IAEA
International Atomic Energy Agency

IAEA Syllabus for the Education and Training of Radiation Oncologists

Endorsed by the American Society for Radiation Oncology (ASTRO) and the European Society for Therapeutic Radiology and Oncology (ESTRO)

VIENNA, 2009

TRAINING COURSE SERIES 36

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FOREWORD

The incidence of cancer is rising steadily in low and middle-income countries. Over the next 25 years, the majority of new cases and deaths will occur in these countries — in part because of population growth, greater longevity, and lifestyle changes, but also because the health systems in these countries have not yet developed the capacity to prevent or control cancer. A major challenge for many developing countries will be finding sufficient resources to address these trends. The IAEA Technical Co-operation (TC) programme already dedicates more than 28% of its total budget to projects focused on human health. The IAEA is currently supporting over 120 Technical Cooperation projects related to radiotherapy in more than 100 Member States.

The lack of sufficiently trained staff is a critical problem for the establishment of adequate radiotherapy services in the developing world. The importance of addressing and eventually solving this problem cannot be overemphasized. Many factors contribute to this limitation, including few job positions, low salaries, lack of training programmes, difficulties in the recognition of accreditation obtained in other countries and emigration of professionals to more affluent countries. The appropriate training and subsequent retention of professionals is essential for planned radiotherapy services to be effective in dealing with this 'silent crisis' of cancer in the developing world.

The IAEA has embarked on the preparation of a series of syllabi for the training of the main professions involved in providing radiotherapy services. These professions include radiation oncology physicians, medical physicists, radiation therapy technologists, radiation oncology nurses and applied radiation biologists. While many countries have already developed and implemented their own syllabi for the training of radiation oncologists, these cannot usually be extrapolated to low or middle income countries. The present publication intends to facilitate the work of managers and directors of radiation oncology training programmes at the time of establishing new programmes or upgrading existing ones. In developing the syllabus, the authors have kept in mind the possible limitation of resources available in many countries and regions, while at the same time keeping a high educational standard that would expose the trainee to modern radiotherapy concepts and well established effective techniques.

The present guidelines for training represent the minimal requirements to be adapted, adopted and implemented in low and middle income countries. Different/higher requirements may be appropriate in more affluent or higher resource environments.

This publication is aimed at programme directors of radiation oncology training programmes, as well as institution managers and teaching staff involved in the planning and implementation of educational activities. The syllabus should be carefully examined and adapted to the realities of the particular training centres or countries. It will be translated into the UN official languages; we encourage the user to translate it to local languages so that this tool can be readily understood, discussed and implemented by all members of the faculty team.

The first draft of this syllabus was prepared during a meeting of external consultants working with IAEA staff in Vienna in August 2006. This group included experts with ample experience not only in the education of residents, but in the preparation of guidelines and syllabi for residency training in their respective countries or regions. The manuscript was subsequently revised by internal and external reviewers familiar with the process of training radiation oncology residents (see acknowledgments).

The professionals and organizations listed in the main text collaborated in the preparation and review of this syllabus. The drafters and reviewers have contributed to the syllabus in their personal capacity as professionals with experience in the training and education of radiation oncology residents in various regions of the world. In addition, ESTRO (European Society for Therapeutic Radiology and Oncology) and ASTRO (American Society for Radiation Oncology) have both revised and endorsed this syllabus for the training of radiation oncologists in low- middle-income countries (LMI) countries. Special thanks are due to J.V. Salvajoli (Brazil), N.R. Datta (India), J.W. Leer (Netherlands), G. Vega (Philippines) and B. Hafty (USA) for their substantial contributions to the drafting and review of this publication.

The IAEA officer responsible for this publication was E. Rosenblatt of the Division of Human Health.

EDITORIAL NOTE

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1. INTRODUCTION

Cancer is one of the leading causes of death globally and cancer incidence is predicted to increase, especially in developing countries. Almost 13% of all deaths worldwide are caused by cancer. In 2005, there were more than 7.6 million cancer deaths worldwide and 10 million newly diagnosed cases of cancer. Today there are more new cancer cases every year in low-middle income (LMI) countries than in industrialized countries, and cancer rates are projected to increase significantly in developing countries. By 2020, two-thirds of the projected 10 million annual cancer deaths will be in developing countries.

Radiotherapy plays a fundamental role in the continuum of cancer care. However, this technology is not comprehensively provided and in some countries not provided at all. According to the IAEA's Directory of Radiotherapy Centers (DIRAC), as of January 2004 there were about 2000 radiotherapy centres in the developing world with fewer than 2500 teletherapy machines dedicated to cancer therapy. The deficit is not just one of machines — each radiotherapy facility needs trained staff (radiation oncologists, medical physicists, technologists, radiation oncology nurses and maintenance engineers) as well as appropriate arrangements for radiation protection, safety, security and a continuing and ongoing effort to ensure the quality of the radiotherapy process. Strengthening the capability of ministries of health and other health sector institutions for assessing options, formulating policies, and setting priorities is also crucial.

The International Atomic Energy Agency (IAEA) has been assisting its Member States in the establishment, operation and upgrading of radiation oncology facilities for many years. Human resource development, which includes training of radiation oncologists, medical physicists, radiation therapy technologists and radiation oncology nurses, is an integral part of the assistance as shortage of such trained professionals would be a serious obstacle to making radiotherapy accessible to cancer patients.

To ensure a uniformity and consistency in the training that could be undertaken by the various medical institutions running their postgraduate programmes in radiation oncology the IAEA's intent in formulating a syllabus for the education and training of radiation oncologists is to provide guidance for all professionals and administrators involved in the training of this discipline. The syllabus seeks to address the training requirements in developing countries in order to establish a common and consistent framework. It provides both a structure for the organization of the training and a core curriculum. The guidelines outlined in the core curriculum could be adopted by the various Member States as a baseline for national curricula.

