

MEDICAL PHYSICS PROFESSIONAL DEVELOPMENT AND EDUCATION IN INDIA

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Abstract—In the treatment of cancer, Medical Physicist works in a hospital environment as a part of a wide clinical team and plays important roles such as treatment planning, radiation dosimetry, quality assurance (QA) of the equipment in order to deliver accurate radiation dose for better tumour control. Medical Physicist also contributes in performance evaluation of radiation generating equipment used in nuclear medicine and diagnostic radiology practice and optimization of radiation doses in imaging modalities. Bhabha Atomic Research Centre had started one year Post Graduate Diploma in Radiological Physics programme in 1962 with support from world health organization (WHO), which was the first course in India in the field of Medical Radiation Physics. Presently, there are 20 universities/institutions conducting Post M.Sc./Post Graduate degree/diploma in Medical Physics across India. Considering the tremendous scope for research in Medical Radiation Physics, some of the universities/institutions are offering Doctor of Philosophy (Ph.D.) in Medical Physics. National Regulatory Authority i.e., Atomic Energy Regulatory Board (AERB) made the provision for internship/ residency programme for Medical Physicists considering the need of clinical training. Each qualified Medical Physicist is registered with the AERB through online e-LORA (Electronic Licensing of Radiation Applications) system and a unique registration number is allotted to them. As on date, there are 1270 qualified Medical Physicists registered with AERB. There are 410 radiotherapy institutions having various types of radiotherapy equipments (conventional to advanced) in the country and there is no dearth of Medical Physicists to cater the present need. In addition to playing crucial role in Radiotherapy, Medical Physicists also contribute in diagnostic radiology and nuclear medicine practices for optimizing image quality and thereby optimizing the radiation doses from these imaging modalities. Association of Medical Physicists of India (AMPI) was founded in 1976 with the objective to work for strengthening medical physics knowledge through conducting annual conferences/workshop/CME, publishing Journal on Medical Physics. For maintaining standard in the practice of medical physics, AMPI has also started College of Medical Physics of India (CMPI), to initiate the evaluation and certification programme for the qualified medical physicists.

Keywords—Medical Physics, Internship, Course, Qualification, e-LORA, AERB

IX. INTRODUCTION

It is well established that ionizing radiation is being used worldwide for the treatment of cancer and diagnosis of the various diseases for past several decades. In treatment, the goal is to deliver the maximum radiation dose to the tumour and minimum radiation dose to the surrounding healthy tissues for obtaining better treatment outcome whereas in diagnosis the aim is to obtain better image quality with minimum radiation dose. Medical Physics is the branch of science that mainly deals with the applications of ionizing radiation in health care through radiotherapy, diagnostic radiology, nuclear medicine and the associated radiological protection. In the treatment of cancer Medical Physicist works in a hospital environment as a part of a wide clinical team and plays an important role for treatment planning, radiation dosimetry, quality assurance (QA) of the equipment in order to deliver accurate radiation dose for maximizing tumor control probability and minimizing normal tissue complication probability[1-2]. Medical Physicist also contributes in QA of the equipment used in nuclear medicine and diagnostic radiology practice and optimization of radiation doses in imaging modalities. Medical Physicists work alongside clinicians in providing scientific and technical expertise and conducting research. Role of a Medical Physicist is multifold and consists of treatment planning, estimation of dose for patients and personnel, the quality assurance tests of radiological equipment, the calculation for radiation shielding requirements and the training of several health professionals (doctors, medical physicists, radiologists, technicians, and nurses). Additionally, Medical Physicist is assigned the responsibilities of Radiological Safety Officer (RSO) in medical radiation facility, subject to qualifying the competency test and approval from AERB, for ensuring radiation safety of workers and members of public. According to GLOBOCAN data of International Agency for Research on Cancer (IARC), a World Health Organization(WHO) entity, about a million new cases were recorded while about 683,000 deaths due to cancer were registered in 2012[3]. Out of these 1 million cancer patients around 60% patients need radiation therapy. At present there are only 600 Teletherapy equipments (Medical Linear Accelerators, Cyberknife, Tomotherapy, Telecobalt units) in

India which is far below the required number of Teletherapy equipments to cater the new cancer patients, even though rapid growth of hospitals with radiation therapy facilities with advanced technologies is seen in India in the last decade. Moreover, considering complexity of the equipments, stringent QA (patient specific QA in addition to equipment) in advanced technologies is needed. In view of the above, there would be requirement of more number of medical physicists which is mandatory requirements as per the national regulatory authority- Atomic Energy Regulatory Board (AERB). This paper presents the current status of Medical Physics professional development in India.

