MEDICAL PHYSICS IN SERBIA – TRAINING, EDUCATION, RECOGNITION AND EMPLOYMENT OPPORTUNITIES

B.Petrovic[1,2], I. Miskovic[3], M.Saric[3], M. Jeremic[4]

[1] Faculty of Sciences, University Novi Sad, Novi Sad, Serbia
[2] Oncology Institute Vojvodina, Radiotherapy department, Sremska Kamenica, Serbia
[3]Institute of oncology and radiology of Serbia, Serbia, Belgrade, Serbia
[4]University clinical center Kragujevac, Kragujevac, Serbia

Abstract— **Profession of medical physics in Serbia is not recognized as health care profession. The training and education are provided through university studies on BSc, MSc and PhD level, as well as specialization and through training in hospitals. The recognition of profession is a task for current generation of medical physicists. Medical physicists are employed in hospitals, and currently there are 70 colleagues who support all radiotherapy, nuclear medicine and diagnostic radiology patients all over Serbia. They also cover radiation protection issues in hospitals within their regular duties.**

Keywords— **Medical physics, education, training, medical physics expert, radiation protection**

I. INTRODUCTION: MEDICAL PHYSICS IN SERBIA

The Republic of Serbia has a population of approximately 7,350,000 inhabitants, and the official language in Serbia is Serbian. Its capital Belgrade has almost 1,700,000 inhabitants, and the three following major cities are Novi Sad (~ 400,000 inhabitants), Nis (~ 260,000 inhabitants) and Kragujevac (~180,000 inhabitants).

There are eight radiotherapy centres in the country, with five brachytherapy machines, 25 linear accelerators and one gamma knife machine, while the purchase of an additional five linear accelerators is in process. The country has 15 nuclear medicine centres, also housing two PET machines. Two nuclear medicine centres are private. Diagnostic radiology departments are equipped with CT, MRI, mammography units, X rays etc.

Radiation protections in clinics are covered by employees whose main job is radiotherapy or nuclear medicine. There are also a number of medical physicists working in institutions of occupational health.

Medical use of ionizing radiation in Serbia actually started with the first X-ray unit, brought in 1897, more than 120 years ago, to the hospital in the small Serbian city of Sabac. This machine arrived to Serbia thanks to the close friendship of Dr Avram Vinaver, medical doctor, with Wilhelm Roentgen. Dr Avram Vinaver was born into a Jewish family in Krakow, Poland, where he finished studies of medicine. He lived and worked in Sabac, Serbia where he developed his private practice.

The second X ray unit was purchased in 1901 for a hospital in Zemun (at that time a part of the Austro-Hungarian empire), and the third X ray for the General hospital in Belgrade in 1905. One of the first patients at that time was the Serbian king Petar I Karadjordjevic, whose hand was imaged by the machine.

Dr Avram Vinaver organized the "First Congress of Serbian physicians and naturalists under the highest protection of His Majesty King Peter I", held in Belgrade in September 1904, which was one of the first conferences with a session dedicated to the use of X rays in the world, and the first in the Balkans [1-3]. Dr Avram Vinaver prophesied that X-rays and X-ray diagnostic application were the method of the future. In his study "Five years of treatment with Roentgen rays" [2] Dr Avram Vinaver presented therapeutic options of X-ray used on 62 treated patients where he cited Prof Holzknecht from Vienna who was one of the eminent radiologists of the world at that time. Dr Avram Vinaver concluded that "it would be an unforgivable sin against our patients to remain indifferent to the Roentgen-therapy and not make it possible for them to be treated and cured by means of X-rays".

At that time, characteristics of ionizing radiation were not known, and there was no room for medical physicists. Many years after, in 1939 the Royal hospital for cancer treatment and diagnosis was founded in Belgrade, and its building was funded by the queen Marija Karadjordjevic. Unfortunately, the Second World War postponed all the plans for nearly 15 years.

The first ever physicist employed in Serbian medicine was Mr Veselin Vujnic, a young and ambitious nuclear physicist, who was working at the Institute of nuclear sciences Vinca on the nuclear reactor installation. His previous knowledge and experience in dosimetry enabled safe implementation of the first external beam treatment unit – cobalt 60 – in Belgrade. The machine started clinically in 1960.

The first Society that gathered people interested in biomedical sciences was formed in Belgrade in 1984. Later on, a Society for biomedical engineering and medical

physics (BIMEF) was formed in 1996. This Society was closed in 2011.

