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Comparison of curricula in radiation technology in the field of radiotherapy in selected European Union countries

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ABSTRACT

Background: Radiation technology is a discipline of medical science which deals with diagnostics, imaging and radiotherapy, that is treatment by ionizing radiation.
Aim: To present and compare the existing curricula of radiation technology in selected EU countries.
Materials and methods: The research work done for the purpose of the comparative analysis was based on the methods of diagnostic test and document analysis.
Results: The comparison of curricula in selected countries, namely Austria, France, the Netherlands and Poland, showed that admission criteria to radiation technology courses are varied and depend on regulations of respective Ministries of Health. The most restrictive conditions, including written tests in biology, chemistry and physics, and psychometric test, are those in France. Contents of basic and specialist subject groups are very similar in all the countries. The difference is in the number of ECT points assigned to particular subjects and the number of course hours offered. The longest practical training is provided in the Netherlands and the shortest one in Poland. The duration of studies in the Netherlands is 4 years, while in Poland it is 3 years. Austria is the only country to offer extra practical training in quality management.
Conclusion: Graduates in the compared EU countries have similar level of qualifications in the fields of operation of radiological equipment, radiotherapy, nuclear medicine, foreign language and specialist terminology in the field of medical and physical sciences, general knowledge of medical and physical sciences, and detailed knowledge of radiation technology.

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1. Background

Radiation technology (in Polish *elektroradiologia*) is a new course of studies at some universities in the European Union. It is a discipline of medical science which deals with diagnostics and imaging of human body, some functions of human organs, and radiotherapy, that is treatment by ionizing radiation. Fast development of this domain of medicine has caused an increase of interest in radiation technology; however, there

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are still very few publications on the subject. There is also not enough information for us to compare this course of study between different European universities.

Radiation technology-related positions in the European Union, broken down by countries (Table 1).

2. Aim

The purpose of this work is to present and compare existing curricula of radiation technology in radiotherapy courses in selected countries, with particular emphasis on conditions to be met by candidates applying for admission to the course in radiation technology, framework teaching content, practical training, degree obtained on completion of a first level course, possibilities to continue education by moving on to Master studies, and qualifications received by graduates.

3. Material and methods

The subject matter of this paper falls in the common ground between sociological and social sciences. It is, therefore, impossible to determine a method of material collection to allow a comparative analysis. The most similar method is that of document analysis. Up to date, the number of publications and studies on curricula used in radiation technology courses is very limited. This applies both to Poland and some countries of the European Union. Embassies and consulates general of particular countries are the only reliable and verifiable source of information on curricula of radiation technology courses. Moreover, authors contacted relevant universities and local Ministries of Education in the following countries: Austria, Poland, the Netherlands and France to obtain information on study programmes in radiation technology. In addition, Google and PubMed, as well as commercial websites of EU universities offering studies in radiation technology were reviewed for publications on radiation technology study programmes. Feedback was coherent with the information obtained from universities, ministries of education and embassies of analyzed countries.

3.1. *Comparative analysis*

The comparative analysis was made using diagnostic tests and the method of document examination. The aim of the diagnostic tests was to identify the actual state, real features and principles regarding curricula of radiation technology courses. Our research has found an actual relationship between teaching contents and graduates' future skills, although the starting point for the study was to examine the current state of affairs only.

4. Results

4.1. *Poland*

Universities offering radiation technology courses are located in Poznan, Bydgoszcz, Warsaw, Gdansk and Bialystok. The Medical University in Gdansk specializes in nuclear medicine, the universities in Warsaw, Bydgoszcz and Białystok in diagnostics imaging, while the University of Medical Sciences in Poznan puts more emphasis on radiation technology in radiotherapy which was the main field of authors' interest, and the subject of the comparative analysis of existing study programmes in radiation technology in EU.

In Poland, candidates are recruited on the basis of results achieved at their final secondary school exam in chemistry and/or biology, depending on the university.[1] The score qualifying for admission is determined annually by senates of medical universities by a resolution on principles and mode of admission to higher education institutions. The final decision is made upon the presentation of a medical certificate from a licensed doctor certifying that an applicant is free of any physical or mental diseases that might be detrimental his or her practicing of the profession and a proof of vaccination against diphtheria, polio and tetanus.