These guidelines have been framed via consultations with representatives of the Member States — both from developed and developing countries at a Consultants' Meeting held at IAEA headquarters in Vienna on 14-17 August 2006 and were commented on by major national and regional societies of radiation oncology.

The IAEA recognizes the variability in the prevalence and spectrum of diseases as well as the variation in the availability of different technologies in the countries and regions. National and regional societies should prioritize the subjects presented in the core curriculum and adapt them to the disease profiles observed in their own countries/regions. Countries with a limited number of radiation oncologists should recognize the fact that cancer care is becoming ever more specialized and other aspects of cancer care such as medical oncology and palliative care should act in collaboration with the radiation oncologists to cover these other partially overlapping disciplines. The IAEA promotes a policy of multidisciplinary decision-making

regarding the management of the individual patient, where the radiation oncologist interacts with other disciplines as a competent and independent specialist.

2. DEFINITIONS

Radiation oncology is the discipline of clinical medicine that uses ionizing radiation either alone or in combination with other modalities for the treatment of patients with malignant or other diseases. The specialty can be practiced as an independent oncology specialty or may be integrated into the broader medical practice of clinical oncology with the use of chemotherapy agents and targeted therapy to enhance the effectiveness of radiation in a multi-modality setting for providing a comprehensive treatment to cancer patients. Radiation oncology includes the responsibility for the diagnosis, the treatment, the follow-up and the supportive care of the cancer patient.

The dual terminology of **radiotherapy or radiation oncology** exists since a number of Member States adopt either of these nomenclatures to indicate this specialty. In our view, '**radiotherapy'** or radiation therapy is a clinical modality dealing with the use of ionizing radiation in the treatment of patients with malignant neoplasia (and occasionally benign diseases). However, **'radiation oncology'** has a broader meaning defining that discipline of medicine concerned with the generation and dissemination of knowledge concerning the causes, prevention and treatment of cancer and other diseases involving special expertise in the therapeutic applications of ionizing radiation. As a discipline that exists at the juncture of physics and biology, radiation oncology addresses the therapeutic uses of ionizing radiation alone or in combination with other treatment modalities such as surgery, chemotherapy and targeted therapy. Furthermore, radiation oncology is concerned with the investigation of the fundamental principles of cancer biology, the biologic interaction of radiation with malignant and normal tissue, and the physical basis of therapeutic radiation (1).

(1) Source: Perez C.A.,Brady L.W. Halperin E.C. Principles and Practice of Radiation Oncology, 5th ed. Lippincott Williams and Wilkins, 2007.

Following the successful completion of training, the specialist could be considered either as a 'radiotherapist' or as a 'radiation oncologist' depending on the term used in the country of his/her training. The term 'radiotherapist' as used here refers to a medical doctor and not to a radiation therapy technologist (RTT). However, the term *radiation oncologist* is preferred in this document particularly as the term radiotherapist refers to non- medical staff in some countries.

3. GENERAL OBJECTIVES OF THE TRAINING

The objectives of the training programme are to educate and train physicians in radiation oncology up to the level of being recognized as a specialist capable of practicing the specialty competently and independently.

Following successful completion of their training, the trainees should have:

1. Enough theoretical knowledge and practical skills for the competent, safe, ethical and compassionate practice of radiation oncology at the level for which they have been trained.
2. A capability to manage cancer patients comprehensively, including:
    a. the complications associated with malignant disease and its treatment;
    b. rehabilitation and palliative care;
    c. psychosocial aspects

3. Knowledge of the epidemiology, etiology, pathology and natural history of human neoplasia, especially of those common in the country of his/her training.

4. Familiarity and skills in the choice of all necessary and available diagnostic aids in the diagnosis and management of cancer.

5. Technical expertise in radiation oncology at the required level based on the available resources and knowledge of the whole scope of radiation oncology and the adverse effects of radiation including radiation related complications.

6. Familiarity with the role of surgery, medical oncology and other medical disciplines involved in the management of neoplastic diseases.

7. Capacity to interpret current advances in cancer care and research (clinical, laboratory or basic).

8. A basic knowledge of the different statistical methods used in the interpretation of data related to cancer (with special emphasis on planning and interpretation of clinical trials).

9. Sufficient interest, knowledge and skills to contribute to future developments in radiation oncology.

4. ORGANIZATION OF THE TRAINING

4.1. NATIONAL AUTHORITY

The IAEA advises Member States to have a National Authority which should be the ultimately responsible body for the organization and monitoring of the training programme in the country, including the implementation of an audit system for the periodical evaluation of recognized training institutions and programmes (Appendix I).

The National Authority should also be responsible for the eligibility of the trainees and their certification. It is advised that the National Authority creates a suitable mechanism for those already certified as radiation oncologists to keep them updated with recent developments in the field, by a system of life-long learning to maintain competence within the evolving practice environment.

4.2. LENGTH AND SCOPE

The overall length of a training programme in radiation oncology should be the shortest possible to assure the initiation of the graduate's work in his/her country, without compromising the quality of the training. It must be recognized that in low-middle income countries, the lack of trained professionals in radiation oncology is an acute problem. Therefore, when resources are available from local or external sources to establish/upgrade radiotherapy services, there is usually a pressing need to have the staff trained in the shortest time possible.

The minimum training period in radiation oncology should be three (3) years full-time following medical school graduation, or if part-time, an equivalent period spent in the specialty. This period of three years should be regarded as the minimal period of time to cover the suggested curriculum.

