STANDARDIZATION AND HARMONIZATION OF MEDICAL PHYSICS EDUCATION AND TRAINING: SURVEY OF STATUS

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Abstract— **The rapid scientific and technological advancements have increased the complexity of physics intensive specialized diagnostic and therapeutic procedures in various fields of medicine and necessitated highly proficient and competent medical physics manpower to ensure the best radiation protection while preserving the necessary diagnostic information or therapeutic outcome from the procedure. This surge in demand has led to the escalation of requirement for education and training of medical physicists and hence opening of numerous educational programs around the world. It is imperative that these programs are standardized and in harmonization with each other. To evaluate the educational and training status of medical physics programs of the member states, a structured questionnaire was shared among the national member organizations (NMO) of International Organization of Medical Physics (IOMP), and the responses received from 31 NMOs were appraised to assess the standardization and harmonization of educational programs across member states. It is observed from this survey that the variations in the number of advanced treatment facilities and the availability of clinically qualified medical physicists (CQMP) for various specialties are hugely diverse among the participated countries. For harmonization of medical physics education and training across the globe, IAEA, IOMP, AFOMP, EFOMP and many regional and international professional organizations have expended huge efforts and resources, still much to be done looking into the growing need of CQMP across the world.**

Keywords— **medical physics, education and training, standardization, harmonization, survey.**

I. INTRODUCTION

Medical uses of ionizing radiation include a wide variety of diagnostic and therapeutic procedures performed in radiology (including dentistry), nuclear medicine and radiation therapy, as well as image-guided interventional procedures in medical specialties such as cardiology, vascular surgery, urology, gastroenterology, neurosurgery etc. [1]. Medical Physicists play an important and vital role in ensuring the best radiation protection while preserving the necessary diagnostic information or therapeutic outcome from the procedure.

The International Labour Organization (ILO) has recognized medical physicists as health professionals and the medical physicists working in a clinical environment should have the required competency to optimally perform the duties and responsibilities of each of the roles [2]. This necessitates the medical physics students to undergo a structured training program and residency under an experienced medical physicist in a recognized institution. Furthermore, the complexity of diagnostic and therapeutic procedures is increasing with advancements in technology demanding a high degree of knowledge and professional competency of medical physicists. The requirement interdisciplinary coordination between medicine, biology, physics, and biomedical engineering also calls for an upgrade in the involved individual's professional competencies and expertise. Implementation of specialized physics intensive procedures such as particle therapy, image-guided & intra-operative radiotherapy, advanced imaging and nuclear medicine techniques led to an unprecedented surge in the requirement of medical physics competency in healthcare. In order to facilitate the highly challenging requirements of these advanced scientific and technological methodologies the quantity of clinically qualified medical physicists (CQMP) needs to be in consonance with the competency needed and hence an escalation in requirement for education and training of medical physicists which led to opening of numerous educational programs around the world [3].

II. MATERIALS AND METHODS

It is imperative that these programs are standardized and in harmonization with each other. To evaluate the educational and training status of medical physics programs of the member states, a structured questionnaire was shared among the national member organizations (NMO) of IOMP, and the responses received from 31 NMOs were appraised to assess the standardization and harmonization of educational programs across the member states.

IOMP, with the aim of harmonization of medical physics education programs provides general guidelines for member organizations in defining the basic requirements for education and training of medical physicists as per IOMP Policy Statement No. 2 [4]. It aims to serve as a reference for medical physics organizations, education institutions and healthcare providers and authorities in planning and development of their national infrastructures for education, training, and certification of medical physicists and for maintenance of standards of practice.

Further, International Atomic Energy Agency (IAEA) is proactively working and helping its member countries in fostering the status of medical physics in radiation medicine through multiple initiatives of technical and cooperation projects and publication of important documents like IAEA

Human Health Series No. 25-Roles and Responsibilities, and Education and Training Requirements for Clinically Qualified Medical Physicists, published by IAEA in 2013 [5] which is endorsed by IOMP and American Association of Physicists in Medicine (AAPM). The document defines appropriately and unequivocally the roles and responsibilities of CQMP in the different specialties of medical physics and recommends minimum requirements for their academic education and clinical training, including recommendations for their accreditation, certification, and registration, along with continuing professional development (CPD). A CQMP is one who has successfully completed an appropriate academic postgraduate medical physics degree and has successfully undergone an appropriate clinical residency training program in a chosen specialty or subfield of medical physics.

In the present survey, the education and training committee (ETC), IOMP circulated a structured questionnaire consisting of 34 questions to assess status of education, training, certification, accreditation, health professional recognition, clinical training, radiation safety and professional scope.

III. Results and Discussion

Medical physics professional organizations from 31 member states responded to the questionnaire.