X. MATERIALS AND METHODS:

Ila) Historical Development of Medical Physics Programme in India

In treatment of cancer, Medical Physicist is a part of clinical team and plays vital role to deliver accurate radiation dose for desired treatment outcome by carrying out radiation dosimetry, quality assurance (QA), treatment planning and other important task. Expertise of the Medical Physicist is also required in nuclear medicine and diagnostic radiology practices for optimization of radiation doses to obtain good image quality. Considering the importance of the Medical Physicist in health care sector, Bhabha Atomic Research Centre (BARC) started one year post graduate Diploma in Radiological Physics programme in 1962 with support from world health organization (WHO), which was the first course in India[4-7]. To cater the need of rising demand of more number of Medical Physicist in the country many more universities started offering Medical Physics courses in addition to BARC[8]. There are two types of courses offered by the various universities in India to become a qualified Medical Physicist namely i) One year post M.Sc. Course in Medical Physics/Radiological physics; and ii) Two years postgraduate degree course in Medical Physics/Medical Radiation Physics after graduation in science with physics as major subject. As per the stipulation by the AERB, minimum qualifications required to work as Medical Physicist in India are [9]:

- i) A post graduate degree in Physics from a recognized university;
- ii) A Post M.Sc. diploma in radiological/medical physics from a recognized university; &
- iii) An internship of minimum 12 months duration in a recognized well-equipped radiation therapy department.

OR

- i) A basic degree in science from a recognized university with Physics as one of the main subjects;
- ii) A post graduate degree in radiological/medical physics from a recognized university; and

- iii) An internship of minimum 12 months in a recognized well-equipped radiation therapy department.

Further, the qualification required, as per the AERB, to work as Radiological Safety Officer (RSO) in Radiotherapy facility in India is as follows:

- i) Minimum qualifications required for a Medical Physicist and ;
- ii) Certification for competency to work as RSO
- iii) An approval from the competent authority to function as RSO.

I Ib) Medical Physics Programme in India:

Only those candidates who successfully complete the Medical Physics course and one year internship from a well equipped radiotherapy centre meeting the internship criteria are eligible to work as Medical Physicist in the country [7-9]. These candidates become eligible to work as RSO in medical institutions after evaluation through competency test and allowed to function as RSO with approval from AERB.

List of the institutions whose Medical Physics course is in accordance with AERB requirements are given in Table-1. As per constitution of AERB, one of its mandates is to prescribe the syllabi for training of personnel in radiation safety aspects at all levels. To meet with the pace of the technological advancement in the field, syllabus of Medical Physics course is reviewed and revised periodically to incorporate the advanced technologies.

I Ic) Medical Physics Internship/Residency Programme:

A medical physicist is professional who is competent to independently practice one or more subfields of medical physics. In a hospital, Medical Physicist is primarily involved with different activities, such as dosimetry, performance evaluation, QA, treatment planning, research and development, and teaching related to use of ionizing radiation and radiation safety. Medical physicist plays an important role in ensuring accurate radiation dose delivery for intended treatment outcome. Significant technological advancements in radiation dose delivery and imaging modalities have led to availability of high precision radiotherapy with highly conformal radiation doses. A number of complex equipments and procedures are used to fulfil the objectives of effective and safe radiotherapy. The use of fully computer controlled radiotherapy equipment e.g. advanced medical accelerator equipped with advanced treatment techniques [e.g. 3D conformal radiotherapy (3D-CRT), intensity modulated radiotherapy (IMRT), image-guided radiotherapy (IGRT), Stereotactic radio-surgery (SRS)/Stereotactic Radiotherapy (SRT), and Volumetric Modulation Arc Therapy (VMAT)] require highly skilled and competent medical physicist. A mere holder of a university degree in radiological/medical physics, without

the acquiring adequate hospital training, cannot be considered as competent Medical Physicist [10]. Therefore, it is necessary for the Medical Physicist to undergo internship/ residency programme from a well equipped radiotherapy centre to gain competence in the field. Internship/ residency is now an integral part of the Medical Physics education and training programmes in most of the developed countries [11-16]. To maintain the quality of the medical physics courses at par with international standards, it is necessary to incorporate and implement internship/ residency in Medical Physics education and training programmes in India. Therefore, considering need of clinical training, AERB made the provision for internship/residency programme for Medical Physicists by stipulating the same as a mandatory requirement in the revised Safety Code [9].