The Serbian Association of Medical Physicists was established in 2012, gathering all medical physicists working in hospitals. The Association is a member of EFOMP (European Federation of Organisations of Medical Physicists) and regularly organizes annual professional and scientific meetings and workshops, and keeps close connections to other regional medical physics organisations through the Alpe-Adria network.

It is a non-profit organization with the task of raising awareness of the importance of the profession, taking part in research and teaching in the field of medical physics, and giving advice on the safe application of physical methods in medicine. Also, the task of the Association is to help in the recognition of the profession, work on roles and responsibilities, and conduct educational and training sessions.

Since the foundation of the Association, the medical physics profession has grown together with other medical specialties, and nowadays there are over 70 medical physicists in Serbia, serving annually more than 13,000 radiotherapy patients and over 50,000 nuclear medicine patients.

Medical physicists in Serbia are employed in hospitals and provide services to radiotherapy departments, nuclear medicine departments, diagnostic radiology and radiation protection in their hospitals. The number of academic staff, also employed in hospitals, is still very low, but due to the future need for education of medical physicists, radiation oncologists, nuclear medicine specialists and radiologists, the number of academic staff will have to increase.

However, the medical physicist profession, although recognized within the Serbian Ministry of labour and approved in the official Serbian catalogue of jobs, still lacks recognition from healthcare institutions and the Ministry of Health. The aim of this paper is to discuss the challenges that medical physicists in Serbia is faced with in everyday work, explain the scheme of training and education, and provide opportunities for future recognition.

Roles and responsibilities of medical physicists are defined by the Serbian Law on radiation and nuclear safety and security, brought in 2018 (Act 84). The definition of medical physicist in the Law (Act 5) describes a medical physicist as a person working in a clinical environment, specialized and qualified to work independently in one of the areas: radiotherapy, nuclear medicine or diagnostic radiology.

There is also a definition of medical physics expert in the Law (Act 103), but this is not yet implemented.

The number of medical physicists, and spread over different areas, is given in Table 1.

Table 1 Medical physicists in Serbia

Item	Total	Diagostic Radiol	Radiat. Oncol	Nuclear Medicine
Univ.Clin.Center Kragujevac	12	1	10	1
Univ.Clin.Center Nis*	7	0	6	0
Univ. Clin.Center Serbia, Belgrade	12	0	8	4
Univ.Clin.Center Vojvodina, Novi Sad	2	1	0	1
Institute of oncol&Radiol Serbia, Belgrade	17	0	16	1
Inst.Oncology Vojvodina, Sremska Kamenica	12	0	12	0
Inst.Pulm.Diseases Vojvodina, Sr.Kamenica	2	0	2	0
Military Medical Acad. Belgrade	4	1	2	1
Health center Kladovo	4	0	4	0
General Hospital Cuprija	1	0	0	1
Total	***73***	***3***	***60***	***9***

* *one physicist works solely as radiation protection officer*

II. ACADEMIC EDUCATION

The established pathway to become a medical physicist in Serbia starts with the university education in the field of physics or technical sciences, and gaining the EQF 6 (European Qualification Framework level 6). There are currently five university centres (Belgrade, Novi Sad, Nis, Kragujevac and Kosovska Mitrovica) where a candidate can obtain a BSc degree at Faculties of Physics, Natural Sciences, Physical Chemistry or Faculty of technical Sciences).

According to the current catalogue of jobs in Serbian healthcare, a medical physicist must have a master's degree in physics or equivalent (EQF 7). There is also a possibility in two university centres to obtain a master's degree in medical physics.

After obtaining an MSc degree, one can go for a PhD degree. One university centre (Novi Sad) offers a PhD programme in medical physics.

All courses are accredited by the National accreditation body in higher education of Serbia.

The first master's programme in Serbia, in the field of medical physics, was offered in 1995 by the Association of Centres for Interdisciplinary and Multidisciplinary Studies and Research (ACIMSI), University of Novi Sad, but in 2010 it is closed down and moved to the Faculty of Sciences.

Students from university centres can select to work on their final diploma work, or MSc thesis or PhD thesis, and it requires very close cooperation with the hospital and good

logistics. It is is not always easy, as still only a few medical physicists are also employed by the University. Currently, this is the case with only one person with a university and clinical professional background. This should be changed in the coming year.

