MEDICAL PHYSICS IN DENMARK: HISTORY, EDUCATION, AND PROFESSIONAL RECOGNITION

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Abstract— **Since Röntgen's discovery of x-rays, medical physics has been a professional topic in Denmark, and from the very beginning physicists have been involved in the application of ionising radiation – both in research, diagnostics and treatment.**

40 years ago the Danish Society for Medical Physics (DSMF) was formed. An important task for the society has always been the education of medical physicists and the Continuing Professional Development (CPD) programme.

In Denmark, medical physicists are recognized and registered, but unlike other health professionals not formally authorized. This is a position DSMF have fought for since the formation of the society and still today finds of utmost importance.

Keywords— **Medical Physics, Education, Development, Accreditation, DSMF**

I. History of Medical Physics in Denmark

Röntgen's discovery of x-rays was announced in Danish newspapers [1] already within two weeks of the original scientific paper "On A New Kind of Rays" [2] having been published at the end of December 1895. As in many other countries, the announcement sparked an immediate public interest in the new fascinating technology. During January, physics professor H.O.G. Ellinger at the Royal Veterinary and Agricultural University in Copenhagen did his own experiments with x-rays, which resulted in the first public demonstration in Denmark on January 28 1896 [3]. During this talk, the professor actually tried to x-ray the hand of a member of the audience.

It was another physicist, 24-year old Martin Knudsen, who on the 12th of February 1896 at the College of Advanced Technology in Copenhagen acquired the first diagnostic radiography in Denmark, that of a broken lower limb [4]. Present was also physics professor Christian Christiansen and King Christian the 9th's royal surgeon Carl Ludvig Studsgaard [5]. Three days later, professor Christiansen published the first Danish monograph on x-rays, an 80-page book describing all the details of the technical equipment needed to generate the rays [6]. Simultaneously, engineer Paul Bergsøe did extensive work on exploring x-ray production and detection, which was published the same year [7,8].

Meanwhile, professor Ellinger joined forces with a medical doctor, Johannes Mygge, who went on to pioneer radiology in Denmark. Together, in March 1896, they installed the first x-ray equipment at a Danish hospital, Copenhagen's Municipal Hospital, and before the end of the year, Mygge had experimented with radiotherapy [9]. The same year, two private x-ray clinics appeared in Denmark, one in Copenhagen and one in Aarhus.

Though physicists and engineers thus were an integral part of the early application of x-rays in medicine, medical doctors soon dominated the field both in scientific literature and public awareness in Denmark.

In 1912, public focus switched from x-rays to radium as a means of treating cancer patients. In May, the newspaper Politiken started a fundraising campaign for a young artist whose wife had fallen seriously ill from cancer and needed to finance radium treatment abroad. The same month, King Frederik the 8th died and his successor asked that the public instead of buying funeral wreaths of silver or gold would donate money to charity. These two events sparked a debate about financing the quite expensive radium treatment in Denmark, and a national radium fundraising committee was established, resulting in the first public radium station in Copenhagen opening in 1913 and radium stations in Aarhus and Odense opening in 1914 [10].

An intense debate followed about staffing of the radium stations, mainly due to the Copenhagen station being headed by a dermatologist, which the local surgeons did not appreciate. However, no mention of physicists was made at the time.

In 1919, reports emerged about a critical shortage of radium with patient treatments being cancelled. This triggered a second national fundraising campaign, which was launched in early 1921. At the same time, professor Niels Bohr opened his famous institute at the University of Copenhagen. His brother, Harald Bohr, had just been elected into the Executive Committee of the Radium Foundation, and this led the surgeon professor Thorkild Rovsing – who had been very active in the 1914 debate about the staffing of the radium stations – to demand that a physicist from the Niels Bohr Institute should be associated to the radium clinics [11].