In India, the candidates after successfully completing course from any of the institutions as listed in Table-1, need to undergo mandatory internship/residency of minimum 12 months duration in a radiation therapy department, meeting the AERB laid down criteria, to become qualified Medical Physicist. To fulfil this requirement, all the Medical Physicists passing out from different academic courses in the country undergo internship/residency in Medical Physics programme under the supervision of a qualified and experienced Medical Physicist at a recognised well-equipped radiotherapy centre in the country for a duration not less than 12 months[8-9]. Minimum syllabus prescribed by AERB for the internship/residency programme for Medical Physics includes 1) Radiotherapy Equipment (treatment and imaging) and QA; 2) Beam Calibration and Dosimetry; 3) External Beam Treatment Planning; 4) Brachytherapy Dosimetry and Treatment Planning; 5) In-Vivo Dosimetry and Patient Dose Verification; 6) Radiation Protection and Safety; 6) Clinical Orientation; and 7) Professional Skill Development and Career Planning. Well equipped radiotherapy centre for the purpose of internship/residency programme must have at least 1) One Linear Accelerator (with photon and electron beams) ; 2) One HDR Brachytherapy Unit; 3) One Simulator/ CT-Simulator; 4) One Treatment Planning System; 5) Adequate dosimetry and monitoring instruments; 6) at least one Medical Physicist with minimum 5 years of experience to become internship supervisor. The ratio of Medical Physicist intern and Internship Supervisor is 1:1. However, a medical physicist with more than 3 years of working experience in a Radiotherapy Department can also be considered as an internship supervisor subject to availability of at least one Medical Physicist having minimum 5 years of experience in the department.

IId) Growth of the Medical Radiation Facilities and availability of Medical Physicists

The usages of ionising radiation sources (radioisotopes and radiation generating equipment) for medical applications have been enormously increasing all over the world. Applications of radiation sources in medical applications (radiotherapy, nuclear medicine and diagnostic radiology) in India have seen huge growth during the last decade. For analysis of growth of radiotherapy facilities in India, eight years data (2009-2016) is depicted in Fig.1. India witnessed rapid growth of medical institutions using ionising radiation for diagnosis and treatment purposes for the last decade.

Ile) Higher Studies and R& D activities in Medical Physics

Considering the tremendous scope for research in Medical Radiation Physics, some of the universities/institutions are now offering Ph.D. in Medical Physics e.g. Anna University, Homi Bhabha national Institute (a deemed to be university) Punjab University, Baba Farid University of Health Sciences, D.Y. Patil University etc. There are various Government organisations e.g. Department of Atomic Energy (DAE), AERB, Department of Science and Technology (DST), Council for Scientific and Industrial Research (CSIR) etc. which are also providing financial assistance for research projects pertaining to the Medical Physics and Radiation Safety.

XI. RESULTS

From the Fig.1, it is observed that institutions using radiotherapy facilities were 266 in 2009 whereas 410 in 2016. We can also observe from Fig.1 that number of accelerators and remote afterloading HDR brachytherapy equipments were 167 and 160 in 2009 whereas this number increased to 374 and 258 in 2016. However, there is decline trend seen in case of Telecobalt equipments which decreased from 300 in 2009 to 224 in 2016.

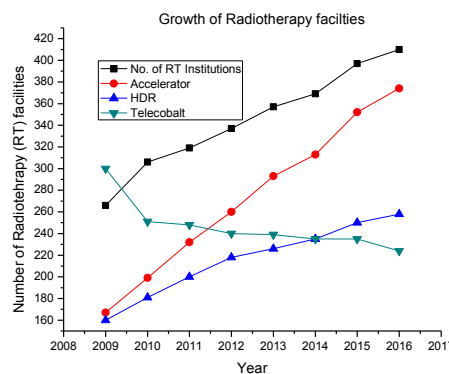


Fig 1: Growth of Radiotherapy facilities in India

Presently twenty institutions/universities are conducting Medical Physics courses and producing on an average 150

Medical Physicists annually across the country. Fig.2 represents the growth of number of Medical Physics courses over a decade (2007-2016). Currently there are total 236 Nuclear Medicine institutions equipped with 125 PET-CT, 163 Gamma Camera and 61 High Dose therapy facilities which are licensed by AERB. The status of these Nuclear Medicine facilities is shown in Fig.3. (Computed Tomography, Fixed, Mobile, Portable, Radiography & Fluoroscopy, Mammography, C-Arm, Dental, OPG, Dental Cone Beam CT and BMD) registered with AERB.