The first level studies cover six semesters with at least 2800 classes (including practical training). Throughout the period of study, students can receive up to 180 ECTS points attending full-time or extramural courses, depending on the choice made at the application stage. Extramural students have their classes at two weekends a month. The number of classes offered at extramural studies is proportionally lower than that of the full-time programmes. The curriculum covers the same issues. Extramural students are not given any practical training.[1]

The curriculum also foresees classes in physical education – 6 h (2 ECTS points), foreign language – 120 h (5 ECTS points). IT classes include IT basics, word processing, spreadsheets, databases, network services, information collecting and processing.[1]

Optional classes include at least 90 h of education credited with 6 ECTS. Final exam (including the preparation of a thesis) is marked out of 10 ECTS points. The curricula also contain some 60 h of humanities – 3 ECTS points.[1]

Practical training in radiation technology is held during the academic year, excluding the holiday period. At least 25% of the training time is arranged *en bloc* to ensure that student

Table 1 – The professional title of radiation technologist in the European Union, broken down by countries.

Austria	France	The Netherlands	Poland
Diplomierte/er radiologisch technische/er; Assistant/in DRTA or Dipl. RTA	Manipulateur en electroradiologic; Manipulateur en radiotherapie; Technicien de radiotherapie; Cadre medicotechnique; Cadre manipulateur	Radiotherapeutisch Laborant; Radiation Therapy Technologist; Therapeutic Radiographer	Elektroradiolog

can participate in several-day medical procedures. The practical training includes: 375 h of X-ray diagnostics and diagnostic imaging credited with 15 ECTS. The minimum training time is distributed as follows: 20% for pediatric radiology, 20% for traumatic examination, and 20% for general radiology. In addition, 10% of the training time is spent on computed tomography and 10% on MRI. Practical training in radiotherapy lasts 325 h corresponding to 13 ECTS. The minimum training time is distributed as follows: 25% for the use of a medical accelerator, 5% for the use of therapeutic devices for brachytherapy, 25% for the use of simulation techniques, 5% for treatment planning of teleradiotherapy and brachytherapy, and 5% for immobilization techniques. Practical training in nuclear medicine covers 100 h corresponding to 4 ECTS. The training involves traditional methods of isotopic testing and positron emission tomography. Practical training in electromedicine takes 100 h credited with 4 ECTS.[1]

4.2. *Austria*

Candidates for this course of study should have a completed upper secondary education with exams passed in biology with environmental science, chemistry, and a modern language. Admission may also be sought by holders of diplomas in nursing or medical technology. In addition, candidates should present supporting documents, such as identity card, birth certificate, medical certificate of fitness to study radiation technology, a criminal record certificate (original, not older than 3 months). To be admitted, a candidate has to appear for an interview, within a set time limit, before a recruitment committee. The interview is meant to assess candidates' professional skills (knowledge about the duties of Diplomierte/er technische Radiologische/er and the basic knowledge of radiodiagnostics and imaging techniques) and communication competences. Courses in this field of study are run by the University of Vienna and, from October 2007, the University of Innsbruck.

The studies cover 6 semesters with 180 credits to win. Each semester accounts for 30 ECTS. The degree program is offered on full-time basis only.[2] The educational approach involves alternating theoretical classes and practical exercise to teach students how to contact a patient and use specialized equipment. The course consists of a theoretical part including anatomy, physiology, pathology, radiation biology, first aid, hygiene and environmental protection, chemistry, laboratory science, basics of pharmacology, physics, radiation physics, radiation protection, projection theory, recording techniques and image analysis (in radiology, orthopedics, pediatrics, trauma surgery, including intraoperative image recording). The practical part comprises conventional diagnostics, interventional radiology, other imaging techniques, angiography, radiotherapy, nursing, nuclear medicine, and radiation protection.[3]

One semester consists of 18 weeks of classes incorporating both theoretical and practical activities carried out in interdisciplinary teams. Each semester, students complete a total of 36 weeks of traineeship during the entire course of study.[2] Practical training can be divided into various stages: examination and procedures using specialized equipment, radiation protection, risk prevention and management, interdisciplinary teamwork, management of human and material resources, and professional development.

