MEDICAL PHYSICS
International

IOMP

The Journal of the International Organization for Medical Physics

MPI

Volume 8, Number 3, December 2020

MEDICAL PHYSICS INTERNATIONAL

THE JOURNAL OF

THE INTERNATIONAL ORGANIZATION FOR MEDICAL PHYSICS

MEDICAL PHYSICS INTERNATIONAL Journal, vol.8, No.3, 2020

MEDICAL PHYSICS INTERNATIONAL
The Journal of the International Organization for Medical Physics

Aims and Coverage:
Medical Physics International (MPI) is the official IOMP journal. The journal provides a new platform for medical physicists to share their experience, ideas and new information generated from their work of scientific, educational and professional nature. The e- journal is available free of charge to IOMP members.

MPI web address: www.mpijournal.org

Published by: The International Organization for Medical Physics (IOMP), web address: www.iomp.org ; post address: IOMP c/o IPEM, 230 Tadcaster Road, York YO24 1ES, UK.

ISSN 2306 – 4609

CONTENTS

EDITORIALS

This issue of the Journal Medical Physics International (MPI, Dec 2020) continues with the focus on the IOMP Regional Organisations (RO). The focus now is on AFOMP (Asia- Oceania Federation of Organizations for Medical Physics), which celebrates this year its 20th Anniversary. This issue follows the previous three issues focussed on the African Region, the South and Central America and the Caribbean Region and the South-East Asian Region . The current issue includes papers tracing the development of our profession in Australia and New Zealand, Bangladesh, Japan, India, Korea, Malaysia, Mongolia, Nepal, Philippines, Singapore, Thailand. All these papers show the steady development of medical physics in AFOMP – the fastest growing Region of IOMP. We are grateful to Prof. Arun Chougule, Prof. Eva Bezak and Prof. Anupama Azhari from AFOMP - our Contributing Co-Editors of the MPI Dec 2020 – who solicited papers from the Region.

It is fully understandable that this MPI Issue reflects also on the reaction of our profession to the very difficult time for all people related to the current pandemic. We included the results of a survey related to the reaction to Covid-19 in the professional societies in AFOMP. Also, we included a paper describing the activities in the International Master in Advanced Medical Physics in ICTP and University of Trieste during this period.

The section of Educational papers show examples for various educational activities, both in normal time and during the Covid-19 pandemic. We also included ideas on the development of Repositories for sharing imaging materials for education and information about the new AAPM Virtual Museum. An invited paper from the USA Society of Directors of Academic Programmes gives example for inter-University collaboration in the field.

The current MPI issue includes also a Technical innovation paper related to Mathematical Probabilistic and Computational Generators of Discrete Probabilistic Distributions Applied to Medical Physics, as well as an extensive review of the Modern Technology in Radiation Oncology. Together with this are included several reviews of new books in medical physics.

MPI – the professional and educational journal of IOMP, continues to provide vital information to our readers worldwide and each issue has thousands of downloads. During the period June-December 2020 there had been c.48,000 visits to the MPI web site (c.37% from N.America, 28% from Asia and 27% from Europe). We believe that many colleagues will find interesting information in the new issue of the MPI Journal. Soon we shall be ready with the new Special Issue on Medical Physics History, focussed on History of Ultrasound in Medicine.

We are taking this opportunity to send best wishes to all our colleagues and readers for the New Year 2021!

Slavik Tabakov MPI Co-Editor-in-Chief

In this Edition we reflect on the life and many contributions to the medical physics profession by Dr. John (Jack) Cunningham, one of the pioneers and leaders in the field of radiation therapy in his long-time collaboration with Dr. Harold Johns, the inventor and developer of Cobalt radiation therapy. The results of his extensive research are documented in the references in Obituary.

It was the textbook, Radiological Physics, authored by the two universally known as “Johns and Cunningham” that served as the foundation of medical physics education around the world for many years. The First Edition was published in 1953 followed by other periodic editions covering advances in medical physics and radiology. The books contained numerous tables of data, attenuation coefficients, scatter ratios, depth dose for treatment planning, etc. that were used as references by physicists in many applications.

Now Johns and Cunningham serves as a major historical resource covering the science and technology of medical physics for several decades. A copy of the 4th Edition can be downloaded from the AAPM Author Archives at: https://w3.aapm.org/pubs/authorArchives.php.

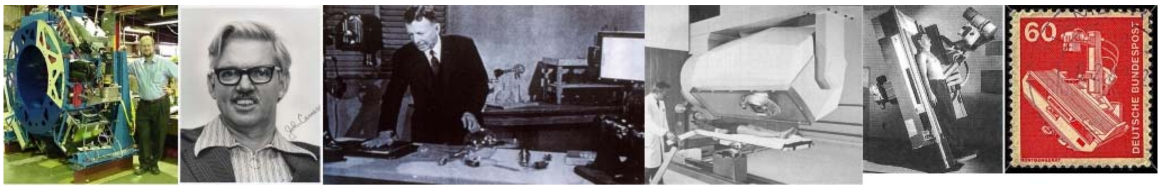
Perry Sprawls MPI Co-Editor-in-Chief

COLLABORATING ORGANIZATIONS

THE VIRTUAL MUSEUM OF MEDICAL PHYSICS

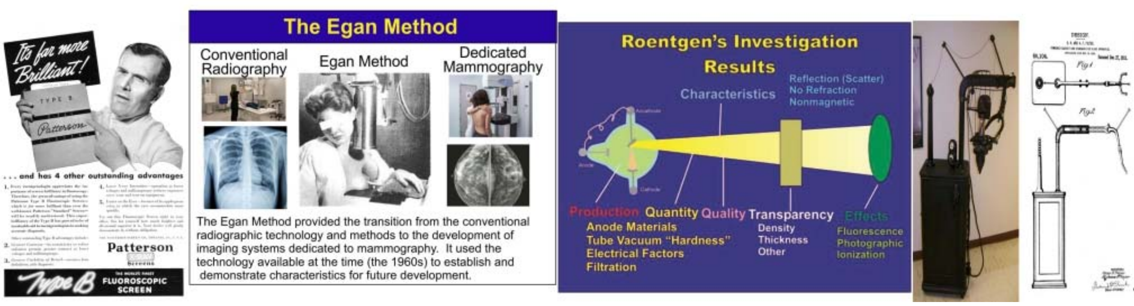
Colin G. Orton[1], Adi Robinson[2], Daniel R. Bednarek[3]

[1.]AAPM History Committee Chair
[2.]Virtual Museum Working Group Chair
[3.]Virtual Museum Curator



Welcome to the
VIRTUAL MUSEUM of MEDICAL PHYSICS

On the Web at: https://museum.aapm.org/



The AAPM History Committee is pleased to announce the launch of its Virtual Museum on November 8, 2020, the 125th anniversary of the discovery of x-rays. The purpose of the museum is to document and preserve the history and heritage of medical physics. It commemorates the pioneers in the field as well as the technology developed by physicists working in healthcare, including medical imaging, radiation therapy and nuclear medicine. The heritage of the AAPM is specifically documented.