III. PROFESSIONAL/ CLINICAL TRAINING

A Medical Physics training programme in clinics was established in 1992, by the Faculty of Medicine, University of Novi Sad. The training programme was approved by the Ministry of Health of Serbia, and was a part of the rulebook of all healthcare specializations. It was written in the form of descriptive text, giving short information on what topics must be learnt and skills obtained. The training lasted for three years, and after the final exam, defence of the research project done during clinical employment in hospital, a candidate obtained a title "specialist in medical nuclear physics".

During 2012, the Ministry of Health required reformation of all healthcare specializations, and the old specialization was terminated while a new one was established in 2013, based on IAEA Guidelines of clinical training of medical physicists as well as ESTRO recommendations on training of medical physicists. The new title that the specialists obtained was "specialist in medical physics". It covers all three areas of medical physics.

This programme is now conducted in two university centres (Novi Sad and Belgrade). It comprises of theoretical lectures and clinical training.

But the main condition to enter clinical training and specialization is that a candidate is employed by the hospital in the field of radiotherapy, nuclear medicine or diagnostic radiology, and that the Ministry of Health approves the candidate's entrance, based on documentation provided by the hospital, describing the need for a medical physicist.

Currently, the number of specialists in medical physics (qualified) and in training is given in Table 2.

Table 2 Qualified and in training medical physicists in Serbia

Specialty	Qualified Medical Physics Specialists	In training
Diagnostic radiology	0	3
Radiation oncology	21	40
Nuclear medicine	7	2
Rad.Protect	0	1
Total	***28***	***46***

IV. ONGOING WORK

The Serbian Association of Medical Physicists is active in national, regional and international activities.

On a national level, it established cooperation with the Ministry of Health and the Directorate for Radiation and Nuclear Safety and Security.

The liaisons of the Directorate as regulatory body in Serbia and the Serbian Association of Medical Physicists are related to generation of regulatory documents, liaised with the Law on ionizing radiation and nuclear safety in the field of radiation medicine. They contain:

1. Set of national quality control and quality assurance documents for the safe use of radiation generators and radioisotopes in diagnostic and nuclear medicine as well as radiation oncology
2. Implementation of EU directive [4] into national laws, as well as implementation of professional recommendations (IAEA, EFOMP, ESTRO) into local legal framework

The work with the Ministry of health has the following directions:

1. Recognition of profession of medical physicist in the healthcare system as healthcare professional
2. Equalizing of status of medical physicist with the status of radiation oncologist, radiologist and nuclear medicine specialist
3. Accordingly change of salary, as it is currently 30% lower than that of medical professionals
4. Employment of more physicists as recommended by IAEA staffing calculator [5]

The Serbian Association is also trying to find its place within professional organisations in Europe, and is acquiring fruitful connections to the International Atomic Energy Agency, EFOMP and ESTRO.

V. FUTURE WORK

The Serbian Association of Medical Physicists marks its 10th anniversary in 2022. We are also hoping to close very important chapters for us: recognition as healthcare professional and improved staffing levels.

Currently, the lack of medical physicists worldwide reflects the national picture in Serbia. The number of physicists is generally very limited in hospitals, due to regulation that has not been changed for decades (staffing levels). On the other hand, less and less students are starting physics studies each year, thus contributing to the future lack of professionals.

Another future task is establishment of national regulation regarding the QA in medical use of radiation sources. Our Association, together with the Ministry of Health and the Directorate, started working on it, by creating dedicated workgroups for different topics related to radiotherapy QA, nuclear medicine QA and diagnostic radiology QA. This is planned to be adopted on a national level and implemented into Serbian regulation.

We plan more involvement in international projects and activities, in the field of radiation protection and medical physics.

VI. Conclusions

Training, education and registration are the most important tasks for a professional association of medical physicists.

The lack of medical physicists worldwide is reflected in Serbia; contributing to this is also the fact that physicists are widely neglected in healthcare, as well as other non-health professions (biologists, chemists, etc).

Physicists in Serbia contribute substantially to implementation of new techniques as well as training of all staff, but their value is not acknowledged through their status and salary. This might lead in future years to the dramatic failure of the Serbian healthcMPI_issue_final_versionsare system relying on ionizing radiation, as the students will turn to more profitable jobs.

The career of medical physicists is very exciting, requires constant education and improvements in knowledge and skills, also enables travelling and meeting new people, but it has to be valued and recognized.

Fig. 1 Members of the Serbian Association of Medical Physicists during the annual meeting in 2021

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corresponding author:
Author: Borislava Petrovic
Institute: Oncology Institute Vojvodina
Street:Put dr Goldmana 4
City:Sremska Kamenica
Country: Serbia
Email: borislava.petrovic@df.uns.ac.rs