4.3. *France*

Training leading to the award of a title of *Manipulateur en electroradiologic* is open to candidates who are at least 17 years old on 31 December of the year of admission to the entry tests, have graduated from a secondary school or passed a special exam entitling to study at a university. The course can also be taken by university students who have graduated from faculties of biochemistry or biotechnology.[4] The entry exam includes written tests in biology, physics and chemistry. Depending on the school, candidates may also be required to sit a psychometric test. The test in physics and chemistry takes 1 h 30 min and is marked out of 20 points. The test in biology also takes 1 h 30 min and is marked of 20 points. A candidate receiving a 0-point mark from any of the tests is disqualified from admission. The exam also tests the knowledge and skills in the area of patient care. This part takes 1 h 30 min (30 min are allowed for preparation). Candidates who receive fewer than 10 points out of 20 are disqualified. The final decision on admission is made upon presentation of a medical certificate from a licensed doctor confirming candidate's physical and mental fitness for the job and vaccination against diphtheria, polio and tetanus.[4]

The line of study leading to the award of the title of *Manipulateur en electroradiologic* includes two courses, each three years long, offered on full-time basis only.[5]

The radiation technology training in France takes a minimum of three years which cover 4444 h, including 1550 h of theoretical classes and 2894 h of practical activities. The training program includes physics, physiology, anatomy, pathology, interpersonal communication, techniques of medical imaging and radiation.

Practical training is supervised by a doctor and comprises medical imaging (80%), radiotherapy (15%), and nuclear medicine (5%).

An official diploma examination features two independent groups of tests: a theoretical test consisting of four written tests (physics, medical imaging, radiotherapy, nuclear medicine) lasting between 1 h 30 min and 3 h, and a practical test consisting of three practical examinations of 25–50 min, recorded on the day of the exam. A graduate, depending a program taken, is awarded an official diploma of an electroradiologist (DE), issued by the Ministry of Health granted by institutes and schools, or a diploma of an radiation technologist (DTS) in medical imaging and therapeutic radiology, issued by the Ministry of Education, and granted by public and private schools. DTS training is the same as DE, the difference being in the institution that conducts the training and awards the diploma.[5,6] Also, holders of DE can continue their education at master medical studies, while DTS diploma does not provide access to higher education.

4.4. *The Netherlands*

Studies in radiation technology are offered e.g. by the University of Groningen. A candidate for a qualification of *Radiotherapeutisch laborant* must hold a graduation diploma of

Table 2 – Requirements for undergraduate admissions at the direction electroradiology in the European Union, broken down by individual countries.

Requirements	Austria	France	Netherlands	Poland
Education	Secondary	Secondary	Secondary (Completed HAVO/VWO or secondary school with A or B level courses in mathematics and physics)	Secondary
Secondary education certificate	+	+ or a special exam giving access to university studies	+	+
Required exam subjects	–	–	–	Biology or Physics (optional)
Age	16 years and 9 months	17 years on 31 December of that year of admission	17 years	18 years
Required medical examinations and certificates	Certificate from an occupational doctor confirming the absence of contraindications to study electroradiology	Certificate from an occupational doctor confirming the absence of contraindications to study electroradiology and certificate of vaccination against diphtheria, polio and tetanus	Certificate from an occupational doctor confirming the absence of contraindications to study electroradiology	Certificate from an occupational doctor confirming the absence of contraindications to study electroradiology
Additional	Clear criminal record, interview	Written test in biology, physics, chemistry and patient care; psychometric test	Application for MBRT HBO hospital traineeship	–
Other	–	Admission also possible for Biochemistry and Biotechnology graduates	Candidates over 21 years of age without proper training may be admitted on the basic of medical examination	–

HAVO/VWO (*Hoger Algemeen Voorgezet Onderwijs* – secondary school of general education/*Voorbereidend Wetenschapelijk Onderwijs* – a pre-university secondary school or other secondary school offering courses in mathematics and physics at basic or intermediate level, apply for traineeship at a hospital the MBRT HBO scheme (*Medisch Beeldvormende en Radiotherapeutische Technieken* – training in diagnostic imaging and radiotherapy techniques). A candidate must be at least 16 years and 9 months old.