The museum is accessible at [History and Heritage of Medical Physics | AAPM Virtual Museum](https://museum.aapm.org/). Please connect and visit. It is a work-in-progress, just like any museum, with much more to come. Many galleries have not been created and we are always looking for volunteers to take the lead in their continuing development any adding new galleries.. Since this has been an AAPM-led project, all of the current contributors have been AAPM members. The goal is to be representative of the world of medical physics, not just the AAPM, and we would like to hear from medical physicists from all countries who would like to develop museum content.

Contact Information: https://museum.aapm.org/contact/

IUPESM Fellowship

This year the union of IOMP and IFMBE - the International Union of Physical and Engineering Sciences in Medicine (IUPESM) celebrates 40 years since its establishment. To celebrate this occasion the Awards Committee of IUPESM developed and launched a new Fellowship scheme. Here below is the List with the elected inaugural Fellows - outstanding international leaders of medical physics and biomedical engineering.

PROFESSIONAL ISSUES

ASIA-OCEANIA FEDERATION OF ORGANIZATIONS FOR MEDICAL PHYSICS [AFOMP] – JOURNEY OF 20 YEARS, PROGRESS MADE IN MEDICAL PHYSICS EDUCATION, TRAINING AND PROFESSIONAL RECOGNITION

Prof. Arun Chougule [1],
[1.] President AFOMP, Sr. Professor Radiological Physics, SMS Medical College, Jaipur, India

Abstract

Asia Oceania Federation of Organizations for Medical physics [AFOMP] was founded in 2000 to increase the cooperation in national medical physics organizations [NMO] for medical physics professional development, promoting medical physics and scientific exchange. AFOMP has 19 NMO's as members and 2 NMO's as affiliate members and accounts for about 11000 medical physicists. AFOMP region is very diverse socioeconomically, culturally and hence every country has started developing medical physics differently. However AFOMP with help of IAEA, IOMP and other international agencies is trying to bridge the gaps and moving towards harmonizing the medical physics, though it is a daunting task. About 850 students per year are admitted for masters in medical physics program in 101 institutes/universities in AFOMP countries.

Key words- AFOMP, Medical Physics, NMO, Radiotherapy, X – ray

Introduction

The idea of forming a regional organization for medical physics in Asia was fostered during World Congress of Medical Physics and Biomedical Engineering [WC1991, held at Kyoto, Japan] in the minds of leading medical physicists of that time from Asia and stimulated by IOMP leaders. The idea and initiatives were carried forward and Asia-Oceania Federation of Organizations for Medical Physics (AFOMP) founded on 28th May 2000 at Beijing meeting by visionary and foresighted medical physics professionals and leaders; it was only possible with the aspiration of and enthusiastic and cohesive efforts made by many medical physicists. It is worth to mention the initiatives and efforts of Dr. KY Cheung, Dr. Yimin Hu, Late Dr. Kiyonari Inamura, Dr. Akira Ito, Dr. Kwan Hoong Ng, Late Dr. Barry Allen, and Dr. Anchali Kisanachinda from AFOMP region. In addition, it was inspiration and guidance of Dr. Geoff Ibbott [the then President of AAPM], Dr. Carrie Boras [Chair of Science Committee IOMP], Dr. William Hendee, Dr. Raymond Wu, Dr. Colin Orton Dr. Gary Fullerton and Dr. Nan-zhu Xie has given the required thrust for formation of AFOMP.

The idea of regional organization for medical physics from Asia –Oceania region was first conceived during the International conference on Medical Imaging, Medical physics and precision radiation therapy at Guangzhou, China on 5th October, 1999. During the conference Dr. Ito and Dr. Kwan organized a meeting of medical physics representatives from China, Japan, S. Korea, Hong Kong, Thailand and Malaysia attending the conference to discuss and take steps towards forming a regional medical physics organization, the seeds were sown.

During the 2nd International Congress on Medical Radiation Physics at Beijing, Yimin Hu and Raymond Wu organized second meeting of medical physicist's representatives who were attending the conference from China, S. Korea, Australia, New Zealand, Hong Kong, Indonesia, Singapore and Taiwan on 28th May 2000 to take forward the initiative of formation of regional organization. The members attending the meeting decided to form a protem committee Chaired by Dr. KY Cheung for drafting the constitution of the regional organization.

During the World Congress of Medical Physics and Biomedical Engineering [WC2000] at Chicago, the first council meeting of AFOMP was held during 24 & 25 July 2000 and was attended by representative from twelve countries from Asia – Oceania. During the first council meeting of AFOMP, Dr. K Y Cheung was elected as first President of AFOMP.

IOMP council meeting held on 26 July 2000, admitted AFOMP as regional Organization [RO] of IOMP, third organization to be RO of IOMP [first was EFOMP, second was ALFIM]. AFOMP has widened its scope and today 19 countries national medical physicist Organizations (NMO) are members and 2 NMO's are affiliate members of AFOMP and represents over 11000 medical physicists from Asia-Oceania region.