The fundraising resulted in the purchase of radium worth about 3.8m Euros (2020 equivalent). When the first shipment arrived in October from the US, the box was opened in the home of the chairman of the Radium Foundation with the presence of Niels Bohr. The box was quite difficult to open, but finally professor Bohr took over and cracked the lid open.

"He is used to splitting the atom", one newspaper reported [12].

The opening of the radium box was documented in a famous photograph (see Figure 1). Close to Bohr another scientist and Nobel laureate can be seen, Hungarian George de Hevesy, who was spending the first half of the 1920s at the Niels Bohr Institute. He went on to work with radioactive tracers to study biochemical processes, thus becoming one of the pioneers in nuclear medicine.

Fig. 1 Opening of the radium box, Dagbladet, October 21 1921.

Shortly after the event, Jacob Christian Jacobsen from the Niels Bohr Institute was associated part time with the radium station in Copenhagen as the very first medical physicist in Denmark.

In 1936, the radium station in Aarhus got a similar part-time association with a physicist from the newly formed Department of Physics at the University of Aarhus. The first permanent position for a hospital physicist in Denmark was established in 1954, when J. Ambrosen became head of the new Radiophysics Laboratory in Copenhagen. In 1955, C.B. Madsen was appointed to a similar position in Aarhus [10], and in 1962 Norwegian P. Omsveen was appointed in Odense [13].

In 1928 the original radium fundraising committees merged into The Danish Cancer Society, and still today private donations are an important part of Danish healthcare technology implementation. For instance, the first Scandinavian full body CT scanner was donated by a private foundation (A.P. Møller Foundation) and implemented in Copenhagen in 1976, the first MRI scanner (1985) was donated by a businessman (Simon Spies). The Cyclotron and PET Center at Rigshospitalet in Copenhagen has from its start in 1992 and to date been generously supported by the John and Birthe Meyer Foundation, and even the very large and expensive Danish Centre for Particle Therapy (2019) was made possible only by a large private donation by the A.P. Møller Foundation.

II. History of the Danish Society for Medical Physics

Initial attempts to found a professional society for medical physicists was done in the early 1970s, but only after the founding of the European Federation of Organisations for Medical Physics (EFOMP) in 1980 was this achieved.

Before this, individual Danish medical physicists had a Scandinavian network through the Nordic Association of Clinical Physics (NACP), formally established in 1965 [14], and the radiotherapy branch of the Danish physicists had a national forum through the Danish Society for Radiotherapy and Oncology. However, with EFOMP the opportunity to establish strong international relations emerged.

After 1½ years of preparation, the Danish Society for Medical Physics (DSMF) was founded in November 1981, with K.A. Jessen from Aarhus being elected the first president. Formal membership of both EFOMP and the International Organization for Medical Physics (IOMP) was achieved in 1982. Jessen went on to become EFOMP president from 1993-1995 [15]. Over the years DSMF has had 10 presidents - the first female president being elected in 2019.

The number of members has risen continuously over the years along with the evolvement of the profession and has recently passed 200 (see Figure 2). Implementation of the 1996 Euratom BSS Directive [16] established the need for medical physicists in Nuclear Medicine and Diagnostic Radiology, and in particular, national cancer plans resulted in heavy investments into new radiotherapy equipment between 2000-2010. The result of these investments was documented in the 2014 ESTRO-HERO project where Denmark now had the largest number of treatment linear accelerators per capita in Europe [17]. All this is reflected in the number of medical physicists in Denmark.

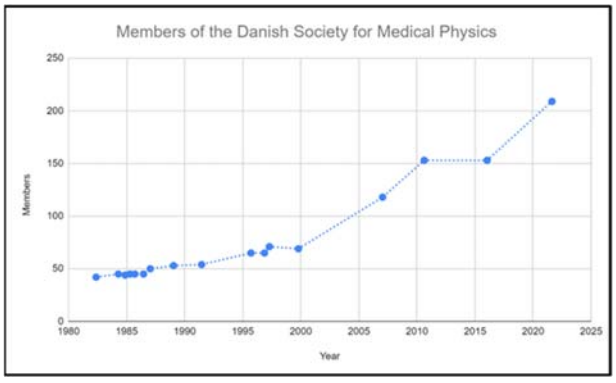

Fig. 2 Ordinary members of DSMF over time.

