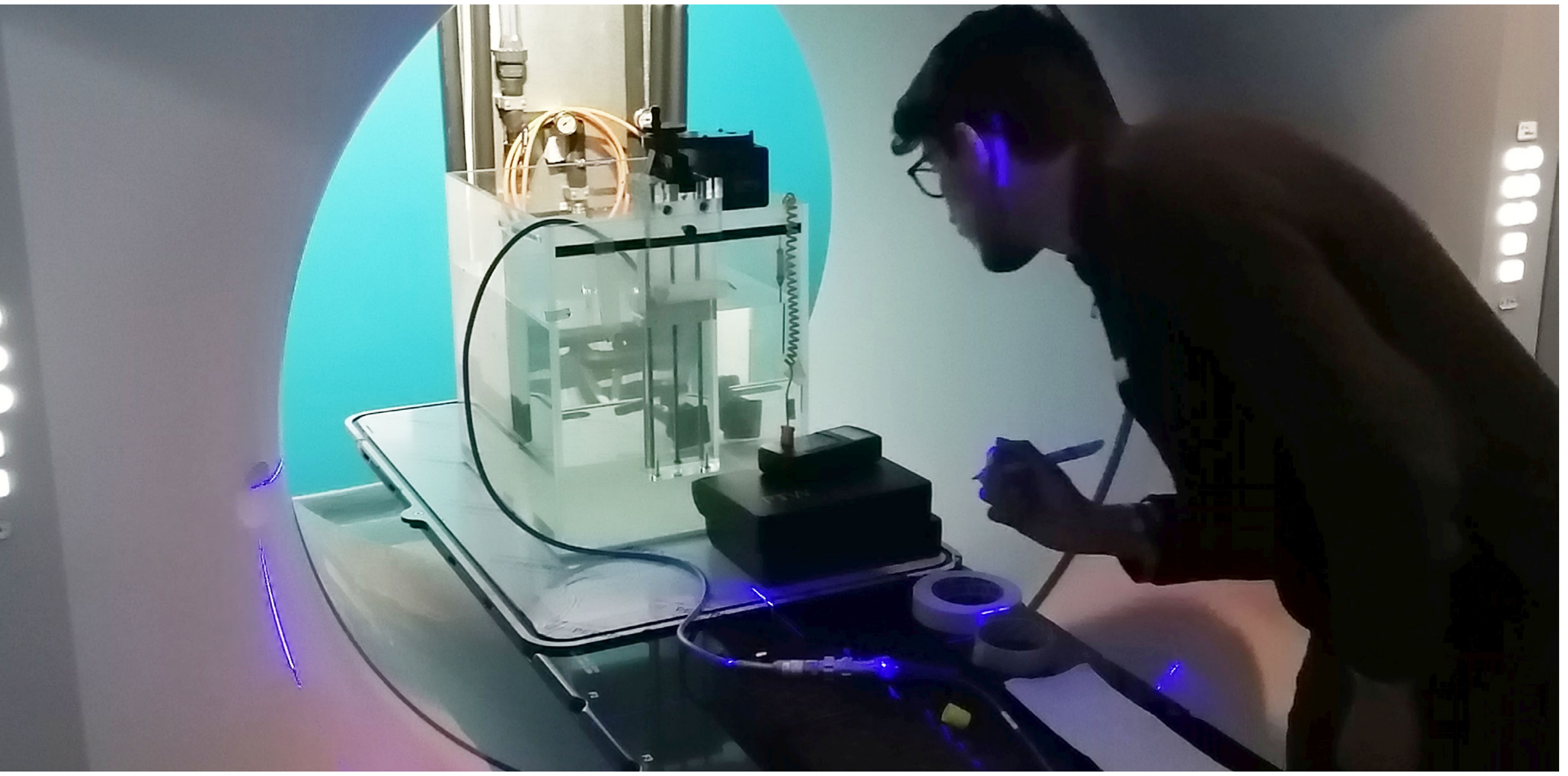


Brachytherapy involves placing radioactive sources inside or on the body, which can be done with tools such as wires, tubes or needles.

(Photo: Auna Oncosalud)

Safely embracing the growing power of radiotherapy

By Nathalie Mikhailova



Specialist preparing a dosimetry setup for ensuring radiation doses are safe and accurate.
(Photo: Tygerberg Hospital)

Advances in radiotherapy technology are making cancer treatment more powerful, more precise and easier to deliver. While this means new benefits for patients, it also opens the door to new safety challenges.

“Introducing new technology doesn’t come without its risks. The issue with each new machine is the possibility of making errors because radiotherapy professionals are still learning how the machine really works. They can’t simply trust that it will do what it should do. They need to verify it, ideally through elaborate testing,” said Christoph Trauernicht, Head of the Medical Physics Division at Tygerberg Hospital and Senior Lecturer at Stellenbosch University in Cape Town.

Since the early 20th century, radiation has played a growing and increasingly indispensable role in cancer treatment. Radiation therapy, or radiotherapy, involves targeting very precise doses of radiation at tumours to kill cancer cells. This can be done with external beams of radiation, such as X-rays, gamma rays or electrons, or by using radioactive sources placed inside or on a patient.

Today, the most commonly used machine to treat cancer with radiation is the linear accelerator, or linac for short. There are more than 12 000 linacs in operation in hospitals worldwide, and their prevalence is only expected to increase.

“As technology continues to advance, it becomes even more important that radiotherapy is provided safely. New technology allows for more automation and complex optimization of radiation doses but also requires additional professional training and different safety systems to ensure that patients are treated correctly,” said Debbie Gilley, Radiation Protection Specialist at the IAEA.

About 50% of cancer patients receive radiation therapy at some point during their treatment. As the number of new cancer cases continues to rise, so will the need for radiotherapy. This also means medical physicists and resources for their training in radiation protection will continue to play a growing role in ensuring the safe and effective use of radiation in medicine.

The IAEA supports countries worldwide in adapting to evolving technologies and safety needs. It has several initiatives in place to strengthen the field of medical physics through the publication of guidelines and factsheets, organization of seminars for health professionals and decision makers, and collaboration with professional societies.

This work is guided by the IAEA's overall efforts to improve access to quality radiotherapy, which includes assisting countries in applying IAEA safety standards on radiation safety. These standards have been developed in close cooperation with governments and organizations around the world and are periodically revised and updated by experts to account for technological advances and new knowledge.

The IAEA has supported the training of radiation health professionals in Africa so that they can safely and effectively embrace new machines in order to expand imaging and radiotherapy services and to shrink gaps in access to care.

"South Africa is a varied landscape when it comes to patients' access to radiotherapy services. There's a large disparity between the public and private sector, with some public sector patients having to wait several months to receive treatment. That's something we're working on changing," said Trauernicht.

Tygerberg Hospital, one of the biggest specialist hospitals in South Africa, treats roughly 1600 patients with radiotherapy every year. The hospital acquired its fourth linac in 2019. Every linac that arrives at the facility must, in line with safety regulations, go through a process of acceptance testing, commissioning and licensing before it is used on patients. This includes the installation of the machine in a specially designed room, commissioning of the treatment planning system and the training of staff.

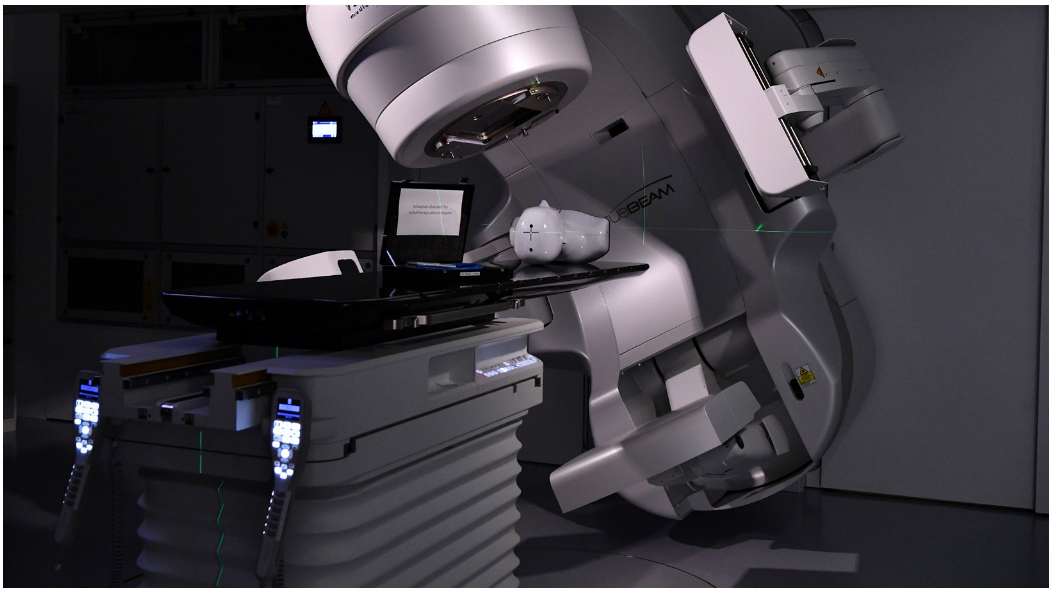
"By acquiring new radiotherapy machines, among other changes to our services, we're hoping to shorten waiting times, possibly shorten treatment times and therefore allow for a quicker throughput of patients. Of course, adequate staffing is also needed," Trauernicht said.

But advancing radiotherapy itself is not the only aspect of radiation safety, added Trauernicht. "A strong national regulatory body is key to safety implementation at the institutional level. In South Africa, we have national societies for medical physics, radiography, oncology, radiology and nuclear medicine physicians, which all play a very important role in ensuring safety. They are trying to further build awareness related regulations around the country."

South Africa continues to refine its regulatory framework to ensure close adherence to the IAEA's safety standards. Current regulations stipulate that medical physicists must be involved in radiotherapy and that safety programmes should be developed and implemented. In parallel, regional activities are gaining momentum through efforts such as the AFROSAFE campaign to increase radiation protection education and the efforts of the Federation of African Medical Physics Organisations towards the accreditation of medical physics training programmes.

"Introducing new technology doesn't come without its risks…They can't simply trust that it will do what it should do. They need to verify it, ideally through elaborate testing."

—Christoph Trauernicht, Head, Medical Physics Division, Tygerberg Hospital, South Africa



A linear accelerator, or linac, is a machine that produces radiation using electricity.

(Photo: D. Calma/IAEA)

Keeping radiotherapy safe and effective

Q&A with leading dosimetry expert

By Nathalie Mikhailova

Radiation is key to the fight against cancer, helping to save countless lives worldwide. But too little radiation can mean ineffective treatment, while too much can cause harm. That's where dosimetry comes in.

Dosimetry is the science of measuring, calculating and assessing absorbed doses of radiation. It is used by medical physicists to ensure that machines delivering radiation to patients are accurate and properly calibrated. This is critical to patient safety.

So, what goes into dosimetry? How do we ensure it is reliable? To find out more, we sat down with David Followill, Director of Imaging and Radiation Oncology Core (IROC) at the Houston Quality Assurance Center at the University of Texas MD Anderson Cancer Center, USA. IROC Houston is home to the largest dosimetry quality assurance centre in the world, which has assisted 2200 radiotherapy centres in 58 countries. As Director of IROC Houston and with over 20 years of experience in dosimetry, Followill has devoted his career to ensuring the accurate, consistent and safe delivery of radiotherapy to cancer patients.

Q: Dosimetry is used to keep radiotherapy safe and effective, but how do we ensure dosimetry itself is reliable?

A: Humans make mistakes. These can be either an individual mistake with one X-ray or electron beam, or a systemic mistake that affects all the beams involved in radiation delivery. These kinds of mistakes can go unnoticed unless someone is double-checking the doses. The dosimetry audits we perform at IROC Houston, and those done by the IAEA, as well as other institutions around the world, are vital to ensuring accurate and consistent doses.