Photo of founding members of AFOMP [28th May 2000, Beijing, China]

Photo of first AFOMP EC [25th July 2000, WC, Chicago, USA]

Photo of founding members of AFOMP and AFOMP EXCOM

AFOMP NATIONAL MEMBER ORGANIZATIONS IN 2020

S.No.	Country/NMO	Name of National Medical Organization	Establishment Year	Number of MPs/Members
1.	Australia	Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM)	1977	500
2.	Bangladesh	Bangladesh Medical Physics Association (BMPA)	1998	100
3.	Peoples Rep. of China	Chinese Society of Medical Physics (CSMP)	1981	4000
4.	Hong Kong, China	Hong Kong Association of Medical Physics (HKAMP)	1985	130
5.	India	Association of Medical Physicists of India (AMPI)	1976	1600
6.	Indonesia	Indonesian Medical Physics and Biophysics Association (HFMBI)	1990	470
7.	Iran	Iranian Association of Medical Physicists (IAMP)	1993	300
8.	Japan	Japan Society of Medical Physics (JSMP)	1977	2000
9.	S. Korea	Korean Society of Medical Physics (KSMP)	1990	360
10.	Malaysia	Medical Physics Group of the Institute of Physics Malaysia	1991	275
11.	Mongolia	Mongolian Society of Medical Physics & Informatics (MSMPI)	2003	10
12.	Myanmar	Myanmar Medical Physicists Association	2016	30
13.	Nepal	Nepalese Association of Medical Physicists (NAMP)	2009	18
14.	New Zealand	Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM)	1977	100
15.	Philippines	Philippine Organization of Medical Physicists (POMP)	1986	130
16.	Singapore	Society of Medical Physicists of Singapore	1998	65
17.	Republic of China, Taiwan	Chinese Society of Medical Physics, Taipei	1996	350
18.	Thailand	Thai Medical Physicist Society (TMPS)	2001	200
19.	Vietnam	Vietnam Association for Medical Physics (VAMP)	2008	155
AFOMP Affiliate National Member Organizations				
20.	Bangladesh	Bangladesh Medical Physics Society (BMPS)	2009	250
21.	Malaysia	Malaysian Association of Medical Physics(MAMP)	2000	75

The aims and purpose of the federation are

1. *To promote the cooperation and communication between medical physics organizations in the region*
2. *To promote medical physics and related activities in the region*
3. *To promote the advancement in status and standard of practice of the medical physics profession*
4. *To organize and/or sponsor international conferences, regional and other meetings or courses;*
5. *To collaborate or affiliate with other scientific organizations*

To fulfill the objectives and to cater to the needs of the medical physicists and their education, AFOMP has created five main following committees to work on number of important tasks.

1. Professional development committee (PDC)
2. Education and training Committee (ETC)
3. Scientific Committee (SC)
4. Awards and Honors Committee (AHC)
5. Funding Committee (FC)

These committees have drafted policy statements to deal with minimum level of education and training of medical physics, continuous professional development and career progression for clinical medical physicist in AFOMP countries. The PDC has brought of six policy statements which are approved by AFOMP council and they are

Policy Statement-1: The role, responsibilities and status of the clinical medical physicist in AFOMP

The document was developed by the AFOMP Professional Development Committee (PDC) and was approved and released by the AFOMP Council in 2006. The main purpose of the document is to give guidance to AFOMP member organizations on the role and responsibilities of clinical medical physicists. The document also provides definition of clinical medical physicist. Further this document discusses the following topics:

- Professional aspect of education and training
- Responsibilities of clinical medical physicist
- Status and organization of the clinical medical physics services
- The need for clinical medical physics services

Policy Statement 2: Recommended clinical radiation oncology medical physicist staffing level in AFOMP countries.

The document was developed by the AFOMP Professional Development Committee (PDC) and was released by the AFOMP Council in 2009. The main purpose of the document is to give guidance for minimum medical physicists required for providing medical physics services to a radiation oncology department. A calculation scheme is presented to estimating minimum medical physics staffing requirements that is primarily based on number of equipments, equipment levels & complexicity of treatment and patient numbers in addition to allowances for staff training, professional development and leave requirements.

Policy statement 3: Recommendations for the education and training of medical physicists in AFOMP countries.

This policy statement prepared by joint efforts of PDC, ETC and Sc committee of AFOMP in 2011 and provides guidance for designing and developing medical physics education and training programs.

Policy statement 4: Recommendations for continuing professional development systems for medical physicists in AFOMP countries.

The document was developed by PDC and released by AFOMP in 2012. It provides guidance to member countries to develop a continuing professional development system for ensuing that the knowledge, skill and competency of clinical medical physicists are up to date so as to discharge the responsibilities effectively & efficiently.

Policy statement 5: Carrier progression for clinical medical physicists in AFOMP countries.

The document was developed PDC and released by AFOMP in 2015. It provides guidance on how clinical medical physicists' carrier should progress from their initial training as carrier progresses. It is intended to be advisory in nature and provides options for member countries and employers of clinical medical physicists to develop suitable carrier advancement structure.

Policy statement 6: Code of ethics for medical physicists in AFOMP countries.

Policy statement prepared by PDC and released by AFOMP in 2017 and provides guidelines on how medical physicists should conduct themselves in ethical manner and discharge the professional duties.

AFOMP works in many areas to enhance medical physics by organizing various scientific activities, conferences and officially publishes & endorses various journals & newsletter. Also promotes students & young professional through various grants.

One of the most important scientific events organized by AFOMP every year is Asia-Oceania congress of Medical Physics (AOCMP). This congress gives a strong platform to AFOMP region medical physics communities to unite, exchange their scientific research & expertise and discuss professional issues.

The AOCMP meetings organized at various places since 2001 are as follows

1. First AOCMP at Bangkok, Thailand, 2001
2. Second AOCMP at Gyeongju, S. Korea, 2002
3. Third AOCMP at Sydney, Australia, 2003
4. Fourth AOCMP at Kuala Lumpur, Malaysia, 2004
5. Fifth AOCMP at Kyoto, Japan, 2005
6. Sixth AOCMP at Seoul, S. Korea, 2006
7. Seventh AOCMP at Huangshan, China, 2007
8. Eight AOCMP at Ho Chi Minh City, Vietnam, 2008

9. Ninth AOCMP at Chiang Mai, Thailand, 2009
10. Tenth AOCMP at Taipei, Taiwan, 2010
11. Eleventh AOCMP at Fukuda, Japan, 2011
12. Twelfth AOCMP at Chiang Mai, Thailand, 2012
13. Thirteen AOCMP at Singapore, 2013
14. Fourteenth AOCMP at Ho Chi Min City, Vietnam, 2014
15. Fifteenth AOCMP at Xian, China, 2015
16. Sixteenth AOCMP at Bangkok, Thailand, 2016
17. Seventeenth AOCMP at Jaipur, India, 2017
18. Eighteenth AOCMP at Kuala Lumpur, Malaysia 2018
19. Nineteenth AOCMP at Perth, Australia, 2019
20. Twentieth AOCMP at Phuket, Thailand, 2020