The MBRT training in the field of radiotherapy is offered by the University of Eindhoven. Studies are conducted on full-time basis only. Applicants must be holders of HAVO/VWO (adequate profile) or MBO (level 4).[7]

Studies in radiation technology offered by the University of Groningen take 4 years,[8] with a total 240 ECTS points to win, of which 40%, or 96, account for theoretical contents and the remaining 60%, or 144, for practical exercise.[9] Contents taught during the first year are of a general nature and include human anatomy, ethics, physiology, pathophysiology, first aid, psychology and epidemiology, while specialist courses in X-ray diagnostics and diagnostic imaging, radiotherapy, nuclear medicine, radiation dosimetry, and operation of diagnostic and electromedical equipment are introduced in the second, third and fourth year of the studies. Training in medical imaging and radiation therapy techniques is referred to in the Netherlands as HBO MBRT. The curriculum contains thematic groups covering the fields of radiotherapy, diagnostic radiology, USG and nuclear medicine. The first year consists of 13 weeks of study (aimed to develop skills in the area of X-ray diagnostics and diagnostic imaging), 7 weeks of theoretical classroom and 22 weeks of practical activities. The second year covers 9 weeks of theory and 33 weeks of practice; the third year, 8 weeks of theory and 34 weeks of practice; and the fourth year, 6 weeks of theory and 36 weeks of practice.[8]

5. Discussion

5.1. *Requirements*

Requirements for undergraduate admissions for radiation technology courses in the European Union, broken down by individual countries (Table 2).

Each university sets its own recruitment criteria according to respective Minister of Health regulations. They also depend on the education system of a country. The common condition to be met by a candidate is to have completed upper secondary school. French universities allow the admission of candidates who have passed a special exam entitling to university studies.

France is the only country to use such strict recruitment rules for radiation technology. This way, incidental admissions are avoided involving individuals who do not intend to con-

Table 3 – Basic contents in taught at electroradiology courses in the European Union, broken down into countries.

Basic contents	Austria[2]	France	Netherlands	Poland
Human anatomy	+	+	+	+
ECT points	5	4	4	4
Ethics	+	+	+	+
ECT points	2	1	2	2
Physiology	+	+	+	+
ECT points	5	4	4	2
Application of mathematics in	+	+	+	+
electroradiology ECT points	2	3	2	3
Pathophysiology	+	+	+	+
ECT points	3	3	2	2
Emergency aid	+	+	+	+
ECT points	1	1	1	1
Psychology	+	+	+	+
ECT points	2	2	2	2
Epidemiology, disease prevention, health promotion and health education	+	+	+	+
ECT points	0.5	1	1	4
Basic computer studies	+	+	+	+
ECT points	2	2	3	4
Physics and biophysics	+	+	+	+
ECT points	6	8	6	13
Statistical data analysis	+	+	+	+
ECT points	2	2	1	2

Table 4 – Specialist contents taught at electroradiology courses in the European Union, broken down into countries.

Group directional content	Austria[2]	France	Netherlands	Poland
X-ray diagnostics and	+	+	+	+
diagnostic imaging ECT points	24	23	24	25
Radiotherapy	+	+	+	+
ECT points	6.5	8	15	14
Nuclear medicine	+	+	+	+
ECT points	5	7	10	9
Impact of ionizing radiation on	+	+	+	+
the medium	1	4	5	8
ECT points Dosimetry of ionizing radiation	+	+	+	+
ECT points	2	4	4	3
Diagnosis and electromedical equipment	+	+	+	+
ECT points	7	4	5	4
Quality control in electroradiology	+	+	+	+
ECT points	4	7	5	9

Table 5 – Practical training in electroradiology in the European Union, broken down into countries.