Audits are independent peer reviews of a clinic's radiotherapy treatments. Clinics are provided with passive dosimeters (devices designed to measure an absorbed dose of radiation), which the clinic irradiates and sends back to the auditing programme to be evaluated. The audit results confirm if clinics are measuring doses correctly and help them identify and correct any potential mistakes. Getting others to take a second look means they can be confident in the accuracy of their dosimetry measurements.

"Since the number of radiation therapy machines worldwide is increasing, we're always looking for ways to improve our efficiency and workflow process."

—David Followill, Director of Imaging and Radiation Oncology Core (IROC), Houston Quality Assurance Center, University of Texas

Q: What do you think is needed to build and maintain a sound dosimetry programme at an institution?

A: Any clinic's dosimetry programme needs to start with the robust training of medical physicists. Medical physicists need to not only know how to use the dosimetry equipment but to truly understand how it works to be able to judge if readings are correct or not. They need to always be critical, constantly reviewing their information and be willing to admit if they have made a mistake.

Every clinic also needs reliable equipment that is continually calibrated and subject to quality assurance reviews, so that it produces accurate and consistent readings. With the help of additional educational courses and peer review papers, health professionals can continue to understand and overcome resource limitations. Only in these ways can clinics be sure that the patients are getting as accurate a dose as possible.

Q: How does international cooperation, such as between the IAEA and IROC Houston, improve dosimetry worldwide?

A: IROC Houston and the IAEA have been collaborating since the early 1980s and are probably the two largest entities that perform audits. Collectively, we monitor a lot of institutions worldwide, develop programmes for local hospitals, and exchange techniques and knowledge on how to best perform audits.

We also compare dosimetry measurements; we both irradiate the same dosimeters from each other's programmes to verify that we're getting the same dose measurements. We not only learn from each other, but also from the results we receive from local hospitals.

These exchanges give us confidence in our system and in the fact that we are putting out correct, precise values. They also allow us to uncover issues that may not have been discovered by individual clinics. In this way, we improve our ability to perform audits, understand why people make mistakes and improve the efficiency of our work. Since the number of radiation therapy machines worldwide is increasing, we're always looking for ways to improve our efficiency and workflow process.

Q: How is dosimetry advancing? What do you think the future holds for the field?

A: Advances are continually being made, but one increasingly common development is in devices that give us the total treatment delivery picture. This means we can use different dose measurement equipment that measures part of or the whole treatment immediately before a patient is treated. This end-to-end quality assurance dosimetry check goes through the whole process, from imaging to delivery of radiotherapy. This way we can, on the spot, double check the actual dose that is going to be delivered by the system before exposing a patient.

Nonetheless, you always have to make sure that the basic components to any radiation therapy programme are done correctly. We still rely very heavily on the simple water phantom (a physical model used for calibrations), ion chamber and electrometer system to take measurements. And in terms of audits, we're still doing the basics because we need something that's portable to transport between clinics. This type of dosimetry has been around for decades. It is the standard and is used widely.

A medical physicist sets up equipment during an on-site audit at a proton therapy center.

(Photo: J. Montgomery/MD Anderson Cancer Center)

The laws behind using radiation for cancer care: opening the door to treatment

By Laura Gil

When we hear the words "cancer treatment", images of doctors, hospitals and machines come to mind. But before the first machine is installed or the first patient is treated, the right laws and regulations should be in place. This can take years of preparation, and countries don't have to do it alone: the IAEA provides support to countries around the world in developing the necessary legal infrastructure, including nuclear laws, for the safe and secure use of radiation for cancer care.

"If we do not have a nuclear law, we cannot have a regulatory authority. And if we do not have a regulatory authority, we cannot offer nuclear medicine or radiotherapy and therefore cannot save cancer patients' lives."

—Nyane Moeti, Legal Officer, Ministry of Foreign Affairs and International Relations, Lesotho

"If we do not have a nuclear law, we cannot have a regulatory authority," said Nyane Moeti, Legal Officer for the Ministry of Foreign Affairs and International Relations in Lesotho. "And if we do not have a regulatory authority, we cannot offer nuclear medicine or radiotherapy and therefore cannot save cancer patients' lives."

Lesotho enacted its first nuclear law in 2018, with the support of the IAEA. This small country of 2.4 million people sends approximately 100 cancer patients a year to South Africa to be treated. With the new law in place and a regulatory body expected to be operational before the end of 2019, experts are now working on building a radiotherapy facility. They plan to have it up and running in three to four years, allowing these patients to be treated close to home.

"The law will help Lesotho in many ways," Moeti said. "It will allow us to cover all the radiotherapy regulations and will help us provide radiotherapy services in compliance with international best practices. In addition, with the law enacted, we can now regulate the use of radiation sources in health and other industries, such as mining or construction, ensuring the safety of users and the areas where these activities take place."

Having no national legal and regulatory framework to protect people and the environment restricts global suppliers from selling radioactive sources to a country.

"An adequate legal and regulatory framework is needed to guarantee the safe use of radiotherapy for the benefit of patients, while protecting workers," said Fanny Tonos Paniagua, a Legal Officer at the IAEA.

Countries need to set up or revise their national legislation when their existing framework is not in line with international standards for the protection of people and the environment. The first step in this case is to develop and adopt a nuclear law establishing a regulatory system of control over the use of nuclear technology. Once the nuclear law is enacted, the second step is to create a national regulatory framework, including the establishment of a regulatory body to ensure the development of general and technical regulations and, through licensing, inspection and enforcement actions, to verify that the legal system is being implemented when using radioactive sources in the country.

The IAEA offers legislative assistance in assessing, revising and drafting national laws. "Based on our experience working with countries, the process of drafting the necessary legislation should be started as early as possible to prevent delays in the implementation of national projects related to cancer treatment or other relevant areas," Tonos Paniagua said.

IAEA assistance

In the past 10 years, the IAEA has provided bilateral legislative assistance to 82 countries for adopting or revising the nuclear laws of these countries, out of which 29 have completed the process, and many others are in the final stages of doing so. In Jamaica, for example, the IAEA has been providing legal support since 2011.

"We need the right laws in place, first of all, to maintain and enforce the standards of safety and, second of all, to minimize the risk to workers, patients, and the environment," said Erica Boswell-Munroe, former Deputy Chief Parliamentary Counsel of Jamaica.

In March 2013, responding to a request from the Minister of Health of Jamaica, the IAEA sent a team of cancer control experts to conduct an in-depth assessment of the country's cancer control capacity and needs. The results of this mission, known as an imPACT Review, are supporting national efforts to develop a comprehensive national cancer control programme that includes laws and regulations.

Further developing a national cancer control programme is the aim of Jamaica's Ministry of Health. "We see the need to expand our cancer care services, as much as we see the need to finalize the laws and regulations that come with it," Boswell-Munroe said. "On more than one occasion, we were unable to import radiation sources because we didn't have the law in place and, therefore, were not able to grant the necessary authorizations."

In 2015, Jamaica passed the Nuclear Safety and Radiation Protection Act with the IAEA's support. The Act, among other things, sets out to protect people from exposure to ionizing radiation and monitor facilities using ionizing radiation and nuclear technology, as well as to facilitate Jamaica's compliance with international obligations.

The Act calls for the establishment of a national regulatory body to grant authorizations and establish operational standards, as well as to regulate and monitor activities, practices and facilities that make use of ionizing radiation and nuclear technology.

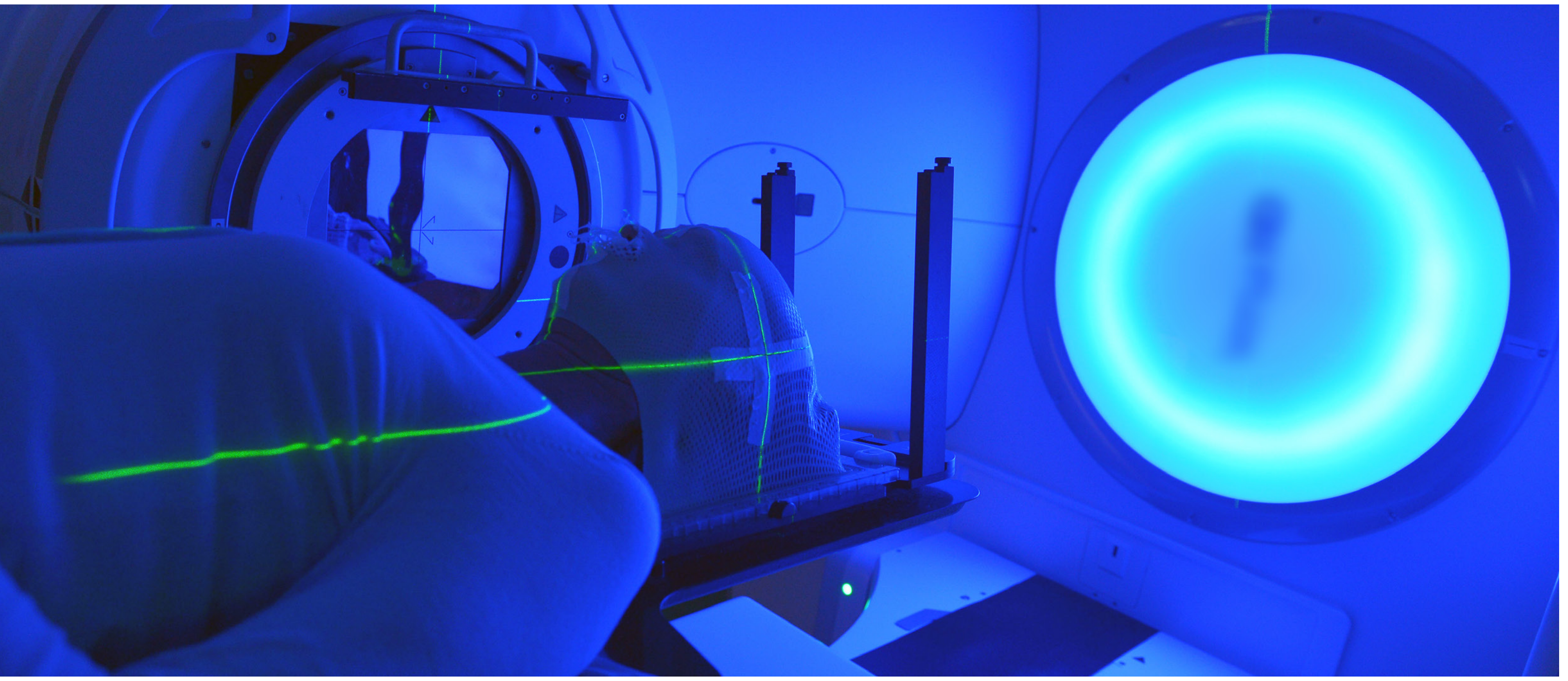
Jamaica is currently upgrading its Nuclear Medicine Centre at the University Hospital of the West Indies with the help of the IAEA's technical cooperation programme. Planned to be completed by 2021, the Centre is expected to become the country's only public nuclear medicine facility.

Delegates from Lesotho met with IAEA experts for a three-day meeting to discuss the country's first cancer facility. From left to right: Mamasiane Tieho, Principal Secretary for Lesotho's Ministry of Tourism, Environment, Tourism and Culture; and Shaukat Abdulrazak, Director of the Division for Africa in the IAEA's Department of Technical Cooperation

(Photo: J. Howlett/IAEA)

From plans to funding: bankable documents and Niger's first radiotherapy unit

By James Howlett



Radiotherapy is an important treatment option for patients. Niger plans to provide radiotherapy services to more than 600 patients a year.
(Photo: D. Calma/IAEA)

Niger is putting the finishing touches on its first radiotherapy unit, set to open at the National Cancer Centre (CNLC) in the country's capital, Niamey. It has been a long road for Niger and its partners, including the IAEA and the Islamic Development Bank (IDB); setting up a new radiotherapy facility is a major and complex task for any country in terms of human and financial resources. Getting the donor funding and support needed requires detailed feasibility documents — often referred to as 'bankable documents' — outlining the infrastructure, training and equipment needs of a cancer care facility.