Photo of valedictory function of 14 th AOCMP- 2014, HCM City, Vietnam

Photo of IDMP2017 rally, Jaipur, India [7 Nov. 2017]

Since 2018 AFOMP has started Prof. Kiyonari Inamura Memorial AFOMP Oration

To recognize and appreciate the outstanding contribution of medical physicists from AFOMP region, an oration award in the name of Prof. Kiyonari Inamura has started by AFOMP since 2018. Prof. Kiyonari Inamura was one of the founders of and contributed significantly to the sustainable development of AFOMP. He served AFOMP at different capacities/positions over years. He was Professor emeritus at Osaka University and a longstanding member of CARS congress organizing committee and Deputy Editor of IJCARS. His pioneering contributions to medical physics and medical engineering include research and development in radiotherapy treatment planning systems, picture archiving and communication systems. It was always on the forefront of his ideology to educate and motivate the students to advance their understanding of medical physics. His efforts in advancing interdisciplinary and international cooperation are unparalleled and his way of leading by example has been of great benefit not only to the medical physicists' community of AFOMP but also to the rest of the world.

The Prof. Kiyonari Inamura memorial AFOMP oration is awarded every year to outstanding medical physicists from AFOMP region for his/her contribution to medical physics education, research and development. Award is presented during AOCMP and awardee oration delivers an oration on first day of the conference.

Oration Awardee of 2018 – Prof. Tomas Kron, Australia

Oration Awardee of 2019- Prof. Kwan Hoong Ng, Malaysia

Oration Awardee of 2020- Prof. K. Y. Cheung, Hong Kong

Photo of Prof. Kiyonari Inamura Memorial AFOMP Oration 2019, Pert, Australia

AFOMP Life time achievement awards

To recognize contribution of medical physicists towards medical physics education, professional development and research, AFOMP has started the **AFOMP Life time achievement since 2020. This year's awardees are Prof. Anchali Kisanachinda, Thailand and Dr. Donald Mclean, Australia.**

AFOMP Outstanding medical physicist award

On the occasion of 20th anniversary of Asia-Oceania Federation of Organizations for Medical Physics (AFOMP), AFOMP decided to recognize contribution of medical physicist from AFOMP region. Medical physicists who worked in the AFOMP region for last 20 years and put tremendous efforts for medical physics professional development, medical physics education and research, those who made significant impact on science and organized scientific activities in AFOMP region to disseminate scientific knowledge for the welfare of the profession and society, they have served in national medical physicist organization and AFOMP, have served their country, AFOMP region and the community, for those AFOMP introduced outstanding Medical Physicist Award. Twenty-one medical physicists from AFOMP NMO's are awarded AFOMP outstanding medical physicist awards, the names of awardees available on AFOMP website [www.afomp.org-https://afomp.org/2020/09/14/afomps-outstanding-medical-physicist-awards/]

AFOMP Travel grants

To encourage and support young medical physicists with limited resources to participate in AOCMP, AFOMP provides about 8–10 travel grants every year. Over the years more than 100 young medical physicists from AFOMP region has received the travel grants. The list of travel grant awardees is available on AFOMP website [https://afomp.org/travel-awards/]. For encouraging research and presentation of their work, young medical physicists and students are awarded with cash prize for the selected best oral and poster presentations in each of the specialties of radiotherapy Medical Physics, Diagnostic Medical Physics and Nuclear medicine medical physics.

For widening the scope and recognize best research publication awards for research papers published in AFOMP journals every year, the award is started from 2020.

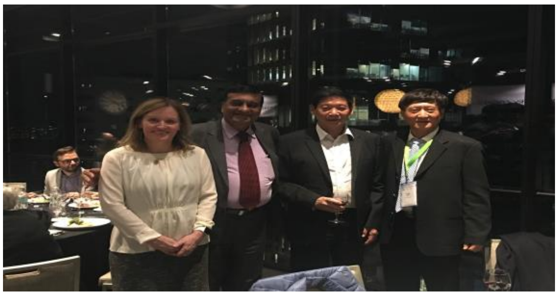
AFOMP publishes AFOMP newsletter regularly since 2007. The newsletter is published half yearly, in January and June. The newsletter is a mouthpiece of AFOMP and provides a platform for publishing medical physics science and research related articles, reports, educational material, scientific activities, workshop and conference related information.

For sustaining the professional organization and carrying out the activities in addition to the devoted and committed office bearers, members of various committees, we need the finances. To generate funds and create win-win situation with our trade partners, AFOMP has started corporate membership. A company, manufacturer or marketing agency connected with medical physics equipment, accessories or services can become a corporate member and gets benefit advertisement on AFOMP website, full page color advertisement in AFOMP newsletter and sharing of AOCMP delegate data as per rule for five years by paying US$ 5000 once. As of now AFOMP has three corporate members and negotiations with others are going on.

1. PTW The Dosimetry Company, Freiburg, Germany
2. SUN Nuclear Corporation
3. Rosalina Instruments

Over last twenty years six executive committee of AFOMP under leadership of President has completed their terms and contributed greatly for making the AFOMP viable and vibrant federation. Past Presidents of AFOMP who along with their executive committee members, chairs of various committees and NMO's have brought AFOMP to this level are

Period	President	Secretary General	Treasurer
2000 - 2003	Dr. Kin-Yin Cheung, Hong Kong	Dr. Akira Ito, Japan	Dr. Anchali Kisanachinda, Thailand
2003 - 2006	Dr. Barry Allen, Australia	Dr. Tae Suk Suh, S. Korea	Dr. Anchali Kisanachinda, Thailand
2006 - 2009	Dr. Kiyonari Inamura, Japan	Dr. Tae Suk Suh, S. Korea	Dr. Anchali Kisanachinda, Thailand
2009 – 2012	Dr. Kwan Hoong Ng, Malaysia	Dr. Tae Suk Suh, S. Korea	Dr. Anchali Kisanachinda, Thailand
2012 - 2015	Dr. Yimin Hu, China	Dr. Howell Round, New Zealand	Dr. Anchali Kisanachinda, Thailand
2015 - 2018	Dr. Tae Suk Suh, S. Korea	Dr. Howell Round, New Zealand	Dr. Kwan Hoong Ng, Malaysia



Past President, Immediate Past President, President and President designate [Photo taken during ICMP2019 at Santiago, Chile]

To increase the scientific an academic cooperation and collaboration among the regional organization for benefit of members of the federations, AFOMP took initiative and an agreement was signed between AFOMP and MEFOMP on 12 December 2017. We hope that this will enhance exchange of experts, resources and sharing of knowledge for mutual benefit for all.