Over this full-time equivalent of 3 years, the candidate will be expected to gain a sound knowledge of radiation oncology as part of the comprehensive management of cancer as well as other diseases. During this period the candidate will work as a resident in clinical radiation oncology and participate in seminars, conferences, teaching assignments and interdepartmental clinics and both external beam and brachytherapy procedures.

4.3. LEVELS OF SKILLS

It is recognized that different levels of skills are needed depending on the differences in infrastructure and equipment present in different institutions.

Levels 1 and 2 (mandatory) as described here are *required* for all radiation oncologists and training should be provided in all training programmes.

The elements presented as level 3 are considered *desirable but not mandatory.* However, each trainee should familiarize him/herself with them, either through didactic training and/or clinical experience.

Level 1:

- Basic radiotherapy planning by orthogonal x rays or a conventional fluoroscopic simulator using bony landmarks, skin marks, intraluminal or intracavitary contrast media and/lead wire or radio-opaque marks identifying target volumes and critical structures..

- Manually calculated dose distributions using isodose charts or a simple 2D calculation programme on a contour reconstruction.

- Treatment by a cobalt unit using simple field arrangements. The use of orthovoltage units for the treatment of skin cancer or superficial tumours is included in this level.

- Brachytherapy using manual/remote afterloading with standard dosimetry.

- Simple mould room techniques.

Level 2:

- Intermediate level of planning using a simulator with patient contouring or a CT-simulator, anatomical reconstruction using diagnostic CT information acquired in treatment- position, identifying target volumes and critical structures. Based on this information an individual treatment two-dimensional (2D) or three-dimensional (3D) plan is created using a treatment planning system.

- Treatment is given using either a cobalt unit or a linear accelerator. Patient position is checked during treatment and corrected if necessary. Mould room and immobilization devices are used.

- Brachytherapy using intracavitary, interstitial and intraluminal afterloading techniques is practiced with individual dose-planning.

Level 3: (desirable but not mandatory)

- Complex treatment planning is performed by the use of a dedicated CT-simulator.

- MRI, PET and/or PET/CT information can be incorporated by image fusion technology. Target volumes and organs at risk are identified. Beam's-Eye Views and Dose Volume Histograms (DVH) are used. An individual 3D plan is made which is highly conformal using multiple fields and/or segments based on forward or inverse treatment planning.

- Treatment is given with a linear accelerator using a multi-leaf collimator (MLC). Portal imaging verification protocols and in-vivo dosimetry are used.

- This level includes techniques such as virtual simulation, intensity modulated radiation therapy (IMRT), image-guided radiotherapy (IGRT), intra-operative radiation therapy (IORT), stereotactic radiosurgery (SRS), adaptive radiotherapy (ART), respiratory gating and three-dimensional (3-D) image-based brachytherapy planning.

- The training in Level 3 should include the study and understanding of axial radiological anatomy, the identification of tumours and organ structures, the delineation and contouring volumes of tumours and organs at risk and the implementation of treatment plans based on volumes.

4.4. REQUIREMENTS FOR THE TRAINEES

The candidate for the postgraduate programme in radiation oncology should be a medical graduate from a medical school (some medical schools also provide education in other disciplines not only towards an MD degree) that has completed the entire core curriculum of the graduate training programme as laid down by the National Authority. It is the responsibility of the Training Institute and Programme Director to ensure that the candidate's background level of knowledge in medicine is adequate to successfully undertake the radiation oncology training programme.

4.5. TRAINING INSTITUTES

4.5.1. General requirements

The institutes offering the training programme should be accredited by the National Authority through an auditing process (Appendix I) taking into consideration the necessary infrastructure, both in terms of the clinical material, radiation therapy equipment and an adequate strength of faculty as described in this syllabus (4.1.7).

A training institute should have the necessary infrastructure, staffing and patient case-mix to provide training for the different skills levels as described in this syllabus. The National Authority can accredit a training institute for the training in the different levels of skills.

If the requirements for training institutes set forth in this syllabus cannot be met by a single institution, several training institutes may collaborate to offer an integrated programme that meets these requirements.

These affiliated institutions should be considered as part of ***one training programme***. Each affiliated institute may have a local programme co-ordinator for their component of the training programme that will be responsible for the educational activities in that particular centre (local programme co-ordinators). One of these will be the Programme Director who should bare responsibility for the full training programme.

The training institute should be embedded in or affiliated with a hospital where adequate medical services are available such as surgical and medical specialties, gynecology, pathology, diagnostic radiology, nuclear medicine and other specialized medical and surgical departments.

In addition, the training institute should have sufficient reference books, journals, and ready access to computerized medical literature search systems.

The training institute must ensure that the clinical and basic sciences are taught through regularly scheduled lectures, case presentations, conferences and discussions relevant to the practice of radiation oncology.

It is recommended that the teaching programme has a number of activities that will greatly contribute to the trainee's education such as: new case conferences, chart rounds, journal clubs, seminars and multidisciplinary tumour boards.

It should also ensure — through a documentation mechanism — that the candidate attends these lectures, conferences, teaching rounds, case presentations on the various topics of radiation oncology including radiotherapy, chemotherapy, cancer biology, statistics, radiation biology, medical physics and others as per the core curriculum.