"For Member States, these bankable documents create a complete picture of what is needed and the costs involved; for donors, they provide the justification and reassurance of the feasibility and sustainability of these urgently needed facilities," said Lisa Stevens, Director of IAEA's Division of Programme of Action for Cancer Therapy.

The IAEA works closely with governments, including Niger's, to develop such bankable documents. Once completed, they can be used to approach potential donors and funding institutions.

Countries face many challenges in addressing their health and development requirements, and the IAEA is committed to supporting efforts to improve access to effective cancer services in low and middle income countries. To achieve this, it is important to work with a broad range of international partners, including financing institutions, in order to implement innovative solutions, mobilize resources, and share skills and new technologies to best support the use of nuclear technology in addressing cancer.

"It is a very complex task for countries to meet the growing need for cancer services, particularly in Africa, where care is already extremely limited, but it can be done," said Shaukat Abdulrazak, Director of the Division for Africa in the IAEA's Department of Technical Cooperation. "Commitment and engagement at the highest levels of government is required to ensure that new radiotherapy services are well planned, properly funded and sustainable."

One of the first steps towards producing a bankable document for setting up new cancer care services is to review a country's infrastructure and capacities in cancer control. Upon request by Niger's Ministry of Public Health, the IAEA conducted an imPACT Review in 2010, in cooperation with the World Health Organization and the International Agency for Research on Cancer. An imPACT Review is a comprehensive evaluation of a country's cancer control system and helps local officials better understand the cancer situation. Recommendations made by imPACT Reviews, which include priorities and evidence-based interventions, support the planning and implementation of IAEA cancer-related technical cooperation projects.

The imPACT Review conducted in Niger highlighted the need to develop a training plan for cancer specialists and establish radiotherapy services, which should ideally be integrated and coordinated within a comprehensive national cancer control programme.

Niger had been collaborating with the IAEA, the Organisation of Islamic Cooperation (OIC) and the IDB to raise funds for the expansion of its cancer services. This collaboration has taken place within a broader partnership framework initiated by the three organizations in 2012, which also involved a high-level seminar with eight countries, including Niger, to review their cancer-related funding needs. IAEA experts took part in the seminar and worked closely with each country's national planning group to develop bankable documents.

"This IAEA support enabled Niger to submit a robust and evidence-based funding request to the IDB that led to the approval of €3.46 million in funding in November 2014. The funding was intended for the acquisition of a linear accelerator (linac), as well as training in Morocco and Tunisia for medical oncologists, radiotherapists and radio physicists on the operationalization of the radiotherapy unit established by the Government of Niger with assistance from the IAEA," said Mamadou Alpha Bah, Operations Team Leader (Health) in the IDB Regional Hub of Abuja, Nigeria.

In May 2019, senior officials from Niger's Ministry of Public Health, the Niger High Authority for Atomic Energy, the IDB and the CNLC met a team of experts at the IAEA to discuss the final steps for the completion of the radiotherapy centre and to plan coordinated actions to support the initiation of radiotherapy treatment in the country, in line with IAEA safety standards.

Participants of national planning groups from around Africa work with IAEA experts to develop their cancer control services.

(Photo: J. Howlett/IAEA)

Housed at the CNLC, the new centre will be staffed with a team of highly trained specialists and will have two new radiotherapy bunkers to accommodate a cobalt-60 radiotherapy machine and an advanced linac for cancer treatment. It will also have, among others, a computer tomography — or CT — simulator, dosimeters and a treatment planning system. The centre is set to provide radiotherapy services for around 600 CNLC patients from Niger and its neighbouring countries each year.

The IAEA and its partners, such as the OIC and the IDB, will continue providing assistance to Niger in establishing quality control and management procedures and for the initiation of clinical operations, to ensure services can benefit patients for many years to come, Stevens said. This includes activities such as a joint global initiative on women's cancers between the IAEA and IDB and other partners, which is aimed at contributing to the global effort to save millions of women's lives. Over a third of the initiative's activities are planned to be implemented on the African continent, and Niger is poised to benefit as well. Hayat Sindi, Chief Advisor to the President of Science, Technology and Innovation at the IDB, highlighted that "as women are increasingly in need of quality cancer care, we will work together to ensure that every country and every patient has access to lifesaving services. Every single woman in the world has the right to get access to cancer diagnosis, and we are proud to be involved in this significant project across Africa and the developing world."

"IAEA support enabled Niger to submit a robust and evidence-based funding request to the IDB that led to the approval of €3.46 million in funding in November 2014."

—Mamadou Alpha Bah, Operations Team Leader (Health), IDB Regional Hub

Cancer control in Bangladesh gets major boost

By Laura Gil

Over 500 more patients a year will now be getting vital medical examinations thanks to a new nuclear imaging machine now up and running in Bangladesh through IAEA support. The machine is an essential tool for advanced nuclear medical diagnosis of health conditions, such as cancer.

"Waiting in line for three months, which is what some patients who cannot afford private healthcare have to do, can in some cases make the difference between life and death," said Kamal Uddin, a radiation oncologist and counterpart of various IAEA technical cooperation projects in Bangladesh.

"We were very anxious because we knew we just couldn't afford the treatment. Now we come and do all of Mahbub's checkups at NINMAS without having to wait so long, and free of cost. We cannot believe it."

—Mohammad Murad, father of young cancer patient under follow-up at NINMAS, Bangladesh

The new positron emission tomography–computed tomography (PET–CT) machine will help expand patient care in the country. PET–CT scans enable doctors to take images of what's happening inside the body in order to diagnose diseases such as cancer and monitor patients' progress during treatment.

Making a difference, saving lives

For little Mahbub Murad, a PET-CT scan changed his life. He was three years old when doctors at the National Institute of Nuclear Medicine and Allied Sciences, or NINMAS, in Bangladesh spotted a cancer lymphoma on Mahbub's PET–CT scan in 2015. Alarmed by the advanced stage of the disease, they began treating Mahbub with chemotherapy. After two sessions, they used PET–CT again to check his response.

Mahbub Murad and his father, Mohammad, during a follow-up visit for his now-cured lymphoma.

(Photo: L. Gil/IAEA)

Fortunately, says Shamim Momtaz Ferdousi Begum, Head of PET–CT at NINMAS, Mahbub recovered so quickly that the oncologists stopped the chemotherapy. "Instead of the six chemotherapy sessions we would've put him through, he only received four," she said. "And he is cured now and under follow-up."

"We were very anxious because we knew we just couldn't afford the treatment," said Mahbub's father, Mohammad Murad. "Now we come and do all his checkups at NINMAS without having to wait so long, and free of cost. We cannot believe it."

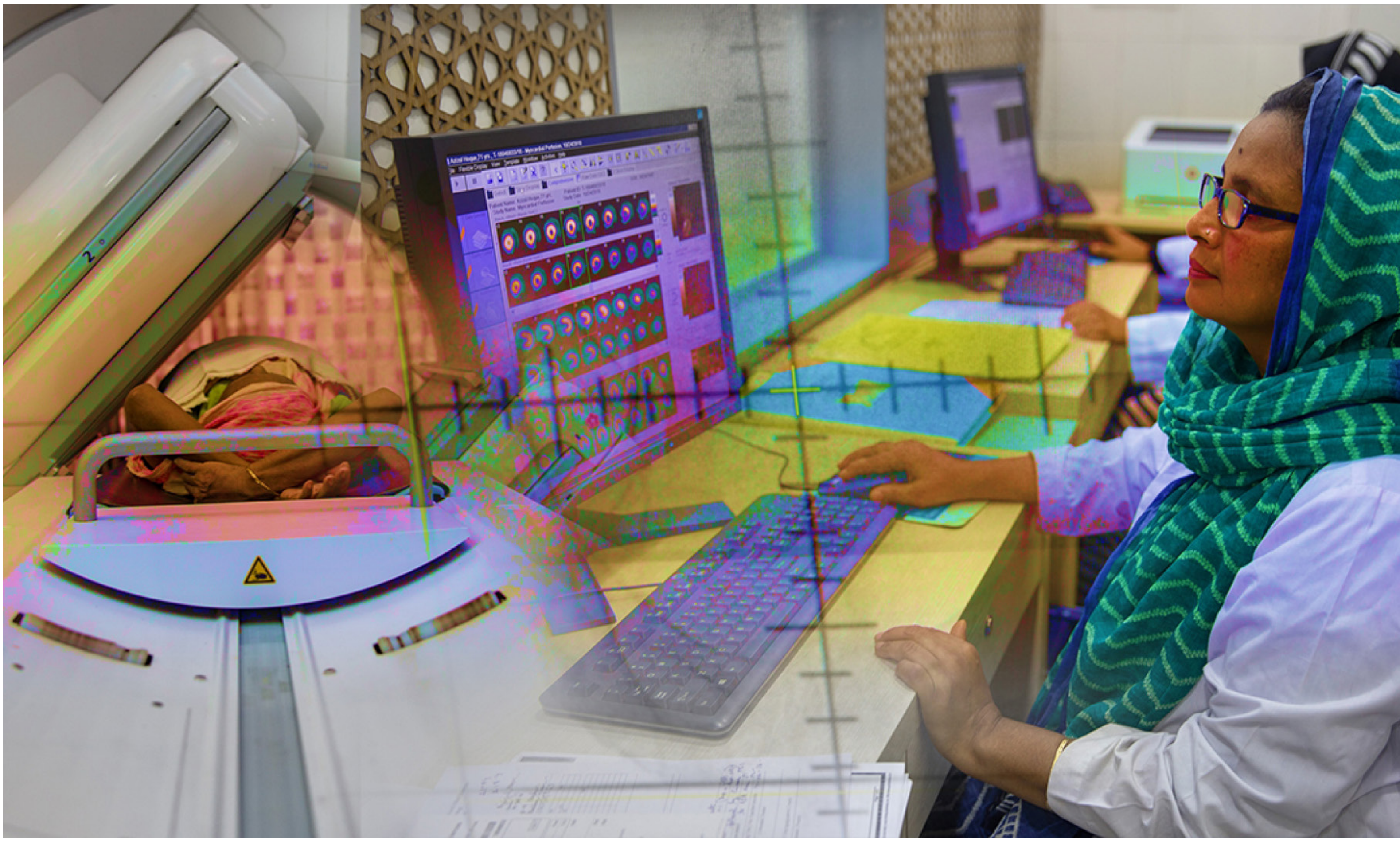
PET–CT scans are just one type of nuclear medicine procedure. These procedures require the use of medical drugs called radiopharmaceuticals that contain medical radioisotopes (see page 4). Many radioisotopes are produced by cyclotrons, which are a type of particle accelerator.

Currently, Bangladesh operates one cyclotron, twice a week, in a private hospital. It is the country's only source of radiopharmaceuticals for public and private centres that provide PET–CT scans. A new cyclotron facility, expected to be operational at NINMAS by late 2019, will produce radiopharmaceuticals four to five days a week.

"The new cyclotron will not only allow the existing PET–CT machines to improve their productivity but will also enable other PET–CT facilities to open and contribute to national cancer management," said Enrique Estrada Lobato, nuclear medicine physician at the IAEA.

Upgrading radiation oncology services

Alongside enhancements in nuclear medicine, Bangladesh is going through a major upgrade in radiation oncology thanks to a fleet of staff who have been quietly training for years. Through 20 national training programmes supported by the IAEA technical cooperation



(Image: L. Gil and F. Nessim/IAEA)

programme, several radiation oncologists, medical physicists and radiation technologists from the public and private sectors have attended advanced training courses since 2012.