Table 1 Details of medical physics education program
Y- Year, B- Bachelors, M- Masters, PM- Post Masters, D- Doctoral, HY- Half Yearly

Country	Duration (Y)	Level of Education B/M/PM/D	Exam HY/Y
Belgium	>2 Y	M/PM	HY
Brazil	2 Y	Residency	Y
Bulgaria	>2 Y	B/M/PM/D	HY
Canada	>2 Y	B	HY
Czech-Republic	2 Y	M	HY
Denmark	>2 Y	B	Y
Finland	>2 Y	M	Y
France	>2 Y	M	Y
Georgia	>2 Y	--	--
Germany	>2 Y	PM	individualized
Ghana	2 Y	B	HY
Hong Kong	1 Y	M	HY
Hungary	>2 Y	PM	HY
India	>2 Y	M/PM/D	HY
Iraq	>2 Y	M	HY&Y
Ireland	2 Y	M	HY
Japan	2 Y	M	Y
Malaysia	1 Y	M	HY
Nepal	2 Y	M	N/A
Paraguay	>2 Y	B	HY
Qatar			
Romania	3+2 Y	B/M	HY
Russia	2Y	M	HY
South Africa	>2 Y	M	HY
Spain	>2 Y	M	Y
Sweden	>2 Y	M	Course wise
Switzerland	>2 Y	M	Y
Taiwan	2 Y	M/D	HY
United Kingdom	>2 Y	M	-
Vietnam	2 Y	PM	HY

Table 2: Details of medical physics education program

Country	Radiation protection part of syllabus	No of programs	Max no of students per year
Belgium	No	6	40
Brazil	No	15	44
Bulgaria	Yes	4	32
Canada	No	13	>100
Czech Republic	No	2	10
Denmark	No	5	8
Finland	Yes	5	20
France	No	7	45
Georgia	No	0	0
Germany	Yes	23	400
Ghana	No	1	10
Hong Kong	Yes	1	15
Hungary	Yes	3	13
India	Yes	22	> 200
Iraq	Yes	15	382
Ireland	No	2	25
Japan	Yes	---	
Malaysia	No	2	30
Nepal		0	0
Paraguay	No	1	5
Republic of Moldova	No	0	0
Romania	Yes	6	290
Russia	No	>10	300
South Africa	Yes	7	15
Spain	Yes	40	43
Sweden	Yes	4	48
Switzerland	Yes	1	15
Taiwan	Yes	2	20
United Kingdom	No	8	150
Vietnam	No	4	40

Further, it was observed that 77% of the responded states have a structured medical physics education program and 90% of the courses are of 2 or more than 2 years of duration. The eligibility level education to pursue the medical physics education program is graduation or above in 93% of responders.

All the programs are graduate level or above. One interesting observation is that only 47% have radiation safety certification course as part of the medical physics education program. The maximum number of medical physics education programs are in Spain (40) and maximum student intake in a year is in Germany (400). The number of courses varies from none to 40 and student's uptake also varies from 2 to 400 per year among the countries participated in the survey emphasizing the need for harmonization and standardization to meet the need for CQMP in respective countries. In Iraq, there are 6 BSc programs in medical physics with up to 300 students, 7 MSc programs with up to 80 students and 2 PhD programs with one student each totaling up to 382 students in a year. Further 66% of these medical physics education programs are accredited by government agencies or government authorized/ approved accreditation bodies.

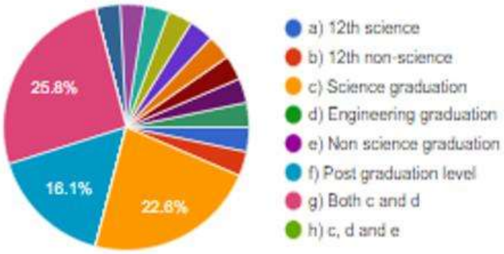

Fig. 1 Eligibility level for pursuing medical physics

As per IAEA to be a CQMP a minimum 2 years residency program [for Africa and Latin America – 1 year residency] in addition to the Master's in medical physics is essential. A residency or a hospital based clinical training is mandatory for 65% of the states participating in the survey and the duration of residency program varies between less than a year to more than 2 years. Only in 34% of the cases, medical physicists are recognized as health professionals by the respective governments. As medical physicists are health professionals, HSS25 of IAEA recommends registration of medical physicists by national agency.