4.5.2. Infrastructure of training institutes

Based on the levels of skills the infrastructure of the (collaborating) training institutes is described as follows:

No.	**MANDATORY FOR LEVELS 1-2**
1.	Teletherapy: at least two megavoltage units one of which may be a cobalt-60 unit and one must be a linear accelerator with or without electron beam.
2.	Brachytherapy unit: preferably high dose-rate
3.	Treatment simulator, either a conventional simulator or a CT-simulator
4.	Treatment planning system or access to computerized treatment planning
5.	Mould room facility
6.	Equipments for dosimetry and physical quality assurance (QA)

	DESIRABLE FOR LEVEL 3
1.	Facilities to execute 3-D conformal, intensity modulated radiotherapy and if available stereotactic radiotherapy, radiosurgery and/or intra-operative radiotherapy. Not all of these activities are required to qualify as level 3.
2.	Tumour biology and/or radiobiology laboratory.

In the event that the training centre cannot provide all equipments/techniques related to levels 1-2, the Programme Director (PD) (see 4.7.) has to make adequate arrangements in collaboration with the other co-ordinators, so that the trainees can rotate to affiliated centres where these techniques are in use.

For level 3 skills the PD can make a decision to send the trainees to the appropriate centres to gain clinical experiences in these modalities.

4.5.3. Size of training institutes

To ensure adequate numbers and variety of patients, a minimum number of patients (suggested: at least 500 patients per year) should be treated in the programme with external beam and adequate number of brachytherapy procedures to fulfill the requirements according to national guidelines.

4.6. TRAINING PROGRAMME

The programme should comply with the guidelines outlined in this syllabus and to the specific national requirements.

The curriculum structure, time frame, distribution of responsibilities and objectives of each module of each individual training programme should be outlined in writing at the beginning of the programme.

The trainee will be made aware of the objectives of the training and will also develop personal objectives for each module.

The educational effectiveness of the programme should be regularly evaluated in a systematic manner by the Programme Director (PD) through evaluation of the curriculum and faculty.

4.7. FACULTY

4.7.1. Programme Director (PD)

Each training institute or integrated programme should appoint a single PD responsible for the trainee education. He/she may or may not necessarily be the Department Director. He/she must be highly qualified (a graduated radiation oncologist) with considerable experience in trainee education and organizational skills.

The PD is responsible for the general administration of the programme, the structure and its contents. The PD ensures that the programme fulfils the criteria set in this syllabus and those required by the National Authority. The PD should organize regular meetings with the teaching staff to assess the overall progress and meeting of the stated objectives.

The programme director should discuss with each individual trainee on a periodic basis his/her progress through the programme, according to the evaluations made by the supervisors, the logbook and results of examinations. These interviews should be documented.

4.7.2. Medical (radiation oncology) teaching staff

A sufficient number of staff members should be involved in the active teaching activities. Adequate staffing means that the ratio of trainee/trainer should not exceed 1.5–2/1. The trainers must devote sufficient time to the teaching programme and must have appropriate qualifications as defined by the National Authority.

4.7.3. Medical physics teaching staff

Medical physics support must be available in each training programme.

Consequently, at least one full-time employed qualified medical physicist should be actively involved in teaching. The physics staff should be responsible for the teaching of chapters on basic radiation physics, applied medical radiation physics including treatment planning, elements of dosimetry, quality assurance and radiation protection.

4.7.4. Radiobiology teaching staff

Recognizing that not all institutes will have cancer biologists or radiation biologists on staff, the minimum requirement is to provide sufficient training in radiobiology and cancer biology to meet the endpoints outlined in the core curriculum.

The IAEA's Applied Sciences of Oncology (ASO) distance learning course available in CD-ROM format and fully downloadable from IAEA's website, could be used to supplement the radiation biology teaching and trainees' self assessment (Appendix II). In addition, two widely used textbooks on radiobiology are recommended (page 38).

5. OTHER RESOURCES

5.1. TELEMEDICINE NETWORK AND E-LEARNING

Electronic learning (e-learning) resources would enhance the scope of the training programme and help supplement the resident's education.

The use of the IAEA Applied Sciences of Oncology (ASO) distance learning course is recommended. IAEA distance learning modules on the basic sciences of oncology could facilitate the teaching programme and also allow for a self assessment of the trainees. This programme is an introduction to the applied sciences of oncology. It is not intended to be a comprehensive course, but will assist the trainee to cover the basic sciences component of the curriculum presented in this document.

The programme covers eight subjects, each consisting of a number of modules. It is designed to supplement textbooks with practical information and examples, and to give an overview of knowledge not easily gained from any one textbook.

The programme has been produced for the IAEA to provide cancer education for doctors in countries where there is little education currently available. The content of this distance learning course is presented in Appendix II.

In view of the rapid strides and the ease of availability of information technology, e- learning through telemedicine networks (teleconferencing or videoconferencing) could be explored to facilitate inter-institutional teaching. These could be adopted as a virtual classroom for the trainers to provide training to a wider section of trainees, ensure uniformity of content, and facilitate training without displacing the trainees for extended periods of time from their home institutions.

Telemedicine systems could also be used for web-consulting, teleconferencing and web-lecturing.

An IAEA strategy is to create regional cancer training networks, whereby countries in any given region that are currently more advanced in terms of cancer control capacity and share similar conditions, can serve as mentors to other countries in the same region. Relying on modern information technology tools and drawing on the positive experience in several developing countries where, despite low resources, successful training systems have been established, each Regional Cancer Training Network will utilize both, a ‘Cancer Control International Mentorship Network’, and a ‘Virtual Cancer Control University’.

A Virtual Cancer Control University could provide internet access to the latest training techniques in radiotherapy, and allow information exchange and video-conferencing on all aspects of multidisciplinary cancer control. Such training will allow large number of established experts to teach without the need to travel long distances.

6. DOCUMENTATION OF THE TRAINING EXPERIENCE

6.1. GENERAL REQUIREMENTS

The training institute should maintain a record of each trainee’s clinical rotations, logbook and evaluations.