“It helps to know that we’re doing things right,” said Nazmun Naher Shanta, radiation oncology registrar at the National Institute of Cancer Research and Hospital (NICRH). “Having senior experts from the region verify that what we’re doing is right gives us confidence in our methods and increases the quality of the treatment we provide.”

The IAEA has been helping Bangladesh in strengthening cancer control for more than 20 years. This support, in addition to the training of specialists, includes guidance on radiation protection and regulations, as well as the provision of facilities and equipment.

A hard reality

The challenge professionals in the field are facing is twofold. On the one hand, there is a scarcity of trained staff. On the other, the population is growing. While international standards recommend operating 1 radiotherapy machine per 1 million inhabitants, Bangladesh still has only 24 machines for its population of 166 million.

In addition, the majority of patients reach hospitals and healthcare centres at such an advanced stage of disease that often the only available treatment is palliative care to alleviate pain. This is not only because of a lack of facilities but also due to a lack of awareness: patients usually do not approach a healthcare centre even if they have symptoms.

“If we address these problems, that is, through accessibility, awareness and more well-trained medical staff, in ten years things will have changed dramatically,” Uddin said. He, like many others in the field, is confident that the development of centres beyond the capital is the way to go.

“Bangladesh has motivated, dedicated professionals and is getting more equipment,” said Syahril Syahril, project manager at the IAEA responsible for technical cooperation with the country. “Although there are challenges ahead, we are working to ensure that the country will continue to receive the necessary assistance through IAEA technical cooperation.”

Managing the ever-increasing demand for cancer services in the developing world

By James Howlett

Nicaragua's first linear accelerator received and set up through support from Japan and the IAEA.

(Photo: Nicaragua's National Radiotherapy Centre)

Cancer is not just a major health issue for people but also a growing development challenge with severe consequences on national well-being and government health budgets. According to the World Health Organization's International Agency for Research on Cancer, the total annual economic cost of cancer in 2010 was estimated at US $1.16 trillion. This number is expected to have continued to increase as more people develop cancer each year — globally, in 2018, the number of cancer cases exceeded 18 million, with 9.6 million deaths. By 2030, these annual figures are expected to rise to 24 million cases, with 13 million deaths.

Many low and middle income countries are unable to provide sufficient cancer diagnosis and treatment services and must send patients abroad for care, which is expensive and can be a burden on patients and their families. Establishing national cancer care services, including radiotherapy facilities and nuclear medicine units, is a complex undertaking that requires careful planning to set up the highly specialized infrastructure, equipment and training, as well as to mobilize funds.

The IAEA has a long history of supporting countries in using nuclear technology for health. In the area of cancer, it has been transferring technology and building human and institutional capacities for cancer diagnosis and treatment using radiation technology. The IAEA, through its technical cooperation programme, has trained over 2000 health professionals and provided more than €172 million since 2011 to assist countries in developing national cancer care services. In 2019 alone, it supported more than 125 cancer-related projects worldwide.

"Our goal is to work with our Member States, particularly from low and middle income countries, to build and strengthen their capacity in cancer control so that a greater number of patients can be treated safely and effectively," said Dazhu Yang, IAEA Deputy Director General and Head of the Department of Technical Cooperation.

The IAEA's support in this area includes specialized training to build human resources and expert advice at all stages of the process, as well as the tools, materials and equipment needed for an operational facility to be set up and be able to provide services.

The impact of this support can be seen in countries such as Sri Lanka, which has been collaborating with the IAEA for more than 40 years to develop the country's cancer care services. In the last eight years, for example, this collaboration has led to enhanced nuclear medicine imaging capabilities, with highly trained specialists to provide diagnostic services in Sri Lanka.

In central Sri Lanka, a fully equipped nuclear medicine unit has been set up in the city of Kandy to complement a similar facility in Galle, a city in the southern part of the country. A new facility is also being set up in the north, around Jaffna. In October 2019, Sri Lanka is expected to host an IAEA imPACT Review mission, where experts will assess the country's progress and assist in defining plans for its future developments in cancer control.

Planning, funding, collaboration

Many countries work with the IAEA to get help in planning, raising funds and developing collaborations for cancer control priorities. The IAEA assists in organizing and facilitating discussions with donors, development banks and financial institutions.

In Nicaragua, for example, in close collaboration with the Ministry of Health and with the support of bilateral funding from Japan, the country's first linear accelerator, or linac, an advanced radiotherapy machine, was inaugurated in May 2019 at the National Radiotherapy Centre. The IAEA supported specialist training of staff for the new system to ensure an effective transition from the existing clinical practice to the latest 3D radiotherapy, allowing for safer and better-quality treatment. This is an important milestone for the country's cancer treatment services and will allow highly specialized radiotherapy techniques to be performed.

Similarly, radiotherapy services in Mongolia have been improved, and two linacs became operational in June 2019. Quality assurance systems for ensuring that patients receive the correct radiation doses were upgraded, and new technologies and a radiation safety system for radiotherapy services were also introduced. In addition, donors provided support in 2016 for a state-of-the-art cancer diagnosis and treatment system, and training through IAEA assistance helped to introduce highly accurate 3D radiation therapy and other modern technologies to the country.

As countries prepare for their new facilities to open, the IAEA, in partnership with leading international medical institutions, provides specialist training and fellowships that help ensure cancer care services have a sufficient number of well-trained staff, such as oncologists, radiologists and medical physicists.

Training professionals

Building a national cohort of skilled medical professionals, trained and ready to operate new facilities, requires carefully timed support, often initiated years in advance, said Fatima Haggar, Medical Oncologist at the University Hospital Limoges Mother and Child Hospital (*Hôpital de la mère et de l'enfant*) in Chad's capital, N'Djamena. "Our new centre will open in around three years, and it will take time for all the staff we need to become qualified."

Chad has recently developed a planning and funding document to establish its first radiotherapy facility as part of its National Cancer Control Plan 2017–2021. The IAEA is assisting the country with the required training of staff by sharing the cost of long- and short-term fellowships with the Government and providing advice and expert assessments.

Given the scale and complexity of cancer treatment facilities, progress can only be made with the close involvement of national governments and the cooperation of a broad range of stakeholders. Governments need to identify cancer as a national health priority to ensure that actions to address the national cancer burden are taken at every level — in national health plans, health budgeting, infrastructure development, fundraising and capacity building.

For a country like Sierra Leone, for example, recognition of the challenge of cancer at the very highest level of government means that the country is well positioned to make progress in the national fight against cancer.

"Our President recognizes that cancer is creating a huge burden for the country," said Frank Kosia, radiologist and focal point for the Ministry of Health and Sanitation in Sierra Leone. "His flagship project looks to make radiotherapy publicly available by 2023." The IAEA is working with the Government of Sierra Leone to make this goal a reality, providing support for the establishment of radiotherapy and nuclear medicine facilities at Lakka Hospital, which will be expanded to accommodate these services.

"Our goal is to work with our Member States, particularly from low and middle income countries, to build and strengthen their capacity in cancer control so that a greater number of patients can be treated safely and effectively."

— Dazhu Yang, Deputy Director General and Head, Department of Technical Cooperation, IAEA

Embracing mobile and online technology to reshape cancer care and education

By Joanne Liou

(Photo: J. Corpuz/Southern Philippines Medical Centre)

The ubiquity of mobile phones and internet access has enhanced the ability to acquire information — consolidating a wealth of information into a compact gadget at one's fingertips. For more than a decade, mobile applications have effectively simplified daily life, and they have now extended into the world of cancer care.

"Information and mobile technologies are increasingly used by the IAEA to deliver innovative and cost-effective educational opportunities to people worldwide," said May Abdel-Wahab, Director of the IAEA's Division of Human Health. "By developing resource-sparing tools and services, opportunities are not limited by geography, availability of resources or financial constraints, so we are able to further support countries in expanding professional development for cancer care globally."

As technologies continue to transform lives and society, the increasing use of mobile apps, e-learning platforms, and information and communication technology-based tools, is influencing cancer care, from assisting diagnostic imaging interpretation and educating practitioners to guiding treatment decisions. Some of the IAEA's freely available applications and e-learning courses are highlighted here.

TNM and FIGO cancer staging applications

The TNM Cancer Staging App is a mobile app that provides navigable information to help physicians determine the level of treatment and prognosis for cancer patients, based on the extent of the tumour (T) and lymph node spread (N) and the presence of growths from the primary cancer site — metastasis (M). The TNM staging system is a recognized standard used to record the anatomical extent of the disease. The classification system, which is updated on a regular basis, was developed by the Union for International Cancer Control (UICC), and it is also used by the American Joint Committee on Cancer (AJCC) and the International Federation of Gynaecology and Obstetrics (FIGO).

The app, developed by the IAEA in cooperation with India's Tata Memorial Centre and All India Institute Of Medical Sciences (AIIMS), lists 65 cancer types and covers more than 100 different types of tumours. "The app condenses a 1000-page book and puts it into the hands of patients, doctors and practitioners," said Diana Paez, Head of the Nuclear Medicine and Diagnostic Imaging Section at the IAEA. Users can enter a patient's details, such as the size of a mass, or the presence or absence of lymph nodes, to help them identify a specific treatment.

"Books containing such information are expensive and are not always available when you are in the clinic with the patient," said Palak Bhavesh Popat, a radiologist at the Tata Memorial Hospital in India. "Having an offline and free app available on the phone, even in remote areas, further increases its utility."

Since the app's launch in 2015, it has been downloaded more than 52 000 times.

In 2016, the IAEA launched a similar app specifically focused on gynaecological cancers. The FIGO Gyn Cancer Management app was developed by the IAEA in partnership with Tata Memorial Centre and AIIMS, and in cooperation with the FIGO. The FIGO app — which has reached nearly 10 000 downloads — evaluates the extent of cancer in female reproductive organs for the staging and management of gynaecological cancers. In April 2019, the app's staging and management flows were updated for cervical cancer.

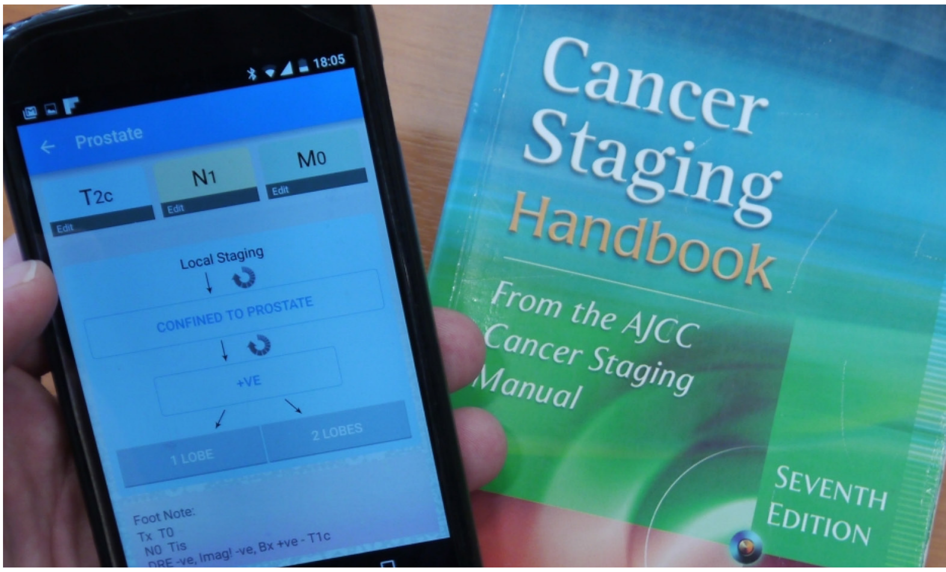
New versions of the TNM and FIGO apps based on clinical updates are expected to be released in October 2020. The two apps, which are available in the Android and Apple app stores, have been most downloaded in Brazil, India, Japan, Mexico, Thailand and the United States.