AFOMP

MEFOMP
Middle East Federation of Organizations of Medical Physics

Date: December 12, 2017

MoU between AFOMP & MEFOMP

Background

It is recognized that medical physics as a profession has become a global enterprise and that on some issues the worldwide medical physics community should collaborate. Increasing scientific interactions and strategic relationships between the **Asia-Oceania Federation of Organizations for Medical Physics** (AFOMP) and the **Middle East Federation of Organizations of Medical Physics** (MEFOMP) is in the interest of both groups, as well as the worldwide medical physics community. This memorandum of understanding (MoU) seeks to establish these relationships, and to identify issues where collaboration between the AFOMP and MEFOMP would be most synergistic.

Purpose and Scope of this MoU

1. To strengthen collaboration in areas of common interest
2. To expand partnership between the two Federations

Areas of Collaboration

The areas of collaboration between the AFOMP and the MEFOMP could include, but are not limited to, the following initiatives:

1. Education/Training

The chairperson of the AFOMP 'Education and Training Committee' and the chairperson of the MEFOMP 'Education and Training Committee' shall liaise on relevant matters of mutual interest to the two Federations;

2. Scientific Matters

The chairperson of the AFOMP 'Science Committee' and the chairperson of the MEFOMP 'Science Committee' shall liaise on relevant matters of mutual interest to the two Federations;

3. Professional Matters

The chairperson of the AFOMP 'Professional Development Committee' and the chairperson of the MEFOMP 'Professional Relations Committee' shall liaise on relevant matters of mutual interest;

Photo of signing of agreement between AFOMP and MEFOMP- 12th December 2019 at IAEA HQ, Vienna, Austria

IOMP has provided valuable supports of various forms to AFOMP over the past twenty years. Likewise, AFOMP has participated and contributed to the work of IOMP and hosted World congress of Medical Physics and Biomedical Engineering [WC] on four occasions. Further, AFOMP medical physicists have served in various committees of IOMP, three of them served as IOMP Presidents and seven of them served as committee chairs. In addition AFOMP takes active participation in activities, programmes and initiatives of IOMP. Since the starting of IDMP in 2013, every year on 7th November AFOMP and its members celebrate IDMP to showcase the contribution of medical physicists. AFOMP actively contributed in developing theme and logo for IDMP. AFOMP participates and contribute in disseminating the IOMP publications such as eMPW, IOMP newsletter, circulars, information, notifications through AFOMP website and emails. The AFOMP website www.afomp.org is completely redesigned and launched in 2018 and is updated very frequently.

AFOMP countries have contributed to IOMP and hosted World Congress of Medical Physics and Biomedical Engineering [WC] and two are planned

5 th WC1991- Kyoto, Japan
9 th WC2003, Sydney, Australia
10 th WC 2006, Seoul, S. Korea
12 th WC 2012, Beijing, China
15 th WC 2022, Singapore
16 th WC2025, Adelaide, Australia

AFOMP members have provided good professional leadership and occupied position of President, Treasurer and Chairs of committees in IOMP

IOMP Presidents from AFOMP
1991- 94 Dr. Udupi Madhvanath, India
2006- 09 Prof. Barry Allen, Australia
2012- 15 Prof. K.Y. Cheung, Hong Kong

IOMP Treasurer from AFOMP
2012- 15 Prof. Anchali Kisanachinda, Thailand
2015- 18 Prof. Anchali Kisanachinda, Thailand

Many Chairs of IOMP committees from AFOMP during last many years

AFOMP members' academic, scientific and professional contribution is recognized by IOMP in terms of bestowing many awards.

Fellow of IOMP was started in 2013 and since then many members from AFOMP are awarded FIOMP

In 2013

1. Prof. Barry Allen, Australia
2. Prof. K.Y. Cheung, Hong Kong
3. Prof. Kwan Hoong Ng, Malaysia

In 2015

1. Prof. Yimin Hu, China
2. Prof. Kiyonari Inamura, Japan
3. Prof. Anchali Kisanachinda, Thailand

In 2016

1. Prof. Tomas Kron, Australia
2. Prof. Tae Suk, S. Korea

In 2017

1. Dr. Agnette Peralta, Philippines

In 2018

1. Dr. Howell Round, New Zealand

IOMP Maria Skłodowska Curie award

2018 Prof. Kwan Hoong Ng, Malaysia

IOMP Harold John Medal

2018 Prof. Anchali Kisanachinda, Thailand

IOMP –IDMP awards started in 2015, since then many members from AFOMP are awarded IOMP-IDMP award

2015 – Prof. Tomas Kron, Australia
2016 - Prof. Arun Chougule, India
2017 Dr. Howell Round, New Zealand
2018 Prof. Hasin Anupama Azhari, Bangladesh
2019 Prof. Eva Bezak, Australia
2020 Prof. Tae Suk Suh, S. Korea
IUPAP Medal-2018- Dr. Kuo Men, China

Application of radiation in healthcare and journey medical physics in AFOMP region