The trainee is in turn responsible to keep a record of his/her clinical training procedures ('logbook'). This can be extended to a full portfolio including 5 sections:

1. Personal data of the trainee.
2. Scientific training documentation.
3. Clinical training procedures documentation (‘logbook’).
4. Records of formal presentations by the trainee.
5. Publications.

6.2. SUGGESTED OUTLINE OF THE PORTFOLIO

The portfolio would be an essential part of the systematic collection of information that would help to monitor the professional development of the individual trainee. The portfolio should be updated by the trainee and should be countersigned by the supervisor for each of the recorded activities:

Section 1: Personal data

This section will include updated curriculum vitae (CV) with details of the local training programmes being followed, including visits to other institutes and registration numbers with the national licensing authority.

Section 2: Scientific training documentation and other courses

This section will include details of teaching courses and programmes attended within the institute or elsewhere.

Section 3: Clinical training documentation

This section should include details of all clinical rotations and a logbook recording all clinical procedures attended and/or performed by the trainee (Appendix III).

Section 4: Record of formal presentations by the trainee

This section could include a copy of any handouts, overheads, copies of slides/power point presentations and written audit reports prepared for meetings within the department.

Section 5: Publications

This section will record posters presented at national or international meetings and copies of any scientific papers that may have been authored or co-authored by the trainee.

7. EVALUATION OF THE TRAINEE

The National Authority will be responsible for establishing the mechanisms of evaluation of the trainee. Trainee evaluation records should be permanently maintained by the training institute. Assessment mechanisms could include:

- Evaluation by the faculty (supervisors)
- Periodical interviews with the Programme Director
- Evaluation of the logbook or portfolio
- Examinations.

The trainee's record should contain a final Programme Director's certification of the satisfactory fulfillment of the programme's requirements. The trainee will then be certified as per the mechanism established by the National Authority to practice independently as a radiation oncologist.

8. CORE CURRICULUM

8.1. GENERAL ENDPOINTS

During the training period each trainee should acquire *knowledge* (Category A = didactic training) or *knowledge and skills* (Category B = interactive/practical training) in the listed topics of the core curriculum for radiation oncology.

Category A: The trainee should acquire knowledge by didactic training.

Category B: The trainee should acquire both adequate knowledge and clinical skills in the management of that disease/site.

To acquire sufficient clinical skills a minimum number of patients should be treated by the trainee under qualified supervision.

The number of patients seen by a trainee is defined as the equivalent to a completely treated patient from the first visit until follow-up ('full case-equivalent'). Each trainee should see at least 400-450 full case-equivalents during the total clinical radiation oncology training course and rotations.

The number and types of brachytherapy procedures required should be defined by the National Authority. By the completion of training, the trainee will be familiar with all aspects of brachytherapy planning, treatment and supervision, including demonstrating familiarity with those tasks of the brachytherapy treatment which are normally performed by the radiation oncologist.

An adequate case-mix for each trainee should be continuously monitored and recorded in the logbook (Appendix IV).

The category of knowledge and skills expected of the trainees for each component of the curriculum should be decided upon by the National Authority taking into consideration the relative cancer incidence frequent in the country or region. The indicated categories in the core curriculum are suggested by the IAEA.

8.2. SCIENTIFIC TRAINING

It is advisable that the trainee understands the principles of the conduct of clinical research in radiation oncology and the basic methodology of data management and statistical analysis. It is desirable that the trainee takes part in clinical research studies ongoing in the department. The trainee should at least be capable of understanding and interpreting published scientific literature.

While participating in ongoing studies in the department, trainees will be encouraged to initiate and complete studies under qualified mentorship, either within the programme, with an outside mentor or both. Trainees should be made aware by the training department of funding and mentorship opportunities and potential venues for optional external rotations wherein such research could take place.

8.3. SPECIFIC ENDPOINTS

8.3.1. Basic sciences curriculum

8.3.1.1. General knowledge

Epidemiology of cancer

Cancer prevention, screening, early detection and education of the public

Tumour classification and staging systems

Treatment with surgery, chemotherapy, endocrine therapy, other forms of treatment and combined modalities including risks and benefits of concomitant chemo-radiation.

The structure/organization of oncology services. Multidisciplinary care.

8.3.1.2. Anatomy (A)

Cross sectional anatomy including practical training in contouring of target volumes and critical structures (B)

8.3.1.3. Pathology (A)

8.3.1.4. Biology of cancer

Tumour physiology (A)

Angiogenesis

Microenvironment

Hypoxia and re-oxygenation

Cell proliferation in tumours (A)

Cell cycle and cell cycle control

Proliferation and cell death

Tumour heterogeneity

Metastasis

Hereditary cancer (A)

Cancer genetics (A)

8.3.1.5. Radiobiology

Interaction of radiation at the molecular level (A)

Radiation absorption

- DNA damage and repair
- Chromosomal aberrations

Cellular effects, mechanisms of cell death (A)

- Cell survival curves
- Models of cell killing
- Radio sensitivity
- Effects of oxygen, sensitizers and protectors
- Signal transduction

Normal tissue systems (A)

- Proliferative and cellular organization
- Response to irradiation
- Volume effects

Acute and late normal tissue reactions (B)

- Clinical manifestation
- Sensitivities
- Re-treatment (re-irradiation) tolerance

Time-dose fractionation (B)

- Fractionation
- Linear-quadratic (LQ) model; α/β-concept
- Time factor (tumours and normal tissues)

Tumour responses (B)

- Overall treatment time
- Accelerated repopulation

Combination of systemic therapy and radiotherapy (B)

- Sequencing of the modalities
- Molecular targets

8.3.1.6. Basic radiation physics

Atomic and nuclear structure (A)