"These apps reflect the cooperation between the IAEA and professional organizations, and they offer a way to allow free access to high-level, scientific content," Paez explained. "Despite a limited budget, we have been able to increase impact and reach through these mobile tools."

Distance assisted training and e-learning tools

Before branching into apps, the IAEA had embarked on an extensive project to develop training modules for distance-learning in the field of nuclear medicine. The development of the IAEA's distance assisted training began in the 1990s and has evolved from CDs and DVDs to the Distance Assisted Training Online (DATOL) platform, which has been available online since 2009. The platform's content is regularly updated to stay relevant and to reflect developments in the field.

The DATOL curriculum consists of 39 subjects representing approximately 900 hours of study along with a formal assessment and certification. It can be completed within two to three years when pursued part time. Accreditation is granted by a nationally recognized body when the DATOL programme is implemented locally using the educational materials developed by IAEA experts and with the support and supervision of the IAEA.



TNM Cancer Staging App

(Photo: V. Fournier/IAEA)

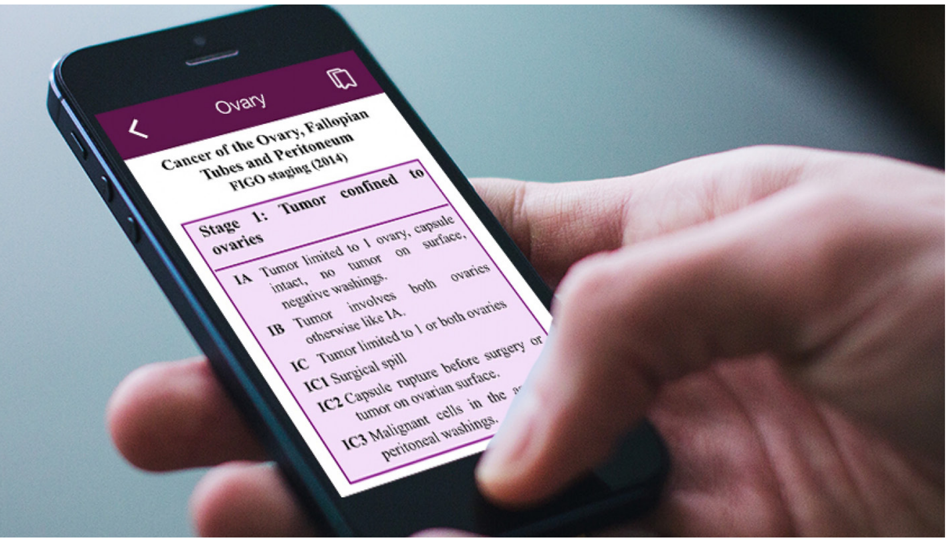
"In the past, nuclear medicine technologists were trained on the job without formal education," Paez explained. "DATOL helps people complete a structured training programme with access to local tutors, presentations, case studies and assessments."

About 700 professionals have completed the programme from more than 30 countries across Africa, Asia, Europe and Latin America. The programme, which is available in English and Spanish, has been adopted in Argentina, Colombia and Thailand as an official training tool for nuclear medicine technologists.

Expanding online resources

The IAEA has continued to expand its online offerings through e-learning tools that help promote IAEA publications and resources. "It's a continuation and complement to our work; our approach is to start from IAEA published guidelines and disseminate them through training courses during which we develop material to be used for e-learning," said Giorgia Loreti, training officer in medical physics at the IAEA. The IAEA develops online courses to facilitate access to best practices in clinical applications of radiation medicine in, for example, the field of medical physics.

"We spend a lot of time testing the e-learning modules and performing extensive quality



FIGO Gyn Cancer Management

(Photo: V. Fournier/IAEA)

control before we release them," Loreti said. "E-learning is a flexible tool that allows accessible, structured yet self-paced learning. It adds value to the learning experience through making it interactive."

For example, to complement the IAEA publication, *Introduction of Image Guided Radiotherapy into Clinical Practice,* released in 2019, an e-learning course was produced based on a training course run jointly with the International Centre for Theoretical Physics (ICTP). The e-learning course, intended for postgraduate medical physics students and professionals, comprises eight modules with videos, slides and self-assessment tests, which provide an overview of the physics and technologies related to image guided radiotherapy.

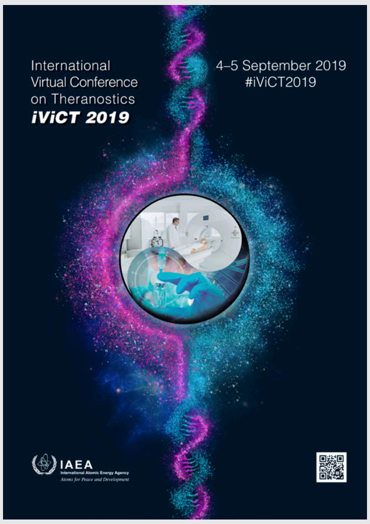
"We know students on e-learning courses may not have access to the practical sessions given in a typical medical physics course nor to the interaction with the lecturers," Loreti said. "We have developed specific self-assessments to ensure topics are understood in-depth before the student can proceed to the next module."

Supplementing training

Following the success of AMPLE — the Advanced Medical Physics Learning Environment for Asia and the Pacific — the IAEA is working on a similar tool for radiation oncologists. Expected to be released in 2020, the Advanced Radiation Oncologist Education Platform (AROLE) will be used to supplement residency training in areas with limited access to experts and educational resources.

"We realize that we are facing a shortage of radiation oncologists, especially in lower income countries. The capacity to produce radiation oncologists is currently very small and expertise is limited, so there is a need for students to be trained more efficiently and for experts to support them without having to travel long distances," said Ben Prajogi, an associate education officer in the IAEA's Applied Radiation Biology and Radiotherapy Section. "In collaboration with academic institutions and professional societies, we will provide access to high-quality learning resources to support the implementation of a global competency-based curriculum."

To access the IAEA's free e-learning courses, users need internet access with a web browser and a Nucleus account, which can be created at nucleus.iaea.org.



IAEA's first virtual conference

Finding new ways to embrace the power of information and communication technologies is helping to further the reach of nuclear sciences and applications. In September 2019, the IAEA hosted its first virtual conference: the International Virtual Conference on Theranostics (iViCT 2019). Theranostics is an area of medicine that couples diagnostic and therapeutic uses of radiopharmaceuticals to diagnose and treat cancer (read more on page 8).

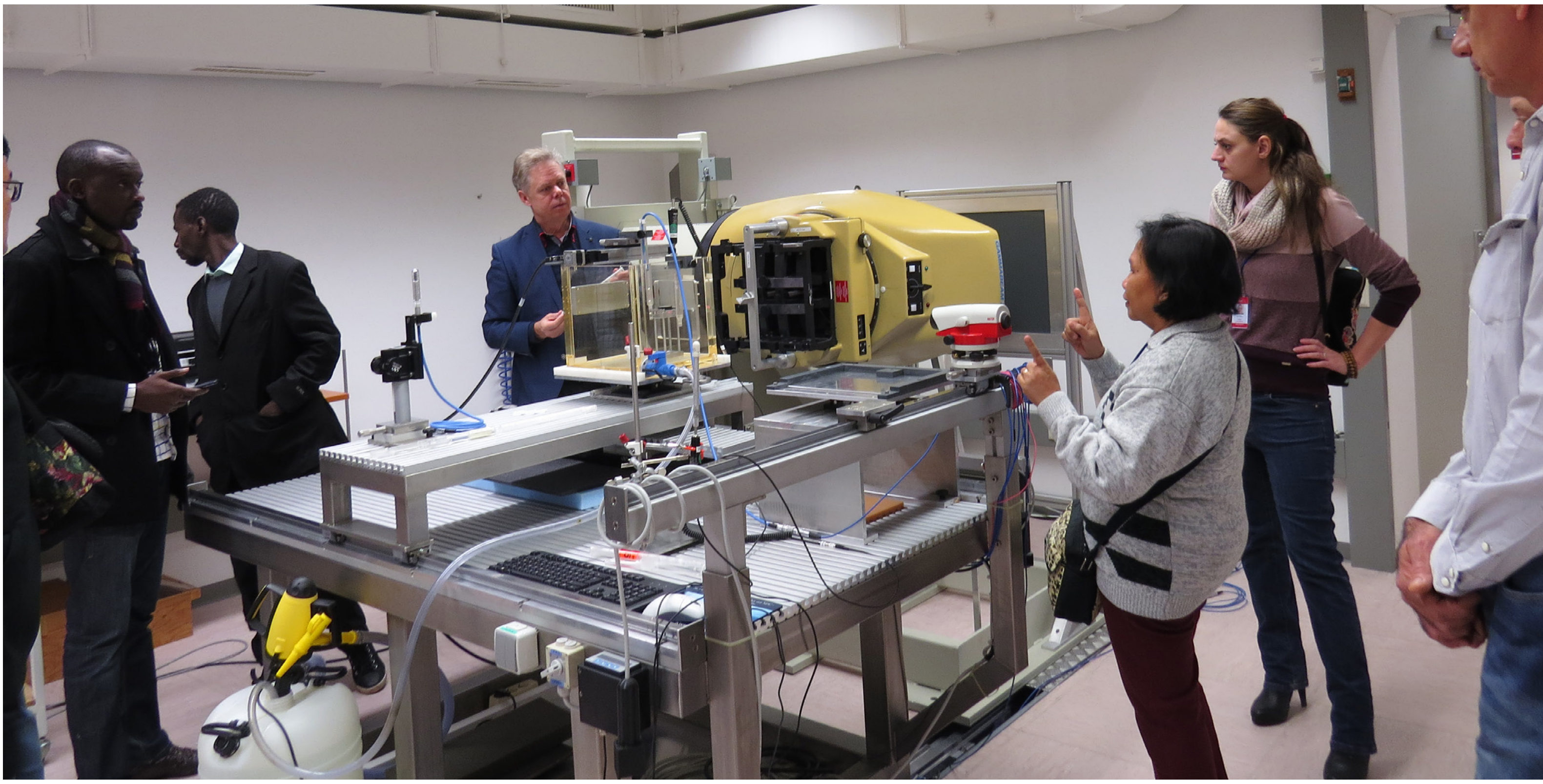
The conference leveraged multiple online platforms to connect nuclear medicine experts with a global audience. Interactive case presentations and an international panel supplemented lectures covering prostate cancer, neuroendocrine tumours and differentiated thyroid cancer patients. Participants were able to interact via the IAEA App, the official conference hashtag #iViCT and WhatsApp, and Q&A sessions were supported by WebEx.

"The virtual conference is a platform and a means that gives us the opportunity to significantly increase the reach of nuclear science and applications, allowing us to support the process of continuing medical education and helping us optimize the available resources," Paez said. The conference was livestreamed at two separate times to accommodate different time zones, and recordings were made available online after the conference.

Accurate dosimetry for quality cancer care

The IAEA/WHO Network of Secondary Standards Dosimetry Laboratories

By Aabha Dixit



The IAEA Dosimetry Laboratory provides practical training on how to perform accurate calibrations for dosimetry.