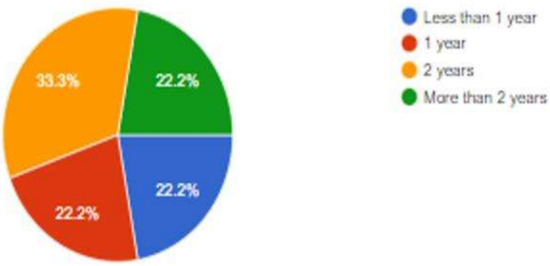

Fig. 2 Duration of Medical Physics Residency/ Clinical Training

Kron et al. [6] reported that though there is an increasing trend in the number of medical physicists in radiation oncology between 2008- 2014, with increase in the number of high-tech treatment modalities and complexity of treatment more experienced medical physicists are required to ensure quality research in medical physics. Similarly, Chougule A [7] observed that in spite of the remarkable growth in medical physics education in AFOMP region over 20 years the growing population and cancer burden demands for higher number of medical physicists in the region to fill the gap. Chougule A, from a survey of the status of medical physics education and training in 20 countries of the Asia-Oceania region also concluded that the existing capacity of medical physics education in AFOMP region needs to scale up to bridge the gap of required numbers of medical physicists in the region [8]. An IOMP survey of 93 countries results show that global increase of CQMP does not meet clinical needs of the world and to meet the double the requirement of CQMP, more medical physics education and training programs are needed [9].

It is observed from this survey that the variations in the number of advanced treatment facilities and the available CQMPs for various specialties are hugely diverse among the participated countries. While Ghana, Qatar and the Republic of Moldova have less than 3 linear accelerators, Germany, India, and Japan have more than 500 linear accelerators. Availability of KV X-ray therapy also varies from none (Finland, Ghana, Republic of Moldova, and Paraguay) to a few in many to more than 40 in Switzerland. As for particle therapy, many do not have the facility, while most have very few and countries like Japan have 20 particle therapy equipments/facilities. Availability of brachytherapy units mostly everyone has only a few while countries like Brazil, France, Germany, Japan and Russia have more than 100 and India have more than 300 brachytherapy machines. Most countries have none or very few tele-cobalt machines and Sweden use it only for calibration and few have only Gamma Knife machines at the same time India have more than 200 and Russia 180 tele-cobalt machines.

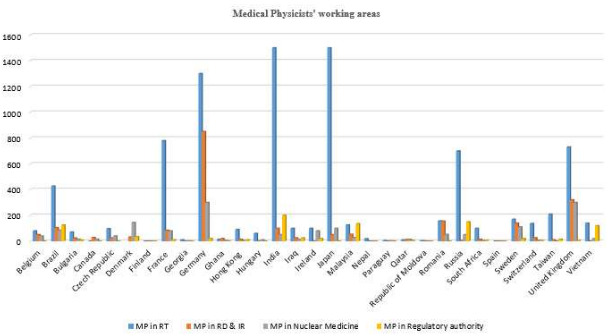

Fig. 3 Distribution of medical physicists in different specialties

Looking at the number of CQMP available for different specialties, other than Ghana every other country has a higher number of CQMP in radiotherapy in comparison to diagnostic and interventional radiology and nuclear medicine. In Ghana, the number of CQMP in radiology is higher though the difference is not significant as the total number of CQMPs is very small. The number of medical physicists working in regulatory authority/ body is also very few in most of the countries while Belgium, India, Malaysia, and Russia have a higher representation of more than 100-200 medical physicists in regulatory authority/body. The number of medical physicists/ million population recommended by European Federation of Organization for Medical Physics (EFOMP) [10], the incidence of cancer [11] and the analysis by Chougule A on the requirement of CQMP to fulfill the estimated gap and the deficit in the number of CQMP per million population for the countries in Asia Oceania [12] are also in line with the observations of present survey.

In order to strengthen the radiation safety culture, the IAEA and WHO gave a recommendation in consensus that recognition of medical physics as an independent health profession with specific radiation protection responsibilities is a key step [13]. Further WHO promotes the role of the medical physicist in ensuring radiation safety and quality in medical exposures and supporting the implementation of the Basic Safety Standards (BSS) by stressing the increase in the role of medical physicists in diagnostic radiology, radiation therapy and nuclear medicine [14, 15, 16]. Considering the total requirement of CQMP in radiation oncology, interventional radiology, nuclear medicine, and regulatory requirements at least three-fold increment is necessary in the number of CQMP [12].

In order to achieve harmonization of medical physics curriculum, infrastructure, faculty and other necessary requirements, IOMP initiated an accreditation board in 2016 for evaluating the educational programs and this accredits medical physics degree programs, residency programs, medical physics education and training institutions/ centers and education and training events. The details regarding accreditation is available on IOMP website [https://www.iomp.org/accreditation/] Further for wider acceptance and credibility of the national medical physics certification boards (NMPCB) of the country, International Medical Physics Certification Board (IMPCB) has started accreditation of the NMPCBs [17]. IMPCB also certificates individual medical physicists from countries where no NMPCB exists through written, oral and practical examinations [18]. IOMP accreditation of the medical physics education program and IMPCB accreditation of NMPCB and individual medical physicists are useful for accreditation of educational program and certification of CQMP [19].

IV. Conclusions

For harmonization of medical physics education and training across the globe, IAEA, IOMP, AFOMP, EFOMP and many regional and national medical physics professional organizations have expended huge efforts and resources, still much to be done looking into the growing need of CQMP across the world.

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