Practical training	Austria	France	Netherlands[9]	Poland
X-ray diagnostics	+	+	+	+
Number of hours	700	2315	2650	375
ECT points	22	40	44	15
Radiotherapy number of hours	+	+	+	+
ECT points	270	405	750	325
	7	14	25	13
Nuclear medicine number of	+	+	+	+
hours ECT points	240	145	385	100
	6	4	9	4
Electromedicine number of hours ECT points	+	+	+	+
	240	29	100	100
	6	1	4	4
Quality control in electroradiology	+	–	–	–
number of hours ECT points	170	–	–	–
	4	–	–	–
Total number of hours of practical training	1620	2894	3885	900

Table 6 – Degree obtained on completion of undergraduate course in electroradiology in the European Union, broken down into countries.

Degree	Austria	France	Netherlands	Poland
Undergraduate degree	+ Diplomierte/er radiologiach technische/er	+ Manipulateur en electroradiologic	+ Radiotherapeutisch Laborant	+ Elektroradiolog

tinue their careers in this area and decided to study radiation technology having failed to qualify for other studies. Internal exams and psychometric tests also enable candidates to confront their expectations with the reality.

5.2. *Framework teaching contents*

As for framework teaching contents, the focus is placed on syllabuses, ECTS credits, number of course hours provided, the duration of studies.

It is recommended that a minimum duration of any programme should be three years. Of this, one year should be devoted to clinical practice as part of a continuous process of shifting from theory to practice over the programme. The emphasis in the first year(s) should be on the academic content and the establishment of a strong scientific basis, while in further years more stress is put on the application of theory to clinical/reflective practice and the development of research skills.

Three years has been agreed as the minimum duration in order to ensure:

The acquisition of sufficient knowledge and understanding of the scientific basis underpinning the practice of radiation oncology. This includes the technical application and psychosocial care of the patient. Sufficient time to develop professional attitudes to practice and to continuing professional development. Sufficient time to acquire the basic competencies necessary for an accurate preparation and application of radiation therapy.[13]

Learning may be defined as changes in knowledge, understanding, skills and attitudes brought about by experience and reflection upon that experience. At the basic level, learning indicates an increase in the quantity of information that a student acquires and retains; the acquisition of new facts or skills. At a higher level, learning involves the processing of the information acquired to make sense of its abstract meaning and identify ways in which it can be related to other situations; it becomes an active, interpretive process which requires higher level of skills. This higher level of learning is necessary for radiation therapists who will work in a dynamic and interactive discipline. There are many routes that lead to learning. What is important is that a wide a range of learning experiences are offered to cater for the whole spectrum of student learning styles. Experience has shown that learning is more likely to take place when the teaching staff adopt an advisory rather than a prescriptive attitude. It is important for the learning process to be active and that the passive content is not the main focus. It is, therefore, a good idea to combine different methods, and to link academic content with clinical practice. Teaching is a process that supports learning. In radiation therapy it is about creating and sustaining an environment that promotes higher level of learning, while supporting students and encouraging personal growth and development. Teaching methodologies should reflect a variety of learning styles and an education programme should be designed to include as wide a range as possible. Appropriate teaching facilities have to be provided. Teaching methodologies and facilities will be dictated to a large extent by local preference and availability but students should be encouraged to be responsible for themselves and their own learning. The use of new technologies such as video conferencing and the Internet should be encouraged but students do need direction and advice when starting to use these methods.[14]

The number of ECTS credits to be won throughout the studies is the same for all countries, amounting to 180, with the exception of the Netherlands, where up to 240 points are credited. Each subject is assigned a specific number of ECTS points which varies across universities, regardless whether they are in the same country or not.

A model for the division of subjects into basic and specialist groups was taken from the Polish educational standards in radiation technology, first-level studies.

Basic contents taught at radiation technology courses in the European Union, broken down into countries (Table 3).

Table 7 – Possibilities to continue education at master studies in the European Union, broken down into countries.

	Austria	France	Netherlands	Poland
Supplementary master degree studies in Electroradiology	+	–	–	+
Supplementary master degree studies in Management in Health Service and Social Organizations	–	+	–	–
Master degree in Public Health	–	–	–	+

Table 8 – Qualification of electroradiology graduates in the European Union, broken down into countries.