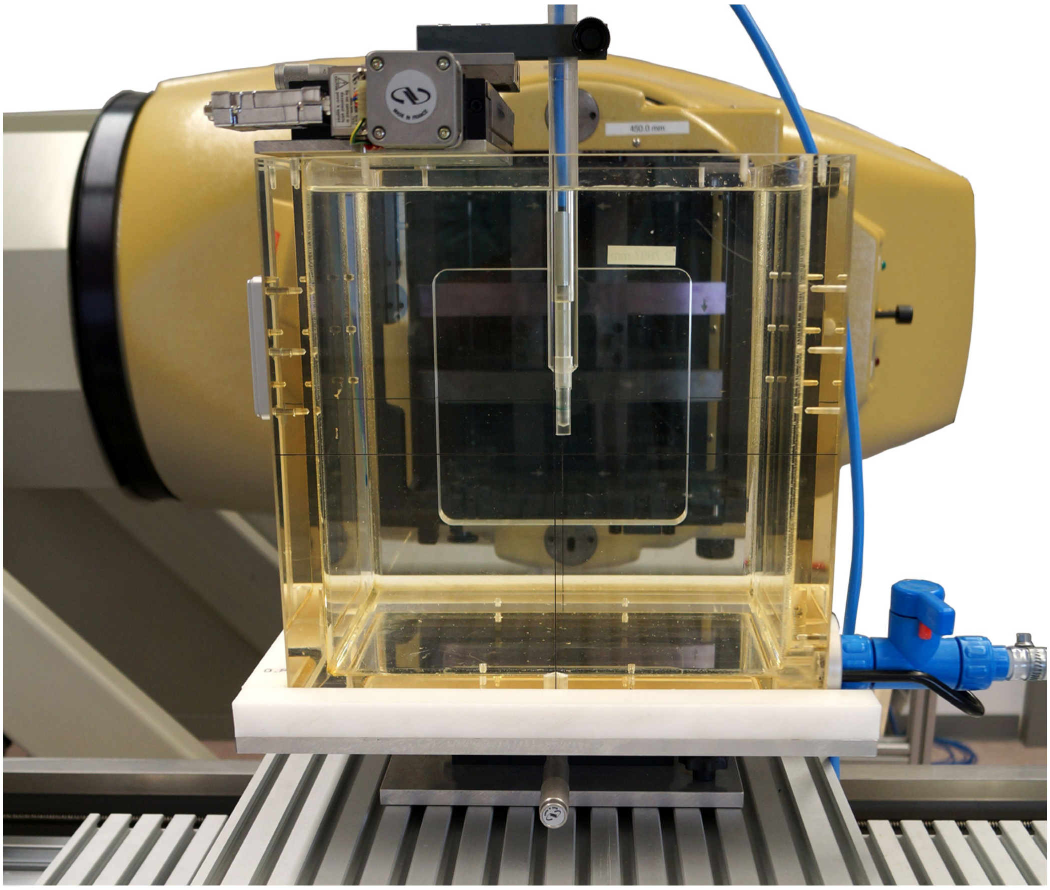
(Photo: P. Toroi/IAEA)

More than half of cancer patients require radiation therapy at some point during their treatment. The outcome of treatment can change significantly if the amount of radiation differs by even as little as 5% from the intended radiation dose. To provide patients with highly accurate doses of radiation, it is essential for measurement equipment to be set up and operated properly.

"Accurate dosimetry is a crucial part of radiation therapy," said Zakithi LM Msimang, Director of Ionizing Radiation at the National Metrology Institute of South Africa. "If the radiation dose is too low, the cancer might not be cured, and, on the other hand, if it is too high, it can have harmful side effects."

Radiation doses are measured using specific measuring equipment called dosimeters. These devices play a central role in ensuring accurate dosimetry, which is the science of measuring, calculating and assessing radiation doses. To ensure accurate dosimetry, measuring equipment needs to be calibrated regularly. This is done by crosschecking the devices' performance against national reference standards maintained by national calibration laboratories, such as secondary standards dosimetry laboratories (SSDLs). These reference standards are traceable and linked to the International System of Units (SI).

"We cannot see radiation, so we have to make sure that the measurement equipment is working correctly," said Paula Toroi, Medical Radiation Physicist — SSDL Officer at the IAEA. "Prescribed dose levels in radiation therapy are typically based on international studies and recommendations. To confirm that the doses used in these recommendations and then measured in hospitals are comparable, dosimetry equipment needs to be calibrated, and the measurement methods need to be harmonized.
SSDLs provide these calibrations for dosimetry equipment, and they also link



Calibration system set up for a radiation therapy dosimeter.
(Photo: IAEA)

the measurements to the harmonized international dosimetry standards."

The SSDL Network was set up by the IAEA and the World Health Organization (WHO) to help countries to improve accuracy in dosimetry. It comprises 86 SSDLs, located in 73 countries, that provide calibrations for dosimeters. The objective of the IAEA/WHO SSDL Network is to improve accuracy and consistency in radiation dosimetry and to promote cooperation among countries.

> **"Training and sharing skills are vital for this field, as technology is developing very quickly. Some developing countries are only now establishing their own national calibration laboratories, and the SSDL Network provides the precise support required."**
>
> *—Zakithi LM Msimang, Director of Ionizing Radiation, National Metrology Institute, South Africa*

"Training and sharing skills are vital for this field, as technology is developing very quickly," Msimang said, adding that "some developing countries are only now establishing their own national calibration laboratories, and the SSDL Network provides the precise support required."

The IAEA's Dosimetry Laboratory in Seibersdorf, Austria, acts as the central laboratory of the SSDL Network. The measurement standards of countries are calibrated, free of charge, at the laboratory, particularly for countries that do not have direct access to primary standards dosimetry laboratories, which are laboratories that establish quantities used for radiation dose measurements.

In June 2019, the IAEA's Dosimetry Laboratory opened a new linear accelerator (linac) facility to further strengthen dosimetry services and radiation safety worldwide, as well as to support research in new codes of dosimetry practices. Linacs are machines that use electricity to create beams of high-energy X-rays or electrons. They are most commonly used for treating cancer.

"With the new linac, the IAEA will be able to meet the increased demand from its Member States, including the direct calibration of SSDL dosimeters," said May Abdel-Wahab, Director of the IAEA's Division of Human Health. "This support will also help enhance audit services for more that 3400 medical linacs in hospitals in low and middle income countries."

In addition to calibration services, the IAEA Dosimetry Laboratory engages in other activities supporting accurate dosimetry worldwide. This includes comparisons and dose audits that allow SSDLs and hospitals to check that they are performing the calibrations and measurements correctly. The laboratory also provides training and conducts research and development in dosimetry and medical radiation physics.

Radiation needs a more prominent role in the fight against cancer

By Mack Roach III

Much of the research conducted in oncology and on cancer is being funded by governmental agencies, such as the United States National Institutes of Health's National Cancer Institute, and pharmaceutical and biotechnology companies. A lot of this research is centered around the development of new chemotherapy drugs. Chemotherapy is generally cancer-site specific in its application, such as cisplatin for head, neck and lung cancer, and various forms of hormonal therapy for prostate cancer, and temozolomide for brain tumours. Radiation, on the other hand, can treat most solid tumours.

Radiotherapy possesses the greatest spectrum of activity against the widest variety of cancers. It has been used to treat cancer for more than 100 years and has proven to be extremely cost effective. This is because once radiation equipment is purchased, it can essentially generate as much radiation as needed, with the primary costs being only electricity and maintenance. This in turn means the more the machine is used, the more cost-effective the treatment per patient. Unlike specific medications that are used up by each patient and cannot be reused, the radiation beam can be used over and over again. In addition, radiotherapy can be used as an alternative to surgery, particularly when the latter would have a profoundly negative impact on quality of life, as can be the case with, for example, laryngeal cancer and anal cancer. The wide spectrum of activity, ability to generate an ongoing supply of treatments and the long-life expectancy of radiation machines of more than ten years explains why radiation therapy as a modality is so cost effective.

Complementing radiation medicine's therapeutic versatility, nuclear medicine facilitates the detection of very small deposits of cancer cells, which allows for better staging of cancer and targeting of a tumour. These attributes of radiation and nuclear medicine make them essential components for ensuring quality cancer care. A number of international organizations, such as the IAEA and the World Health Organization, have come to play a critical role in facilitating the adoption of these modalities into the global standard oncological portfolio, which, in turn, is also helping patients in developing countries get access to effective treatment that can increase life expectancy and save lives.

Mack Roach III MD, Fellow, American Society for Radiation Oncology and Fellow, American College of Radiology, University of California San Francisco Helen Diller Family Comprehensive Cancer Center

Future treatment options using radiation

Numerous studies both in animals and people have shown the potential for radiation to stimulate the immune system in unique and targeted ways. In addition, new and exciting data suggest that there is great potential for further extremely promising advances in 'nuances' to the conventional application of radiation that are actively being investigated. These 'nuanced' approaches, such as 'flash', microbeam and mini-beam, and particle radiation, may very well result in less toxic, much less expensive and more effective treatment for cancer patients and may have a profound impact on cancer care worldwide, particularly in developing countries.

Though already highly cost effective and critical to the cure of our most common cancers now, I predict that the role of radiation and nuclear medicine is likely to continue to expand. The use of these modalities points to an extremely optimistic future, and their 'invisible' nature and effectiveness at a distance may make them the closest thing to 'magic' we will see in my lifetime!

A decade of action on cancer control

By Cary Adams

Cary Adams, CEO,
Union for International Cancer Control (UICC)

The past decade will be noted in future years as the decade in which cancer and the other non-communicable diseases (NCDs) became recognized as a global health and development issue: three high-level meetings have taken place; a new World Health Organization (WHO) Global Action Plan on NCDs was released; targets were agreed by all countries to help reduce premature deaths by 25% by 2025; a new World Health Assembly resolution on cancer was agreed in 2017; and NCDs were embedded in the United Nations Sustainable Development Goals (SDGs). It was a decade of agreement and commitments.

Such steps did not happen by accident. The UICC has played a critical role in placing cancer at the heart of a movement that sought to establish NCDs as a global priority. It has worked in collaboration with the IAEA and other key partners to spearhead and support this global campaign. In 2009, the NCD Alliance was formed by the UICC, the World Heart Federation and the International Diabetes Federation. Its aims were simple: secure a United Nations high-level meeting on NCDs and ensure that NCDs featured in the SDGs. Some frowned upon the Alliance in its early days, seeing little political leverage being achieved by grouping NCD diseases through a set of common risk factors. However, the NCD Alliance secured credibility in the UN system and, working with a group of committed countries, pushed for a high-level meeting, which took place in 2011 and led to the WHO Global Action Plan on NCDs and the nine targets that we aspire to in 2025. Further high-level meetings took place in 2014 and 2018, where countries committed to developing and implementing action plans. NCDs are included in SDG 3 with a commitment to reduce premature deaths caused by NCDs by more than one third by 2030. It has been an unprecedented period of UN-led commitment to a set of diseases that impact all people in all countries.

In parallel, the UICC and its members and partners have pressed for specific action on cancer and its unique risk factors. The WHO Model List of Essential Medicines was comprehensively updated in 2017 and a new publication from the WHO entitled *WHO list of priority medical devices for cancer management* was also released that year. The publication sets out the core technologies every country should have in place for effective cancer management.

For the UICC, the IAEA is also a pivotal partner; the IAEA's engagement in cancer control has helped to ensure a broad understanding of the need for balance between investments in prevention and access to treatment and palliative care, and that the role of multidisciplinary services and care is central to cancer plans. This also includes helping national decision makers see the associated upfront costs of developing radiotherapy services in terms of the returns that investment brings.

As we enter the last months of the decade, it is natural to ask the question "Have the agreements and commitments secured at a global level had a material impact on the lives of people with cancer in countries around the world?"

The answer is 'yes', according to a global review of national cancer control plans and NCD plans around the world conducted by the UICC in collaboration with the International Cancer Control Partnership.[1] Over the past decade, we have seen the number of national cancer control plans increase from 66% in 2013 to 81% in 2017. Granted, many plans are still not fully funded and the degree to which they are being implemented can be questioned, but given that the UICC considers the existence of political will and a plan to be the preconditions required to address cancer in any country, we should take comfort in the evidence that suggests we are making material progress. We can see that countries with political support and a published and funded national cancer control plan are taking steps to reduce their population's exposure to risk factors by, for example, implementing stricter tobacco control laws or implementing population-wide screening for common cancers or protecting girls from the human papillomavirus through vaccination. The existence of more plans is therefore a good indicator that cancer is being taken more seriously today than it was at the beginning of the decade.