Radioactivity and decay (B)

Production of x rays, photons and electrons

Properties of particle and electromagnetic radiation (A)

Radiation interactions

Radiation beam quality and dose

Radiation measurements and calibration

Radioisotopes (A)

8.3.1.7. Applied medical radiation physics

X ray tube (A)

Cobalt-60 units (B)

Linear accelerators (B)

Specialized collimating systems (A)

Absorbed dose distributions (B)

Target volume specification (B)

Brachytherapy (A)

Target absorbed dose specification in external beam radiotherapy (B)

Target absorbed dose specification in brachytherapy (B)

Dosimetry and treatment planning including three-dimensional conformal radiotherapy (3D-CRT) (A)

Immobilization for 3D-CRT (A)

Imaging for radiation oncology; use of imaging for treatment planning

Verification of setup and dose delivery (portal imaging, in-vivo dosimetry) (A)

CT and cone beam CT (A)

New technologies in radiation oncology; IMRT/IGRT (A)

Informatics (DICOM, networking, PACS, data management)

Special irradiation techniques:

- Total body irradiation (TBI) (A)
- Stereotactic radiosurgery (SRS) (A)
- Total skin electron irradiation (TSEI) (A)
- Particle therapy (protons, heavy ions) (A)

Quality assurance

8.3.1.8. Principles of radiation protection

General philosophy, ALARA (A)

Basic framework of radiation protection

Regulation and national infrastructure

Safe operation of teletherapy and brachytherapy equipment

Risk of induction of secondary tumours (A)

Equivalent dose-tissue weighing factor (B)

Prevention of accidental exposures in radiotherapy

Radiation protection issues with imaging technology

Medical exposure

Occupational exposure

Public exposure and emergency planning

Stochastic and deterministic effects (A)

Radiation carcinogenesis

Hereditary effects of radiation

Effects of radiation on the embryo and fetus (A)

8.3.1.9. Imaging and target volume

Imaging modalities, procedures and technology (A)

Disease oriented imaging (A)

Image handling in radiotherapy (B)

Target volume determination in clinical practice (B)

Gross Tumour Volume (GTV), Clinical Target Volume (CTV), Planning Target Volume) PTV and relevant ICRU (International Commission for Radiation Units and Measurements) recommendations (B)

Developments in imaging (A)

8.3.1.10. Measurements of treatment outcomes and clinical research

Cancer epidemiology (A)

Searching for evidence (A)

Design of clinical trials (A)

Critical appraisal of scientific papers and presentations (A)

Survival analysis (A)

Patient-based endpoints in clinical trials (A)

Systematic reviews and meta-analysis (A)

Clinical decision analysis (A)

Prognostic indices (A)

Reporting (A)

Effect of waiting times on treatment outcomes (A)

8.3.2. Clinical curriculum

8.3.2.1. General clinical competencies

As a responsible and independent member of a multidisciplinary team a specialist in radiation oncology should be able to:

- Recognize symptoms and signs of cancer.
- Make a diagnostic plan for suspected tumours or metastases and perform staging and classification of manifested tumours.
- Perform a prognostic assessment, define the treatment aim, choose the radiation modality (or interdisciplinary modality), plan and apply optimal radiation therapy and carry out the follow-up during and after treatment.
- Apply radiobiological skills in clinical practice.
- Diagnose, score and treat side-effects of radiation therapy, assess the impact of radiation oncology on quality of life.
- Communicate adequately and accurately with cancer patients and their families.

- Manage common psychological reactions to crises and to the final stage of life.
- Perform supportive care/symptomatic treatment and terminal care.
- Recognize own limitations and refer to appropriate allied staff and colleagues when appropriate and available (radiologists, medical oncologists, specialists in palliative care, pain specialists).
- Practice medicine in accordance with medical ethics and patients' rights.

8.3.2.2. Specific organs and/or diseases

During the training period each trainee should acquire *knowledge* (Category A) or *knowledge and skills* (Category B) in the below listed topics. The indicated categories can be modified by national authorities taking national or regional epidemiological differences into account.

Head and Neck Cancer

- Oral cavity (B)
- Oropharynx (B)
- Nasopharynx (B)
- Hypopharynx (B)
- Larynx (B)
- Nasal cavity and paranasal sinuses (B)
- Eye and orbit (B)
- Salivary glands (B)
- Thyroid gland (A)
- Others (e.g. cervical lymph node metastases, melanoma)(A)

Gastrointestinal (GI) tract

- Oesophagus (B)
- Stomach (B)
- Liver and biliary tract (A)
- Pancreas (A)
- Colon/rectum (B)
- Anus (B)

Thorax

- Non-small cell lung cancer (B)
- Small cell lung cancer (B)
- Thymomas and/or mediastinal tumours (B)
- Mesothelioma (A)

Bone and soft tissue (B)

Skin cancer, including malignant melanoma and non-melanoma tumours (B)

Breast cancer (B)

Gynaecology

- Cervix (B)
- Endometrium (B)
- Ovaries and fallopian tubes (B)
- Vagina (B)
- Vulva (B)

Genitourinary (GU) tract

- Prostate (B)
- Bladder (B)
- Testes/seminoma (B)
- Testes/ non-seminoma (B)
- Kidneys (A)
- Ureter (A)
- Urethra (A)
- Penis (A)

Lymphomas and leukemias

- Hodgkin's disease (B)
- Non-Hodgkin's lymphoma (B)
- Leukemia (B)

Central nervous system (B)

- Intracranial tumours in the adult including pituitary tumours (B)
- Intracranial tumours in childhood (B)
- Spinal cord tumours (B)

Cancer of unknown primary (B)

Radiotherapy for palliation

- Skeletal metastases (B)
- Brain metastases (B)
- Spinal cord compression (B)
- Superior vena cava syndrome (B)
- Obstructive syndromes (B)
- Bleeding syndromes (B)

Re-irradiation (B)

Paediatric tumours (A)

Benign disease (A)

Appendix I

AUDITING CHECK LIST TEMPLATE

An audit system should be in place as part of the training programme evaluation.