Immediately after discovery of X- rays, the application in X – ray imaging started as early as 1896 in New Zealand & Australia, 1900 first X- ray machine came to India and in 1910 in Hong Kong, in 1913 in Singapore. The use of Radium 226 for cancer treatment started in India in 1913 when radium was brought in India for cancer treatment. Radiotherapy by started in India with a 200 kV, X-ray unit in 1924 and then started in 1930's in Australia, China, India, Hong Kong and Medical physicists got an appointment in 1934 India, 1935 in Australia, 1939 in Hong Kong, in 1940 in China [1]. With more and more cancer treatment centers started in this region a need for qualified medical physicists increased to fulfill the requirement the medical education programs started. In 1962, Directorate of Radiation Protection, Bhabha Atomic Center Mumbai started one year postgraduate diploma in radiological and Hospital Physics [Dip. R. P.] Course with help of WHO. In 1977 first M.Sc program started in Australia. Slowly and steadily other countries in AFOMP region started use of radiation for cancer treatment and need of starting medical physics education program. Today over 101 institutes/Universities are offering masters in medical physics [MMP] program with intake of over 850 students per year. If we compare the data of Mclean et al [2], since 2013, in 7 years period the number of institutes imparting MMP has increased from 67 to 101 [increase of 51 %] and student intake capacity from 359 t0 850 [increase of 137 %] . The details of MMP programs in AFOMP region is given in Table. For providing a platform to increase the cooperation and dissemination of knowledge a need for professional organization of medical physics was felt. Association of Medical physicists of India [AMPI] was formed in 1976 and today over 1600 medical physicists are active members of AMPI. In 1977 Australasian College of Physical Scientists and Engineers in Medicine [ACPSEM] and Japan Society of Medical physics [JSMP] were formed. Latest Myanmar Medical Physicists Association [MMPA] was established in 2016, making total 21 MP organizations in AFOMP.

However we need to harmonize and follow the basic minimum educational curriculum prepared by IAEA [3] and recommended by IOMP [4] for all its NMO's. The MMP program needs to be accredited however, only few programs are accredited by international external accreditation bodies like IOMP, IPEM, and CAMPEB. The present number of medical physicists [MP] in the region is around 11000 for a population of 4500 million, i.e. the medical physicists per million population is 2.4 which is much below the recommended number of medical physicists of 18 per million [5]. Further our study shows that 64.2 % MP work in radiotherapy and only 7.6 % work in radiology.

To be a Clinically Qualified Medical Physicists [CQMP] as per IAEA [6], after a MMP, two years full time residency in one of the speciality [Radiotherapy, Nuclear Medicine, Radiology] is essential. Few countries in AFOMP region mandates compulsory residency program to work as MP but many countries do not yet have the mandatory residency program. Further many countries mandatory services of MP in radiology are not specified and hence many countries have not employed any MP in radiology.

AFOMP Response to COVID19 situation

AFOMP immediately rose to the unprecedented situation due to COVID19 pandemic and acted upon within the available resources. AFOMP has created a COVID19 resource tab in AFOMP website and provided guidelines, information about COVID19. Further AFOMP brought out guidelines for Medical Physicists in radiation oncology and AFOMP guidelines on diagnostic radiology services [7]. To help the young medical physicists and medical physics students, AFOMP has started monthly virtual webinars by experts since June 2020 with free registration so that the education and training continues in absence of in person meeting due to COVID19 pandemic. The participants are provided with CPD certificate and 2 CME credit points each webinar accredited by ACPESM accreditation board. Due to the pandemic International Medical Physics Week

[IMPW] was also celebrated by AFOMP by arranging two virtual webinars on 11 and 14 May 2020. IDMP2020 was also celebrated by AFOMP on 7 th November 2020 by arranging virtual webinar with talks from eminent speakers. The organizers of AOCMP2020 had very difficult time due to pandemic as initially they planned in person meeting but due to the situation now this meeting is being arranged as a hybrid meeting. The AFOMP EXCOM and council meetings are also planned virtually in this difficult situation.

Challenges and difficulties

In last 20 years, under the great visionary leaders and subsequent AFOMP officials efforts, the National Member Organisations [NMO's], AFOMP has done substantial progress towards fulfilling the objectives of AFOMP such as promoting medical physics, development of professional status and standards, education and training of physicists, scientific meetings and exchanges of resources in the region. AFOMP is playing a lead role in scientific and professional development of medical physics communities in Asia-Oceania region. Due to its continuous efforts in subsequent years surely the status of medical physics and physicist has increased but still there is long way to go ahead to reach its goals. ***In 2000 AFOMP had 12 members NMO's representing about 2500 medical physicists and about 25 MMP programs, in 20 years the number of NMO's is increased to 21 representing over 11000 medical physicists and 105 MMP programs which shows fourfold increment in number of medical physicists and MMP program in AFOMP region.***

If we look at socio-economic & educational status of AFOMP countries we found huge diversity in socioeconomic and educational levels and therefore task of AFOMP to homogenize the medical Physics education and profession is quite challenging.

AFOMP region hosts about 4.5 billion people [60 % of world population] in about 50 countries. We have national medical physics association in 19 countries only and therefore efforts needs to be put in creating and facilitating formation of medical physic associations and in those countries which are lacking in medical physics experts and a structured medical physics education program, efforts needs to be put by AFOMP to promote medical physics.

Further the AFOMP region is multilingual, multiple religious faiths and full of heterogenic in socioeconomic, educational, healthcare and research areas. Countries like Australia has highest GDP per capita of around 6000 US$ whereas Nepal has 750 US$ in the region. In AFOMP countries there is no binding force like European directives and therefore with huge diversity the task of AFOMP to homogenise the medical Physics education and profession is quite challenging.

In AFOMP countries there is no binding force like European directives. In Europe a decision taken at the level of European Union like the Euroatom directives becomes binding on all member states. All member countries in European Union translate and implement the directives incorporating in national regulations. In absence of common union in Asia each country has developed Medical Physics education in its own way and there is no harmonization.

Medical physicists are health professionals and are in great need of close integration and cooperation. To be clinically qualified medical physicist needs knowledge of principals of physics applied to medicine, acquire sufficient practical experience, special talent and many years of work. However the role and importance of medical physicists is not rewarded or regarded in most of Asian countries by the health authorities and public it so deserves.