However, there is still much to do to elevate cancer control in global public health. Many countries that have signed up to the WHO Framework Convention on Tobacco Control have yet to implement significant price hikes on cigarette packets. Cervical cancer remains a leading cause of death of women in low and middle income countries. The UICC has therefore joined the WHO in a renewed push to eliminate this specific cancer for future generations of girls and women. And while the WHO essential medicines list continues to be constantly updated, many countries lack the skilled resources to ensure that quality medicines are routinely available to those who need them. In addition, we still see the huge and avoidable global disparity in access to pain relief, where millions of cancer patients with moderate to severe cancer pain do not have access to opioid analgesics. These challenges are large but not beyond our reach.

As we enter the next decade, we should take comfort in how much has been achieved in the last ten years to steer and encourage all countries to enhance their abilities to address the growing burden of cancer. To take advantage of the current momentum, cancer advocates must work swiftly to mobilize other civil society groups and organizations across the public and private sectors to create and sustain the changes that can positively impact the health and wellbeing of communities around the world.

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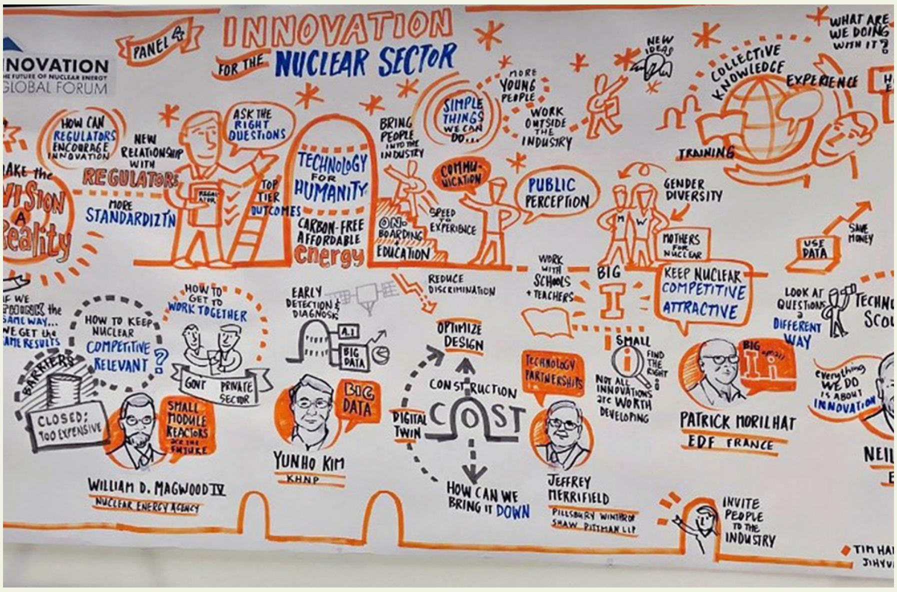
[1] *Romero Y, Trapani D, Johnson S, Tittenbrun Z, Given L, Hohman K, Stevens L, Torode JS, Boniol M, Ilbawi AM. 2018. 'National cancer control plans: a global analysis.' Lancet Oncology 19(10): e546–e555.*

Current and future nuclear energy leaders issue call to action for innovation



Over 250 nuclear industry leaders, regulators, researchers, government representatives and technology providers have issued a ‘call to action’ to accelerate the use of innovative solutions to sustain and advance the current operational fleet of nuclear power plants (NPPs) around the world. The ‘call to action’ emphasizes the four innovations identified by the participants of the three-day Global Forum on Innovation for the Future of Nuclear Energy, co-organized by the IAEA and held from 10 to 12 June in Gyeongju, the Republic of Korea.

The key goal of the event was to tackle the most urgent challenges facing the nuclear sector and to examine barriers and opportunities for deploying innovative technological and process solutions to maintain or even enhance nuclear safety while reducing costs. For this, the participants highlighted 28 innovations related to various aspects of operating the current NPP fleet, topped by the following four:

1. Digital twinning (the virtual recreation of a process into a computer-based model) to improve NPP performance and to reduce costs;

2. Advanced manufacturing, including 3D printing, to address supply chain challenges;

3. Machine learning to make better use of the big data already available in the nuclear power sector for optimizing maintenance; and

4. Using more innovative frameworks for information exchange, to share data on research and development, operations and maintenance.

The ‘call to action’ forms the basis of developing actionable items for deployment and implementation beyond the event itself.

The forum was co-organized by the IAEA, the Electric Power Research Institute (EPRI), the United Kingdom’s National Nuclear Laboratory (NNL), the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA) and the Korea Hydro & Nuclear Power Company (KHNP), which hosted the event.

“The nuclear industry is a vital part of the global energy mix, in particular to address climate change because it’s a zero-carbon energy source,” said Neil Wilmshurst, EPRI Vice President and Chief Nuclear Officer. “This unique forum prioritized critical innovations needed in the nuclear industry, came to an understanding of the barriers and committed to working together to eliminate them.”

The event’s participants, from early career professionals to industry leaders, were guided by the following: to collaborate, foster change, disrupt and make a difference within their respective organizations — and across the nuclear sector. Sessions focused on topics such as the challenges facing innovation in the nuclear sector today and successful examples of nuclear innovation. A roundtable discussion held with regulators, facilitated by Director-General William D. Magwood, IV of OECD/NEA, provided perspectives from leaders in the field.

“The effective support from the younger generation of nuclear professionals, working in tandem with management, is an inspiring sign that innovation will be driven by the combined dynamism and engagement of current and future leaders,” said Ed Bradley, Team Leader for NPP Operation and Engineering Support at the IAEA’s Department of Nuclear Energy.

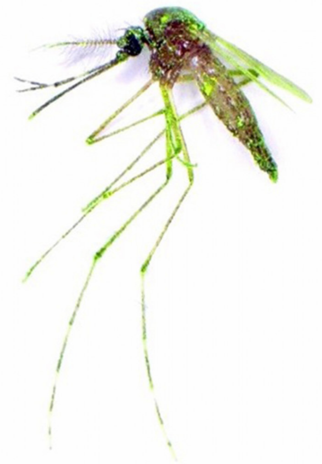
Joan Knight, Innovation Director at Exelon and Chairperson of a discussion session at the forum, added: “I’m pleased to be part of an effort that advances more powerful practices of innovation across the nuclear sector and to shape attitudes that are supportive of related activities.”

The event was the first of its kind between the co-organizing institutions and was facilitated by meetings on innovation held in Vienna in 2018 and 2019. Similar forums are expected to take place in the future as platforms for sharing progress on relevant actions, meeting new challenges, strengthening collaboration and fostering new partnerships.

“We are delighted to host the next Global Forum in 2020,” added Rob Whittleston, Vice President of NNL, during the closing ceremony.

— By Marianne Nari Fisher and Vincent Roué

Mosquito population successfully suppressed through pilot study using nuclear technique in China



Aedes albopictus is the world's most invasive mosquito species. A successful pilot trial for controlling this insect pest recently concluded and the results were published in Nature on 17 July 2019.
(Photo: N. Culbert/IAEA)

For the first time, a combination of the sterile insect technique (SIT) with the incompatible insect technique (IIT) has led to the successful suppression of mosquito populations, a promising step in the control of mosquitoes that carry dengue, Zika virus and many other devastating diseases. The results of the recent pilot trial in Guangzhou, China, carried out with the support of the IAEA in cooperation with the Food and Agriculture Organization of the United Nations (FAO), were published in Nature on 17 July 2019.

SIT is an environmentally friendly insect pest control method involving the mass rearing and sterilization of a target pest using radiation, followed by the systematic area-wide release of sterile males by air over defined areas. The sterile males mate with wild females, resulting in no offspring and a declining pest population over time. IIT involves exposing the mosquitoes to the Wolbachia bacteria. The bacteria partially sterilize the mosquitoes, which means less radiation is needed for complete sterilization. This in turn better preserves the sterilized males' mating competitiveness.

While SIT, as part of area-wide insect management strategies, has been successfully used to control a variety of plant and livestock pests, such as fruit flies and moths, the control of mosquitoes still had to be demonstrated.

The main obstacle in scaling up the use of SIT against various species of mosquitoes has been overcoming several technical challenges related to producing and releasing enough sterile males to overwhelm the wild fertile population. Researchers at Sun Yat-sen University, and its partners, in China, have now successfully addressed these challenges, with the support of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, which is leading and coordinating global research in SIT.

For example, the researchers used racks to rear over 500 000 mosquitoes per week that were constructed based on models developed at the Joint FAO/IAEA Division's laboratories near Vienna, Austria. A specialized irradiator for treating batches of 150 000 mosquito pupae was also developed and validated with close collaboration between the Joint FAO/IAEA Division and the researchers.

The results of this pilot trial, using SIT in combination with IIT, demonstrate the successful near-elimination of field populations of the world's most invasive mosquito species, Aedes albopictus (Asian tiger mosquito). The two-year trial (2016–2017) covered a 32.5-hectare area on two relatively isolated islands in the Pearl River in Guangzhou. It involved the release of about 200 million irradiated mass-reared adult male mosquitoes exposed to Wolbachia bacteria.

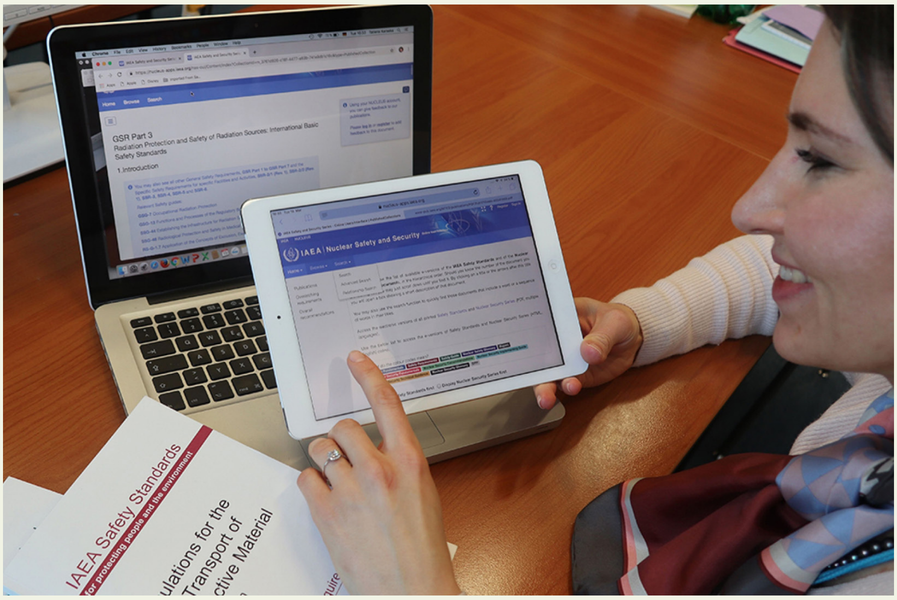
The study has also shown the importance of socio-economic aspects for the successful use of the IIT–SIT approach. Social acceptance, for example, increased during the study, as the support of the local community went up following mosquito releases and the resulting decrease in nuisance biting; for the IIT–SIT approach to be successful, the local community needs to be on board and work together to ensure the consistent and integrated use of the approach over the entire area in order to effectively counteract and control the movement of the insects. Another aspect is cost-effectiveness; overall future costs of a fully operational intervention are estimated at between US $108 and $163 per hectare per year, which is considered cost-effective in comparison with other control strategies.