During the site visit there should be a tour of the facility and interviews with the PD, faculty members and trainees, as well as with some members of other specialties.

The following checklist is provided as a model for assisting the audit visitor in carrying out the programme evaluation.

	THE AUDITOR (SITE-VISITOR) SHOULD BE ABLE TO ASSESS:
1	Is there a National Authority in place for certifying the training institutes and monitoring and auditing the training programme?
2	Is the training institution accredited by the National Authority?
3	Is there a process in place for certified radiation oncologists to continue their medical education (CME)? Provide details.
4	Is there a national auditing system in place? Provide details.
5	Is the training period a minimum of a full 3 years or its equivalent?
6	Are all trainees in the programme medical school graduates?
7	Is the training programme embedded in or affiliated with a hospital with appropriate medical and surgical services?
8	Provide a list of the services available.
9	Does the training institute have an appropriate library service and internet access? Provide a list of books and journals.
10	Does the training programme provide a structured curriculum in the basic and clinical sciences?
11	Are there multidisciplinary tumour boards, chart rounds, journal clubs? Please, list them.
12	Is there a mechanism in place to ensure trainees attendance to these activities?
13	Is the training programme a single institution or a multiple institution one? Is there a written contract/agreement between these institutions?
14	Is there a single PD responsible for the educational content of the programme?

15	Is the PD qualified according to the national criteria?
16	Is there a formal outline of the structure of the training programme for each individual trainee?
17	Are there stated objectives for each module?
18	Are these objectives known to the trainees?
19	Is the educational effectiveness of the programme evaluated on a regular basis by the PD? Give details.
20	Is the faculty evaluated on a periodic basis?
21	Does the PD meet periodically with the trainees to discuss their progress and evaluations? Are these meetings documented?
22	Are there periodic evaluations of the trainee by the faculty?
23	Are there periodic examinations conducted?
24	Is the ratio trainees/trainers less than 1.5-2 /1?
25	Does the teaching staff have appropriate qualifications?
26	Does the teaching staff devote sufficient time for teaching activities?
27	Is there at least one full-time employed medical physicist available for teaching?
28	Is the physics staff involved in the teaching of basic and applied medical physics?
29	Is teaching in cancer biology and radiation biology available? Give details.
30	Does the training programme have at least 2 teletherapy units, at least one of which is a linear accelerator?
31	Is brachytherapy available? Give details.
32	Is there a treatment simulator available? Give details.
33	Is there a treatment planning system? Give details.
34	Is there a mould room and immobilization devices?
35	Is there equipment for physics quality assurance (QA)? Give details.
36	Is there a minimum of 500 patients treated/year in the training institute?
37	What is the number of brachytherapy procedures and do they fulfill the requirements outlined in the national guidelines?

38	Is there an adequate case-mix for each trainee and how is it monitored? Give an overview of cases seen by the trainee.
39	Does each trainee participate in a minimum of 400-450 full-case equivalents during the training?
40	Is there an acceptable balance between the patient care obligations and the learning activities for the trainee? Provide the programme for theoretical training.
41	Is the trainee exposed to clinical research and data interpretation?
42	Does the training institute maintain a permanent record of the trainees' rotations, procedure logbook and evaluations?
43	Is there a portfolio/logbook maintained by the trainee?
44	Are the essential components of the curriculum (basic sciences, clinical sciences, medical physics) incorporated in the training programme of the institute?
45	Are the general clinical competencies adequately provided by the training programme?
46	Were trainees independently interviewed during the site visit?
47	Comments by the auditor(s):

Appendix II

THE IAEA APPLIED SCIENCES OF ONCOLOGY (ASO) DISTANCE LEARNING COURSE.

The course is presented as a two CD set and is an introduction to the applied sciences of oncology. It is not intended to be a complete course or to replace textbooks, but will help students prepare for Part I (theory) specialist or board examinations. It has been produced for the IAEA to provide cancer education for doctors in countries where there is little currently available.

The course covers eight subject areas. It is designed to supplement textbooks with practical information and examples, and to give an overview of knowledge not easily gained from any one textbook. Within each subject there are a number of individual modules that should each take about one hour to complete.

Participants in the ASO course are awarded an IAEA 'Certificate of Completion'. The 'Certificate of Completion' is not a specialist qualification.

At present the ASO course is on CD format and it can be available from IAEA's website. A CD-ROM copy can be obtained on request by sending full postal address details to Jan Wondergem (J.Wondergem@iaea.org).