The present AFOMP executive members are

President : Dr. Arun Chougule, India
Vice President : Dr. Eva Bezak, Australia
Secretary General: Dr. Hasin Anupama Azhari, Bangladesh
Treasurer: Dr. Kwan Hoong Ng, Malaysia
Immediate past President: Dr. Tae Suk Suh, S. Korea
Chair Science Committee [SC] : Dr. Tomas Kron, Australia
Chair Education & Training Committee [ETC] : Dr. Jin Xiance, China
Chair Professional Relations Committee [PRC] : Dr. Chai Hong Yeong, Malaysia
Chair Finance Committee: Dr. Hajime Monzen, Japan
Chair Honors and Awards Committee [AHC] : Dr. Eva Bezak, Australia

Only together can we solve our many problems and successfully protect our professional and social interests. This includes advanced training, prestigious status, and a decent salary, corresponding to the uniqueness, scarcity and responsibility of a medical physicist. We need effective and strong professional organization with remarkable leadership. Despite of all these efforts some areas still needs special attention, as some NMO's in AFOMP are still not participating in active manner as desired, do not maintain updated websites. This may be because of various challenges, which include absence of structured medical physics programs, lack of support from Institution/Govt., in-active national associations or lack of directional leadership. However development is always a gradual and slow process. So to achieve our goals we have to conquer all of these challenges and move forward with enthusiasm. Still we have to go a long way in fulfilling the aspirations of our members and rise to growing demand of skilled and knowledgeable MP's in the era of high tech healthcare delivery system and also to bridge the gaps. This is the great opportunity for whole community to celebrate the achievement so far and also pledge to work even harder with great enthusiasm for development of subject and medical physics profession in the region.

Conflict of interest: None ; Financial support: None ; Ethics Committee permission: Not applicable

Reference

1. Round WH, Jafari S, Kron T,Azhari HA et al Brief histories of medical physics in Asia-Oceania. Australas Phys Eng Sci Med (2015) 38:381–398
2. McLean D, Thomas B et al. Recommendations for accreditation and certification of medical physics education and clinical training programmes in the rca region 2014 https://humanhealth.iaea.org/HHW/MedicalPhysics/TheMedicalPhysicist/EducationandTrainingRequirements/Accreditation_and_Certification/Recommendations_for_accreditation_and_certification_in_medical_physics.pdf
3. IAEA : Postgraduate medical physics academic programmes- TRAINING COURSE SERIES No. 56, 2013
4. IOMP policy statement 2 [2010]: Basic Requirements for Education and Training of Medical Physicists. https://www.iomp.org/wp-content/uploads/2019/02/iomp_policy_statement_no_2_0.pdf
5. Evans S, Christofides S, Brambilla M. The European Federation of Organizations for Medical Physics. Policy Statement No. 7.1: The roles, responsibilities and status of the medical physicist including the criteria for the staffing levels in a Medical Physics Department approved by EFOMP Council. Physica Medica. 2016, 32, 533–540
6. IAEA. Roles and Responsibilities and Education and Training Requirements for Clinically Qualified Medical Physicists. *IAEA Human Health Series No. 25*. Vienna: IAEA; 2013.
7. AFOMP COVID19 resources. https://afomp.org/covid-19-information-resources/

Number of institutes/Universities offering master MMP program and number of students per year in AFOMP region

Country/NMO	Number of Institutes/ Universities offering masters MP program Present study	Number of students per year Present study	Number of Institutes/ Universities offering masters MP program Mclean D 2014	Number of students per year Mclean D 2014
Australia	06	30	05	50
Bangladesh	03	15	06	ND
Peoples Rep. of China	07	60	06	50
Hong Kong	01	15	--	--
India	22	250	17	178
Indonesia	06	30	01	10
Iran	14	235	--	--
Japan	22	70	16	20
S. Korea	05	20	08	ND
Malaysia	02	40	02	16
Mongolia	00	00	00	00
Myanmar	00	00	00	00
Nepal	00	00	00	00
New Zealand	01	10	01	10
Philippines	01	10	01	10
Singapore	00	00	00	00
Republic of China, Taiwan	03	35	--	--
Thailand	08	30	04	15
Vietnam	03	60 [B. Sc]	00	00
Total	**101**	**850**	**67**	**359**

Information about Medical Physics education program and associated details

Country/ NMO	MP Education duration	Masters Program	M.Sc degree Med Phys /other	Course accredited	Residency	Registration of MP
Australia	2 Years	Yes	MP	No	3 Years	Yes
Bangladesh	2 years	Yes	MP	No	No	No
China	2 years	M.Sc Post M.Sc Graduate	MP& E	No	No	No
India	2 years 1 year	Yes Post M.Sc	MP,P,RP	Yes	1 Year	No
Japan	2 years	Yes	Health Science Medical Science	Yes	No	Yes
Hong Kong	2 years	Yes	MP	No	No	Voluntary
Malaysia	2 years	Yes	MP	N0	No	No
Indonesia	2 years	Yes	MP, P	No	2 Years	Yes
Iran	2 Years	Yes	MP	Yes	No	Yes
Taiwan	2 Years	Yes	MP,P	Yes	2 Years	Yes
Thailand	2 years	Yes	MP	Yes	2 Years	Yes
S. Korea	2 Years	Yes Post M.Sc	MPE, P	Yes	2 Years	Yes
Singapore	No	N/A	N/A	N/A	2 Years	No
Philippines	2 Yeas	Yes	MP	Yes	2 Years	Yes
Nepal	No	N/A	N/A	N/A	No	No
New Zealand	2 Years	M.Sc.	MP	Yes	3 Years	Yes
Myanmar	No	N/A	N/A	N/A	No	No
Mongolia	No	N/A	N/A	N/A	No	No
Vietnam	01 Year	Bachelor Last 01 year	Bachelor MP & P	No	No	No
Total	Y- 14 N-05			Yes-08	Yes-9 No- 10	Yes-09, Voluntary -01 No-9

Contact Information: arunchougule11@gmail.com

MEDICAL PHYSICS TRAINING, EDUCATION AND PROFESSIONAL RECOGNITION IN AUSTRALIA AND NEW ZEALAND

Scott Crowe[1], Eva Bezak[2], Lyn Oliver[3] and Tomas Kron[4]

[1] Cancer Care Services, Royal Brisbane & Women's Hospital and School of Chemistry and Physics, Queensland University of Technology, Brisbane, Australia
[2] Cancer Research Institute, University of South Australia and Department of Physics, University of Adelaide, Adelaide, Australia
[3] Better Healthcare Technology Foundation, Sydney NSW, Australia
[4] Physical Sciences, Peter MacCallum Cancer Centre, Melbourne, Australia and Centre for Medical Radiation Physics, University of Wollongong, Wollongong, Australia