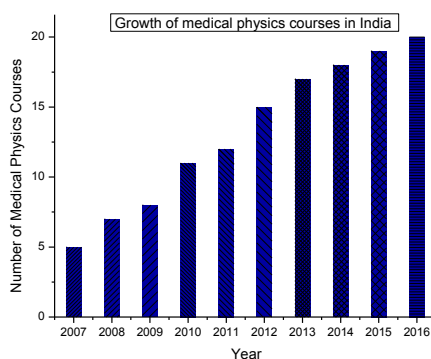


Fig.2: Growth of Medical Physics courses in India

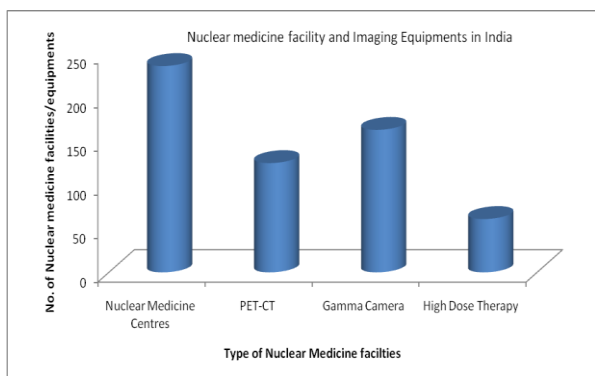


Fig.3: Present status of Nuclear Medicine facilities

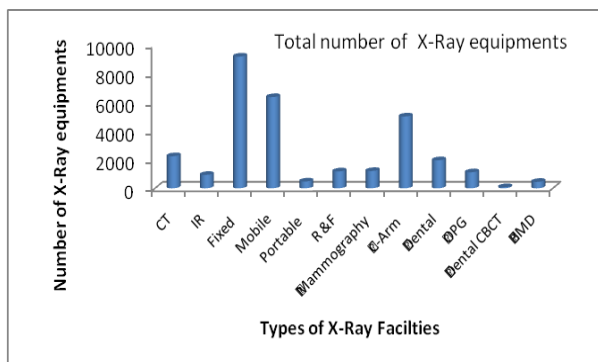


Fig.4: Present status of diagnostic X-Ray facilities

XII. DISCUSSION

The maximum number of cancer patients that can be treated annually is around 500 per Teletherapy equipments. Therefore, using present 600 teletherapy equipments available in India, the maximum number of patients that can be treated annually is about 300000, which is far below the required equipments to cater the total cancer patients in India (~600000 as per the WHO report). Thus there is a need for double the number of existing teletherapy equipments which in-turn requires large number of Medical Physicists to cater the need. The required number of Medical Physicists will further increase considering complexity as it will require more man-hours for performing QA of the equipment & patient specific QA, treatment planning etc. in advanced technologies. Initially BARC has started One year post graduate diploma in radiological physics course (Dip.R.P.) in 1962 whereas presently 19 more institutions conducting various Post M.Sc./ Post Graduate courses in Medical/Radiological physics due to growing demand of Medical Physicists producing 150 on an average number of Medical Physicists annually across the India.

Each qualified Medical Physicist is registered with AERB through online e-LORA (Electronic Licensing of Radiation Applications) system and a unique registration number is allotted to them [17]. As per the records, there are 1270 qualified Medical Physicists registered with AERB. There are 410 radiotherapy institutions in the country and therefore the ratio of available Medical Physicists to number of radiotherapy institution is around 3:1. Similarly, available number of Medical Physicists per Teletherapy equipment is more than 2. Therefore, there is no dearth of Medical Physicists to cater the present need. The average growth rate of radiotherapy equipments (addition of new equipments) in the radiotherapy institutions spread across the country is around 60 over the past 5 years whereas the average number of Medical Physicists being produced around 150 annually i.e. by a factor of >3 per equipment. Therefore, no shortfall of required number of Medical Physicists is anticipated with the current growth trend of radiotherapy equipments in India.

Further, in India, Medical Physics activities started in the mid 40s with the appointment of Dr. Ramaiah Naidu as the first Medical Physicist at the Tata Memorial Hospital [18]. The Association of Medical Physicists of India (AMPI), an affiliate of the Indian National Science Academy and the International Organization for Medical Physics, was founded in 1976 with the objective to work for strengthening Medical Physics knowledge through conducting annual conferences/workshop/CME, publishing Journal on Medical Physics, encourage Research and Development and Education in the field of medical physics, and disseminate world-wide information in this field to all

members of the association and to participate actively in programmes on Medical Physics conducted by international organisations such as International Organization for Medical Physics (IOMP), The Asia-Oceania Federation of Organizations for Medical Physics (AFOMP) etc. For maintaining standard in the practice of Medical Physics in human healthcare programme towards the fulfilment of objectives of medical imaging and radiation therapy, AMPI has also started College of Medical Physics of India (CMPI), to initiate the evaluation and certification programme for the qualified Medical Physicists. Currently AMPI has an active membership more than 2000.