DSMF had their first web page in 1999 and a logo was approved in 2000 after suggestions were sent in by members. In 2010 a new professional website (www.dsmf.org) was launched where the logo played an important role in the design. The same logo is still in use today.

DSMF is also quite active on social media, with the Facebook page being launched in 2014. The goal was to increase the knowledge of both our society and also medical physics in general and give room for discussion. For several years the number of followers has exceeded our member count and news thus reaches a larger audience.

In 2018, DSMF hosted the 2nd European Congress of Medical Physics (ECMP2018). With more than 800 participants from all over Europe visiting Copenhagen, this marked a major milestone in the history of the society and for medical physics in Denmark.

III. National Educational Programme

Even today, there is no formal university degree in medical physics, while an important task for the society has always been to formalise and strengthen the education of medical physicists. The first work on this was started in April 1972, before the founding of the society, when the Danish Society for Radiotherapy and Oncology established a committee with the task of assessing the need for education of radiotherapy physicists.

The report of the committee [18], which was approved in May 1973, listed all the theoretical subjects that should be mastered by a physicist working within radiotherapy. Some of these subjects would require further education after employment at a radium station. Since formal educational courses could not always be found at the universities, substantial self-study would be needed, and the report suggested that all educational activities should be documented and approved by a national educational committee under the Danish Society for Radiotherapy and Oncology. The need for education of new radiotherapy physicists from 1973-1985 was estimated to about 3 per year.

In parallel with the development of this report, work was being done to establish a committee that could evaluate the professional qualifications of candidates for chief physicist positions. The inspiration for this was the Danish Medical Practitioners Act, which stated that any chief medical doctor before employment was to be evaluated by a national committee established by the national medical societies. In a meeting with the Danish Health Authority in October 1972, this model was presented and unanimously approved, though the committee would be an advisory body and not a mandatory step in the recruitment process. The committee was subsequently formed in 1974 under the Danish Society for Radiotherapy and Oncology.

In 1985 DSMF published a new report on education of medical physicists, as an update of the 1973-report. This report focused on the demographics of current medical physicists and the future need for educating new physicists. Again, the need for education was stressed, and it was proposed to setup a national Educational Council that could participate in the planning of individual education programmes and also in organising much needed teaching courses. This council was established by DSMF the same year.

The report was widely distributed and used as a political lobbying tool, and finally, in 1995, the Danish Health Authority issued legal guidelines to hospitals on the education of medical physicists.

The document for the first time describes the system which is still in use in Denmark, where the education is based on a Master's degree in physics or engineering with relevant levels of physics and mathematics. The education is divided into three sub-fields: 1) Oncologic Radiotherapy, 2) Diagnostic Radiology, and 3) Nuclear Medicine. The candidate is first employed in a residency position at an approved hospital department, a qualified supervisor is assigned, and an individual educational programme of at least 3 years duration is planned. The programme is approved by the Educational Council of DSMF, and a status report has to be submitted each year.

The membership of DSMF is similarly divided into the three sub-fields, with Radiotherapy being the largest group (almost 70% of all members), see Table 1. With the emerging use of MRI, DSMF hopes to formally include MRI physicists in the society in the future as well.