Experts in China plan to test the technology in larger urban areas in the near future using sterile male mosquitoes from a mass-rearing facility in Guangzhou, said Zhiyong Xi, Director of the Sun Yat-sen University–Michigan State University Joint Center of Vector Control for Tropical Diseases and Professor at Michigan State University in the United States. The company operating the facility uses advanced mosquito mass-rearing and irradiation equipment that has been developed in collaboration with the Joint FAO/IAEA Division.

Global cooperation on the development of SIT to control mosquitoes intensified following the Zika epidemic in 2015–2016. The incidence of dengue is on the rise, with the number of cases reported to the World Health Organization (WHO) increasing from 2.2 million in 2010 to over 3.3 million in 2016. The actual incidence is much higher, and one estimate, according to WHO, indicates 390 million new infections each year.

— By Miklos Gaspar

Use an online tool to comprehensively navigate IAEA safety and security publications



(Photo: P. Shaw/IAEA)

The IAEA collection of Safety Standards and Nuclear Security Series includes more than 150 publications, all of which contain multiple cross references. Many important areas are covered in more than one publication. To make finding comprehensive information in this vast resource easy, the IAEA has developed an advanced search tool, the Nuclear Safety and Security Online User Interface (NSS-OUI), which offers users multiple ways to systematically browse and search these publications.

The Safety Standards Series and Nuclear Security Series provide guidance to authorities and other relevant stakeholders on how to enhance the safety and security of nuclear technologies. They cover activities relating to nuclear installations and application of radiation sources in medicine, industry, agriculture and research. The content of the publications is developed by the IAEA in close cooperation with governments and organizations around the world. The publications are revised and updated periodically. The two sets of publications are organized in a hierarchical manner, with the Safety Fundamentals and the Nuclear Security Fundamentals applying to all activities and lower-level publications providing more specific recommendations.

"NSS-OUI forms a key part of the IAEA's work to support countries in applying these publications," said Gustavo Caruso, Director of the IAEA's Office of Safety and Security Coordination. "It is the only platform where all these publications are accessible as a complete set. It also illustrates how higher-level publications, which state the conditions that need to be achieved, are connected with more practical publications, which explain how we get there."

NSS-OUI enables users to search for specific keywords or text, as well as offering them an advanced semantic search tool. This way, users can quickly find specific requirements, recommendations and guidance related to selected subject areas or concepts.

The interface also allows for more effective revision of the content of publications by experts, said Mr Caruso. "It is the only way consistency can be assured during the establishment of new standards and the revision of existing ones," he said. "The tool includes a mechanism for collecting feedback from authorized users, which helps us link new knowledge to existing content and allows for effective revision focused on topics, rather than on individual publications."

The platform has several hundred regular users. They include members of the Safety Standards Committees, the Commission on Safety Standards and the Nuclear Security Guidance Committees. Over 1500 new users have started using NSS-OUI since the beginning of this year alone, following training courses in several countries.

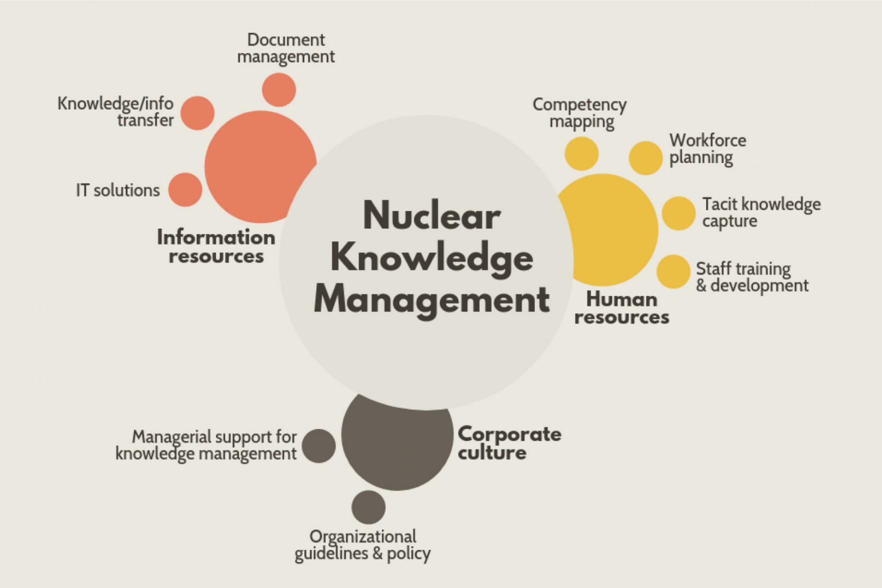
"This interface is a powerful time-saver. It is a one-stop-shop search engine specifically designed for easy access to the content of the IAEA's nuclear safety and security series," said Fiona Charalambous, Assistant Director and Senior Scientist for Assessment and Advice at the Australian Radiation Protection and Nuclear Safety Agency. "It helps me to identify key areas of interest from the standards, to technical reports and much more. It helps me to efficiently discover cross references that may be of use to my work. For example, I can use key search terms and compare these across standards, guides, recommendations and technical reports within a particular context."

NSS-OUI provides updated information on related publications and on references that have been superseded. It also features references and links to other relevant IAEA publications, such as the IAEA Technical Documents series. Newly added standards will contain links to the definitions in the IAEA Safety Glossary to help ensure the correct understanding of any special terms that are used.

"Without this interface, you might get lost among all the material included in the Safety Standards Series and the Nuclear Security Series. With it, you will be able to find the information you need," said Mr Caruso. "In this way, NSS-OUI contributes to global nuclear safety and security."

— By Nathalie Mikhailova

Over 700 professionals trained through IAEA's Nuclear Knowledge Management Schools



Education and training are necessary to ensure that the next generation of nuclear industry professionals are prepared to manage complex nuclear power programmes. Helping national authorities, especially in developing countries, to obtain and manage this knowledge is key to the sustainability of nuclear power. With the closure of the 15th Joint IAEA-ICTP Nuclear Knowledge Management School on 9 August, the IAEA celebrates a milestone of training over 700 young professionals, since the inception of the Nuclear Knowledge Management School in 2004.

Jointly organized by the Abdus Salam International Centre for Theoretical Physics (ICTP) and the IAEA, the Nuclear Knowledge Management School, to date, has trained professionals from over 80 countries and provides participants with specialized education and training on the development and implementation of nuclear knowledge management programmes in nuclear science and technology organizations. Topics include, among others, human resource development, developing policies and strategies in managing nuclear knowledge, managing nuclear information resources, risk of knowledge loss and knowledge transfer.

"Nuclear technology is complex and multi-disciplinary. In order to ensure safety, each country has a responsibility not only to establish adequate technical knowledge and expertise in their nuclear organizations, but also to maintain this knowledge and ensure its availability," said Wei Huang, Director of the Division of Planning, Information and Knowledge Management. "This is why the IAEA heeded calls from its Member States in the early 2000s, to establish a knowledge management programme."

Nuclear knowledge management has become an increasingly important element of the nuclear sector in recent years, not only because of challenges posed by capacity building needs, an ageing workforce, declining student enrolment in science and engineering programmes, but also because having an effective knowledge management programme in place is crucial for the development of a sustainable safety culture.

"We have helped our organization identify, transfer, preserve and spread critical knowledge, especially as we face the retirement of our ageing workforce," said Belgica Villalobos, Head of Organizational Development in Human Resources at CChEN. "With the tools I have learned at the School in 2011, I have been able to implement an 'in-house' nuclear knowledge management system at the Chilean Nuclear Energy Commission."

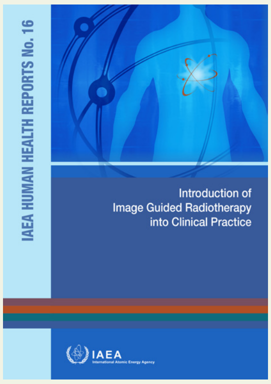
Building capacity through training and education and improving access to existing knowledge through sharing and pooling methods are essential, Huang said. Nuclear knowledge management not only directly impacts human resources but also information and communication technology, process and document management systems. National and organizational strategies relating to nuclear safety can be significantly influenced by the ability to manage knowledge both now and in the future.

Lesego Moloko, Senior Scientist at the South African Nuclear Energy Cooperation (NESCA), underlined the importance of the School: "I would certainly recommend to scientists, managers and HR professionals alike to participate in the School, to ensure that necessary skill transfer mechanisms are in place. Since my return from the School, NESCA has established a special office which ensures that the knowledge management programmes in nuclear science and technology are implemented within the company."

"As we open up to the prospect of rolling out a significantly greater number of NKM Schools next year, in response to more requests from Member States, a new standardised curriculum and model has been developed," said Maria Elena Urso, knowledge management specialist at the IAEA and the scientific secretary of the School. This includes both an online digital component and traditional classroom methods.

"The aim of all of our Schools is to encourage participants to think about the future and apply learned knowledge management theory directly in their workplace," she said.

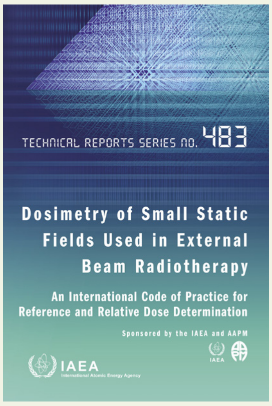
— By Shant Krikorian



Introduction of Image Guided Radiotherapy into Clinical Practice

provides guidelines and highlights the milestones to be achieved by radiotherapy departments in the safe and effective introduction of image guided radiotherapy. Recent advances in external beam radiotherapy include the technology to image the patient in the treatment position and in the treatment room at the time of treatment. Since this technology and associated image techniques — termed image guided radiotherapy — are perceived as the cutting-edge of development in the field of radiotherapy, this publication addresses the concerns of personnel in radiotherapy departments as to the preparatory conditions and resources involved in implementation. Information is also presented on the current status of the evidence supporting the use of image guided radiotherapy in terms of patient outcomes.

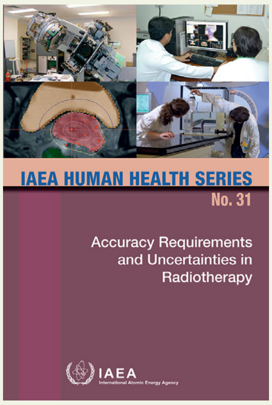
IAEA Human Health Reports No. 16; ISBN: 978-92-0-103218-8; English Edition;
31.00 euro; 2019
www.iaea.org/publications/12264/image-guided-radiotherapy



Dosimetry of Small Static Fields Used in External Beam Radiotherapy

provides consistent reference dosimetry, traceable to metrological primary standards, and enables common procedures within a country to be followed. The publication presents an overview of the physics, followed by a general formalism for reference dosimetry in small fields. Guidelines for its practical implementation using suitable detectors and methods for the determination of field output factors are given for specific clinical machines that use small static fields. The development of this code of practice has been done through an international working group, established jointly with the American Association of Physicists in Medicine. Internationally harmonized guidelines in this field will ensure worldwide consistency in dose delivery to radiotherapy patients and will contribute to dose standardization in international clinical trial studies, comparing outcomes of various radiotherapy treatment modalities using small fields.

Technical Reports Series No. 483; ISBN: 978-92-0-105916-1; English Edition; 52.00 euro; 2017
www.iaea.org/publications/11075/dosimetry-of-small-static-fields



Accuracy Requirements and Uncertainties in Radiotherapy

is an international consensus document on accuracy requirements and uncertainties in radiotherapy in order to promote safer and more effective treatments on patient. This publication addresses accuracy and uncertainty issues related to the vast majority of radiotherapy departments, including both external beam radiotherapy and brachytherapy. It covers clinical, radiobiological, dosimetric, technical and physical aspects.

IAEA Human Health Series No. 31; ISBN: 978-92-0-100815-2; English Edition;
76.00 euro; 2016
www.iaea.org/publications/10668/accuracy-requirements-and-uncertainties-in-radiotherapy

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