XIII. CONCLUSIONS

India has vast experience in the field of Medical Physics. Medical Physics courses are being conducted in the country since more than five decades. All types of radiotherapy equipments with conventional to advanced treatment technologies (Telecobalt, standard and advanced medical accelerator, IORT) and specialized equipments (Cyber Knife, Gamma Knife and Tomotherapy) are in operation in the country. India has well structured Medical Physics courses and presently several Medical Physics courses are being conducted by various universities in different parts of the country producing adequate number of Medical Physicists annually to cater the need in the healthcare sector of the country. India has initiated various steps for strengthening its Medical Physics programme by reviewing and revising syllabus periodically to incorporate the topics related to advanced techniques introduced in the field of Medical Physics and introducing one year compulsory internship/residency programme by AERB. AMPI is also taking keen initiative in conducting workshop/seminar/CME/conferences on various topics in order to update and share the knowledge among the professionals. India is also promoting research and development activities by providing financial aid to the institutions/universities carrying out research activities in the Medical Physics. In addition to playing crucial role in Radiotherapy, Medical Physicists also contribute in diagnostic radiology and nuclear medicine practices for optimizing image quality and thereby optimizing the radiation doses from these imaging modalities.

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Table 1: List of Medical Physics courses in india

Sr. No.	Name of the Institute	Affiliated by	Entry level qualification	Course Name	Duration
1.	Radiological Physics & Advisory Division, Bhabha Atomic Reseraach Centre Mumbai ,	Homi Bhabha National Institute (Deemed University), Mumbai	Master's degree in science (Physics)	Post M.Sc. Diploma Course in Radiological Physics (Dip. R. P.)	1 Year
2.	Osmania University, Hyderabad	Osmania University, Hyderabad	-do-	-do-	-do-
3.	* Pt. J. N. M. Medical College & Dr. B.R. Ambedkar Memorial Hospital,Raipur	AYUSH and Health Sciences University of Chhattisgarh, Raipur	-do-	-do-	-do-
4.	Guru Gobind Singh Indraprastha University,New Delhi	Guru Gobind Singh Indraprastha University, New Delhi	-do-	-do-	-do-
5.	Regional Cancer Center,Thiruvananthapuram	Kerala University of Health Sciences, Thrissur	-do-	-do-	-do-
6.	Amrita Institute of Medical Science & Research Center,Kochi	Amrita Vishwa Vidyapeetham, Coimbatore	-do-	Post Graduate Diploma in Medical Radiological Sciences(PG DMRP)	-do-
7.	Jadavpur University,Kolkata	Jadavpur University, Kolkata	-do-	Post M.Sc. Diploma in Medical Physics	-do-
8.	*Mahavir Cancer Sansthan, Patna	Aryabhatta Knowledge University, Patna	-do-	-do-	-do-
9.	Anna University, Chennai	Anna University, Chennai	Bachelor's degree in science (Physics major)	M.Sc.(Medical Physics)	2 Years
10.	Dr. B. Borooah Cancer Institute, Guwahati	Gauhati University, Guwahati	-do-	M.Sc. (Radiological Physics)	-do-
11.	Vydehi Institute of Medical Sciences,Bangalore	Rajiv Gandhi University of Health Sciences, Bangalore	-do-	M.Sc.(Radiation Physics)	-do-
12.	Kidwai Memorial Institute of Oncology,Bangalore	Rajiv Gandhi University of Health Sciences, Bangalore	-do-	-do-	-do-
13.	Calicut University,Calicut	Calicut University, Calicut	-do-	-do-	-do-
14.	Manipal University,Manipal	Manipal University, Manipal, Karnataka	-do-	M.Sc.(Medical Radiation Physics)	-do-
15.	Panjab University Chandigarh	Panjab University, Chandigarh	-do-	M.Sc.(Medical Physics)	-do-
16.	*PSG College of Technology,Coimbatore	Anna University, Chennai	-do-	M.Sc.(Medical Physics)	-do-
17.	Christan Medical College, Vellore	The Tamil Nadu Dr M. G. R. Medical University, Chennai	-do-	-do-	-do-
18.	Bharthiar University, Coimbatore	Bharthiar University, Coimbatore	-do-	-do-	-do-
19.	Dr. N.G.P. Arts & Science College, Coimbatore	Bharthiar University, Coimbatore	-do-	-do-	-do-
20.	D.Y. Patil University, Kolhapur	D.Y.Patil University, Kolhapur	-do-	-do-	-do-

*Although the courses are in line with AERB requirement but temporally not offered by the institutions/Universities