Table 1 Number and distribution of DSMF member physicists 2021. MPE: Medical Physics Expert

Medical Physicists	Total	Male/Female	MPE
Radiotherapy	145	93/52	74
Nuclear Medicine	34	30/4	17
Radiology	30	21/9	7
Total	209	144/65	98

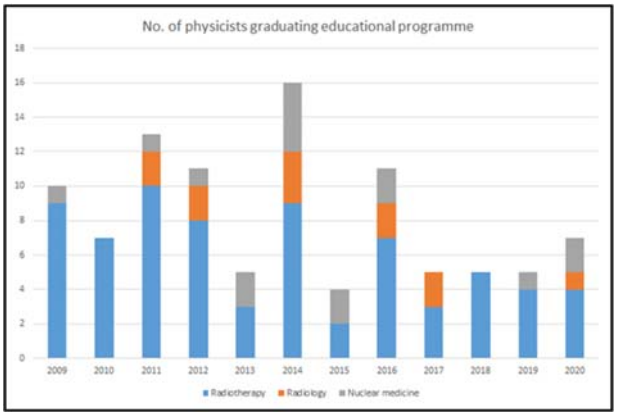

Fig. 3 Number of physicists graduating from the national educational programme per year.

In 2010 the educational structure was upgraded and consolidated into a law, but with more or less the same contents as the 1995 guidelines.

The number of new physicists annually graduating the national educational programme can be seen in Figure 3.

In parallel with the basic educational programme, a Continuing Professional Development (CPD) programme was formalized in 1997 with the formation of a CPD Evaluation Committee. This committee was actually based on the concept of a qualified medical physics expert which had emerged during the 1980s in European Economic Community directives [19], and which needed a formal evaluation system to qualify for the title.

Today, after finishing the basic educational programme, Danish medical physicists register professional development activities, which are then annually reviewed and converted into CPD points by the Evaluation Committee. With a sufficient number of CPD points, a medical physicist can obtain the Medical Physics Expert (MPE) title, which then has to be maintained and renewed every 5 years.

IV. Professional recognition

The educational programme described is in reality just guidelines for departments to train physicists to obtain the qualifications needed to carry out their duties at a hospital. Because medical physicists are not formally authorized by the Danish Health Authority, you can actually work as a medical physicist in Denmark, without having completed the educational programme.

This lack of healthcare authorization is in strong contrast to the Danish Authorization Act, which clearly states that the purpose of healthcare authorization is to "strengthen patient safety and promote quality through the authorization of healthcare professionals, where the activities of others in the business area in question may be associated with particular danger to patients" [20].

This obviously covers our profession but it has yet to be acknowledged by the authorities. As important as ionising radiation is for radiation therapy and diagnostics, as damaging it can be if mishandled due to lack of knowledge of the applied equipment and procedures. Quality assurance in relation to ionising radiation is of the utmost importance for patient safety. There are few other places in the healthcare system where one individual's mistakes can make so much detriment to so many patients. Furthermore, medical physicists train and educate staff members like physicians, RTTs, and radiographers to work in the field of ionising radiation, and as such we are responsible for the qualifications of authorized personnel. The term MPE was included in Danish law with the *EU Council Directive 2013/59/EURATOM* in 2013 [21], but still no formal authorization of medical physicists exists.

For more than 30 years DSMF has fought for professional recognition like our authorized colleagues, and in 2012 the importance of this was emphasized in The Lancet [22]. Despite several enquiries to politicians in the Danish Parliament and especially the different Ministers for Health, the arguments have not been acted upon. In many of the countries Denmark normally compares to, medical physics is a protected profession, so this is an important position DSMF will continuously pursue.

V. Conclusions: future of medical physics in Denmark

A continuous high level of education is important. Private funding and priority by healthcare decision makers continues to introduce state-of-the art equipment in Denmark shortly after release. In addition, there is a long and proud tradition for well-reputed evidence-based research in medical physics. All are important points that are worth to retain and protect in the future for the continuous development of medical physics in Denmark. Looking at the current number of Medical Physics Experts there is a genuine request to continue the professional development throughout one's work life – we need to incite this in the future as well.

As a society we shall continue the support of our medical physicist members and make awareness of our important field of expertise – both to future medical physics students and the public in general.

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