Qualifications	Austria	France[10,11]	Netherlands	Poland[12,13,15]
Operation of equipment				
Radiation	+	+	+	+
Radiotherapy	+	+	+	+
Nuclear medicine	+	+	+	+
Electromedicine	+	+	+	+
Knowledge of foreign language and specialist terminology in the field of medical and physical sciences	+	+	+	+
General knowledge of medical and physical sciences and detailed knowledge of electroradiology	+	+	+	+

The subjects shown above can be found in the curricula of all presented universities, although sometimes under different names where lexical features of a language disable literal translation into Polish. However, the contents of the subjects are comparable as proved by relevant teaching standards. They differ in the number of hours assigned to particular subjects at different universities. The disparities are not large, though, amounting to several hours at most.

Specialist contents taught at radiation technology courses in the European Union, broken down into countries (Table 4).

Specialist contents are characterized by higher disproportion in the number of hours between universities. Proportions between subjects change in line with technological progress. If a stronger emphasis is put on modern methods of imaging such as MRI or CT, the number of hours spent on X-ray is reduced accordingly. Modern methods of radiotherapy and imaging are almost identical in the analyzed countries, differences relating only to availability of advanced medical equipment, causing specialist teaching contents to be similar. As in the case of basic contents, differences, if any, are language-determined. France and the Netherlands tend to increase the independence of a radiation technologist, therefore, they increase the number of specialist classes or subjects which sometimes refer to the same area but are presented in other (broader) terms.

The number of course hours offered are different across universities, the example being Poland and France, with 2800 h and 4444 h, respectively. The difference results from the number of hours scheduled for practical training. Disparities in the number of theoretical classes are not that big.

The duration of undergraduate studies is three years, except for the Netherlands where they are four years long. This is due to the fact that Dutch universities offer more practical training than in any other countries.

5.3. *Practical training*

Practical training in radiation technology in the European Union, broken down into countries (Table 5).

Practical training in the analyzed countries covers the same range of skills, involving X-ray diagnostics, imaging techniques, radiotherapy, nuclear medicine and electromedicine.

The differences lie in the number of hours scheduled for particular skills and the total amount of practical training offered. In Austria, the practical training takes 36 weeks throughout the programme distributed accordingly among semesters. In Poland, practical activities are held during the academic year, excluding holiday periods. As a rule, at least 25% of the training time is arranged *en bloc* to ensure that student can participate in several-day medical procedures. Each thematic group is assigned an appropriate number of hours, e.g. 100 h scheduled for electromedicine. A similar content breakdown is applied by French universities where 80% of time is used on medical imaging methods. Dutch universities spend three days a week, on average, on practical activities, thus achieving a 40:60 ratio of theory to practice. The University of Groningen offers 22 weeks of practical training during the first year of the course, 33 weeks in the second year, 20 weeks in the third year and 36 weeks in the fourth year. The strongest emphasis is put on radiology, than radiotherapy and nuclear medicine.

The form of practical training depends on the university. An innovative solution is applied by Austrian universities where multi-disciplinary teams are formed, composed of representatives of different fields, including medicine, radiation technology, or nursing, with the aim to promote cooperation during the training. This approach helps understand the responsibilities of particular positions and learn to cooperate, which is not always easy because of the overlap of professional competence or differences of opinions. This approach based on cooperation is not easy, but it is the most effective one, as it shows trainees what they can expect after graduation. It allows them to dispel doubt, if any, as to their fitness for the position. Practical training is concluded with an analysis allowing to identify weaknesses in the organization of activities and students' deficiencies, as well as to define goals to be accomplished in the next training session. Each practical training is evaluated in terms of theoretical knowledge and its practical application and the student-patient relationship. As in other countries, practical training is conditioned by successful completion of the theoretical part. In France, the Netherlands and Poland, practical training is held in groups supervised by a physician or radiation technologist. This method enables students to gain a relatively high work experience, as tasks performed during the training are typical for the job with little time spent on other assignments. This way, however, teamwork opportunities involving representatives of other disciplines are restricted, which may result in future problems in team communication. At Dutch universities each student is assigned a practical training tutor, who responds to students' needs, helps them plan their activities and evaluate their performance. In France, students are assessed at two traineeships only, which are subject to marking by a supervising doctor.

5.4. *Degree awarded on completion of undergraduate studies*

Degree obtained on completion of undergraduate course in radiation technology in the European Union, broken down into countries (Table 6).