The subjects included in the distance learning course are:

Communication

Breaking bad news

Communication with the patient

Communication issues in different cultural settings

Communication with colleagues

Critical appraisal

Cancer epidemiology

Searching for evidence

Design of clinical trials

Critical appraisal of treatment studies

Survival analysis

Patient-based endpoints in clinical trials

Systematic reviews and meta-analysis

Clinical decision analysis

Prognostic indices

Functional anatomy

- Central nervous system and peripheral nerves
- Head-and-neck
- Lung and thorax
- Gastrointestinal
- Genitourinary
- Gynaecological
- Breast
- Lymphatics

Molecular biology, pathology and pathogenesis

- Genes and cancer
- Genetics of colorectal and breast cancer
- Pathology, molecular diagnosis and new diagnostic techniques
- Infections associated with malignancy
- Familial aspects of cancer

General patient care

- Pain and analgesia
- Bone and hypercalcemia
- Symptom control
- Infections in the cancer patient

The physics of radiation technology

- Glossary
- Radioactivity
- Photon generation
- Photons interaction with matter
- Electron beam generation and interactions
- Dosimetry of ionising radiation

Photon beam radiotherapy treatment planning

Intensity Modulated Radiation Therapy (IMRT)

Computers in radiotherapy

Stereotactic radiosurgery

Brachytherapy

Radiation protection

Dose reporting

Advanced treatment aids

Dynamic wedge

Multi-leaf collimators

Organ motion and patient immobilisation

Electronic Portal Imaging Devices (EPIDs)

Tomotherapy

Proton radiotherapy

Radiation biology

Principles of x ray therapy

Acute effects

Late effects

Tumours

Fractionation

Treatment time effects

Dose-rate effects

Molecular effects and apoptosis

Interactions with chemotherapy and chemical modifiers of the radiation response

Systemic therapy for cancer

Principles of cytotoxic treatment

Cytotoxic drugs: mechanism of action

Administering chemotherapy

Acute complications

Late complications

Alkylating agents/Platinum compounds/antibiotics

Antimicrotubule agents/Epipodophyllotoxins

Anti-metabolites

Endocrine therapy

Immunomodulators and anti-growth factors

Pre-clinical drug development

Appendix III

MEDICAL PHYSICS HANDBOOK

'Radiation Oncology Physics: A Handbook for Teachers and Students'

E. Podgorsak, Technical Editor, IAEA, Vienna, 2005

This publication is aimed at students and teachers involved in programmes that train professionals for work in radiation oncology. It provides a comprehensive overview of the basic medical physics knowledge required in the form of a syllabus for modern radiation oncology. It will be particularly useful to graduate students and residents in medical physics programmes, to residents in radiation oncology, as well as students in dosimetry and radiotherapy technology programmes. It will assist those preparing for their professional certification examinations in radiation oncology, medical physics, and dosimetry or radiotherapy technology. It has been endorsed by several international and national organizations and the material presented has already been used to define the level of knowledge expected of medical physicists worldwide.

The book is supplemented with a CD containing more than 2500 slides for teaching and illustration.

Appendix IV

EXAMPLE OF CLINICAL EXPERIENCE DOCUMENTATION (logbook)

The logbook is one (#3) of the five components of training documentation portfolio that may include:

1. Personal data of the trainee
2. Scientific training documentation
3. Clinical training procedures documentation (logbook)
4. Records of formal presentations by the trainee
5. Publications

The logbook is a structured tool to record and document the increasing experience throughout the training period. It is a tool that allows the systematic collection of information that needs to be recorded to monitor the professional development of a trainee in radiation oncology.

The trainee should be responsible for the satisfactory completion of his/her logbook. This can only be achieved optimally if they are introduced to the core curriculum and all the elements of the logbook at the beginning of their training and are encouraged and assisted to collect and retain the relevant documentation at each stage. The logbook in turn should be periodically reviewed by the direct supervisors and by the Programme Director at the time of the final evaluation.

The clinical logbook should:

- be relevant to the core curriculum of training
- only include data that is essential for the purpose of appraisal
- be user friendly
- concentrate on the quality of the data and not on its volume

Below is an example of a typical trainee's procedure logbook for external beam radiation therapy. It contains the patient's identification number, the date, the trainee's role in the procedure (W=whole care, P=partial care), the tumour site and stage and the supervisor's attestation.

Clarification of terms: whole care (W) vs. partial care (P):

Whole care — the trainee saw the individual patient as outpatient at the initial consult, following relevant investigations, at simulation and planning, informed consent, treatment prescription and during treatment. Completion of this whole pathway constitutes an optimal training experience and should be noted as 'whole care' in the 'level of care' section.

Partial care — In departments where trainees rotate through specific-function units (outpatient clinic, radiotherapy planning) and where the monitoring of the whole process of radiation therapy is not possible, it is recommended that record would be kept of patients whose treatments are prescribed and planned and should be noted as 'partial care' in that column.

Head and Neck:

LARYNX

RT Number	Date	Level of care (Whole/Part)	Diagnosis	Teacher (Signature)
123/06	30.1.07	W	T3 glottis	…
456/06	20.2.07	W	T4 palliative	…
789/07	10.3.07	P	T3 post-operative	…
123/07	2.1.08	P	T3 concurrent chemotherapy	…
456/07	15.6.08	W	T3 subglottic	…
789/07	30.8.08	P	T2 supraglottic	…

Source: HUNTER, R.D., MACIEJEWSKI, B., LEER, J.W., KINAY, M., HEEREN, G., for the European Board of Radiotherapy (Radiation Oncology). Training Logbook for Radiotherapy, *Radiotherapy and Oncology* 2004:**70** 117–121. .

A similar table with the type of procedure can be produced for brachytherapy and for physics.

Brachytherapy	**Practical Physics**
Intracavitary	Manual Isodose Distributions
Interstitial	Dosimetry of irregular fields
Intraluminal	Patient dosimetry
	Mould room

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IAEA International Atomic Energy Agency

http://www.iaea.org/

ESTRO European Society for Therapeutic Radiology and Oncology

http://www.estro.org

ASTRO American Society for Radiation Oncology

http://www.astro.org/

ABS American Brachytherapy Society

http://www.americanbrachytherapy.org/

ACGME Accreditation Council for Graduate Medical Education

http://www.acgme.org/acWebsite/home/home.asp

TROG Trans-Tasman Radiation Oncology Group

http://www.trog.com.au/

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