Students receive a qualification called differently depending on the country of award.

5.5. *Possibilities to continue education at master studies*

Possibilities to continue education at master studies in the European Union, broken down into countries (Table 7).

Poland offers the widest range of opportunities to continue education at supplementary master studies. It also provides, like Austria, the possibility of choose radiation technology at a second-level study. In France, education can be carried on at a faculty of Management of Health Service and Social Organizations. Austria and the Netherlands do not offer second level medical studies suited for graduates of first-level course in radiation technology.

5.6. *Graduate's qualifications*

Qualification of radiation technology graduates in the European Union, broken down into countries (Table 8).

Graduates of first-level course in radiation technology are qualified to operate specialist equipment for radiation, radiotherapy, nuclear medicine, electromedicine; speak a foreign language and a specialist language in the field of medical and physical sciences, have general knowledge of medical and physical sciences and in-depth knowledge of radiation technology. They have competence in operating teletherapy machines: linacs, Co 60 units, and superficial and orthovoltage X-ray units; operating simulator and other imaging devices for therapy purposes: CT scanners and simulators (RTT-Sims); providing mould room services: producing immobilization masks, lead blocks, etc. (RTT-MRs) under the supervision of medical physicists, they are also qualified to calculate monitor units for treatment, and operate HDR brachytherapy machines (RTT-Brs) or treatment planning units (RTT-TPSs).[16]

Worldwide, there are very few publications detailing specific radiographer (radiation technologist) staffing levels for radiotherapy service delivery. This may arise from the fact that many staffing models have been developed locally to meet local service needs, taking into account the respective skills of various professionals within the team, and frequently changing roles of those professionals as they develop their skills to meet the needs of their services.[17]

Qualifications of a first level course graduates are comparable across UE countries, yet professional entitlements differ. In the presented countries, except for Poland, qualifications overlay professional entitlements, which means that graduates are entitled to carry out particular work activities.

Unfortunately, Polish radiation technology graduates of first level studies are entitled, and at the same time limited, to the same activities as alumnae of secondary vocational schools in radiation technology, even though they have broader knowledge and skills in this field. However, if their qualifications were translated into professional entitlements, the problem of role division between radiation technologists with secondary education background and graduates of first-level radiation technology courses could be solved.

This issue is directly connected with the professional title of radiation technologist used in Poland. The title of radiation technologist in Poland is used regardless of the education level, whether secondary vocational, tertiary first or second level. Consequently, university graduates feel frustrated and disappointed, as they are usually offered the same jobs as those graduates of two-year vocational schools. Therefore the roles, titles and entitlements should be clearly differentiated to change the current situation where opportunities for better positions, promotion and self-development are unduly limited.

6. Conclusion

1. Admission criteria for studies in radiation technology are varied and depend on respective ministerial regulations. The most restrictive criteria, including written test in biology, chemistry, physics, and psychometric test, are those in France.
2. The groups of basic and specialist contents are very similar in all the countries concerned. They differ in the number of ECT points for particular subjects and the number of course hours. A more detailed analysis is impossible as no data are regarding ECT points are available for France and the Netherlands.
3. Students take practical training covering similar contents and differing only in the number of hours, with the Netherlands offering the longest practical training, and Poland the shortest one. Studies in the Netherlands take four years, while in Poland three years. Austria is the only country to carry out additional training in quality management.
4. On completion of their undergraduate students in the European Union their bachelor degree: Austria – Diplomierte/er technische Radiologische/er; France – Manipulateur en electroradiologic; the Netherlands – Radiotherapeutisch laborant, Poland – Elektroradiolog.
5. Supplementary master studies in radiation technology is possible in Austria and Poland.
6. Graduates in the EU countries under study have similar qualifications, including operation of radiological equipment, radiotherapy, nuclear medicine, electromedicine, foreign language skills and specialist terminology in the field of medical and physical sciences, general knowledge

of medical and physical sciences and detailed knowledge of radiation technology. In the presented countries, qualifications are equivalent to professional entitlements. Poland is an exception, constraining professional development of Polish radiation technologists.

Conflict of interest statement

None declared.

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