Abstract— **Over the last fourty years the Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM) has developed a Training, Education and Assessment Program (TEAP) that provides medical physicists with a pathway to a career in radiation oncology, diagnostic imaging or nuclear medicine. The program is ambitious in its scope and aligned with international guidelines by IOMP and IAEA. More than 400 colleagues have so far been assessed by ACPSEM forming the foundation of better technical and scientific services to patients in Australia and New Zealand.**

Keywords— **Medical Physics, Education, Accreditation and Certification, A.**

I. INTRODUCTION: MEDICAL PHYSICS IN AUSTRALIA AND NEW ZEALAN

The history of medical uses of radiation in both countries goes back to 1896.(1) William Hosking, a medical doctor in New Zealand, and in Australia three gentlemen from very different background (Professor Thomas Rankin Lyle at University of Melbourne, Railway engineer Walter Drowley Filmer in Newcastle and Father Joseph Slattery in Bathurst) commenced taking x-ray images. The need for medical physicists however, only became apparent in the 1930 when the first radiotherapy departments opened and the first 'hospital physicists' were employed with physics background being the only requirement. The medical physics community grew and was for many years closely associated with the UK Hospital Physicists Association. In 1977, the Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM, http://www.acpsem.org.au/) was founded with Kenneth Clarke as Foundation President.(2)

Since then, the organisation and medical physics has grown considerably and ACPSEM represents now more than 500 medical physicists working in Australia and about 100 in New Zealand. ACPSEM ('the college') has been publishing the scientific journal Physical and Engineering Sciences in Medicine (formerly Australasian Physical and Engineering Sciences in Medicine) for more than 40 years and holds annual scientific conferences (Engineering and Physical Sciences in Medicine, EPSM) which regularly attract 300 or more attendees. ACPSEM has six branches across Australia and New Zealand, which provide opportunities for members to meet and host local educational and professional development events.

Medical physicists in Australia and New Zealand are mostly employed in hospitals and provide a wide range of services to radiation oncology, diagnostic radiology, nuclear medicine and a variety of other areas, including academia. Six universities in Australia and one in New Zealand offer a master's program in medical physics. This is backed by several active research groups throughout the countries resulting in many important contributions to radiation medicine (3, 4) and lively discussions about the future (5).

However, challenges remain with professional recognition. The present paper discusses these challenges and their relation to education, certification and, in the context of New Zealand and Australia, based on a description of academic education and clinical training as it has developed over the last 30 years.

II. GRADUATE TRAINING

There are currently seven universities offering degrees in medical physics across Australia (6) and New Zealand (1). They vary from an undergraduate degree at the University of Wollongong, through MSc by coursework and research to PhD programmes (with a coursework component). The first medical physics MSc degree was offered at the Queensland University of Technology (QUT) in 1977, followed by the Otago University in 1983 (now discontinued) and the University of Adelaide (1992).

Most of the universities offer several degrees (MSc, PhD or even MPhil) to have flexible educational offerings for potential students. All degrees contain coursework accredited by ACPSEM and a research project as per the particular degree requirements. If a PhD graduate from another physics discipline wishes to train in medical physics, they can also undergo the Graduate Diploma pathway, where they only participate in medical physics coursework but a research project is not required. While ACPSEM prescribes overall knowledge expectations for graduates of these degrees, there is some freedom for the universities to construct the content of courses. In general, the following topics are covered: basic radiation and nuclear physics, radiation therapy physics, dosimetry, imaging and nuclear medicine physics, anatomy and physiology, radiation biology and epidemiology, radiation protection. Practical sessions and research projects are often conducted in collaboration with hospitals and clinical physicists as supervisors. Graduates of these ACPSEM accredited degrees are then eligible to apply for trainee medical physics positions (known as registrar positions) to complete their clinical training.

III. Clinical training

At the core of the pathway to becoming a clinical medical physicist is a structured training program. Similar to many other countries, Australia and New Zealand established examinations and certification (then called accreditation) of individuals before a training program was developed.

In 1985, ACPSEM Council considered the need for formal recognition of members qualified to practice and decided to take steps to introduce an accreditation scheme for individuals (now referred to as 'Certification'). ACPSEM Accreditation was a voluntary system for members who sat a written, practical and oral examination set by their peers. Radiotherapy examination was established in 1987, Radiology by mid 1990s and Nuclear Medicine soon after that. However, it was soon realised that a competency based assessment such as ACPSEM accreditation would also require developing a suitable training program based on a formal syllabus.

Several surveys over the years probed the medical physics workforce(6) and a professional survey sent to all radiotherapy departments in 1998 showed that there were 100 linear accelerators and 97 medical physicists employed in radiotherapy of which only two thirds had achieved five years of experience. The rest were learning on-the-job. Considering this, an important position paper in 2001 defined the requirements for radiation oncology physics in Australia and New Zealand.(7)

After a major Federal Inquiry (the Baume Committee) into Australian radiotherapy services in the early 2000s recommended the establishment of a medical physicist training program, Richard Fox (ACPSEM President), Lyn Oliver (ACPSEM Vice-President and co-ordinator of the ACPSEM submission to the Inquiry), Natalka Suchowerska (Chair of the ACPSEM Education Committee) and John Drew (Chairman of the Radiation Oncology Medical Physics (ROMP) Accreditation Examiners) met and took action in establishing the 'Training, Education and Accreditation Program' (TEAP – is now the acronym for Training, Education and Assessment Program). The program consists of three years clinical training, academic education to a postgraduate level and a combination of written, oral and practical examinations.

The TEAP program for radiation oncology formed the creation of an IAEA training guide (8) when John Drew was appointed to the agency. The syllabus was expanded, improved and adjusted to suit radiation oncology practice for all across the world. Clinical training requirements in Australia and New Zealand are three years as opposed to two in the IAEA document and most AFOMP countries.(9, 10) However, the syllabus is very similar and distinguishes five core modules (Radiation Protection, Dosimetry, External Beam Radiotherapy Equipment, Treatment Planning and Brachytherapy) and accompanied by several other requirements in the areas of professionalism, leadership and imaging. It is expected that candidates achieve level 3 competence in each of the core modules to allow certified physicists to practice safely and independently in their chosen specialty. Competence is also demonstrated in a progressive fashion through work submitted to a webpage and graded by a supervisor.

2013 marked the 10th anniversary of TEAP.(11) In her editorial to Phys. Eng. Sci. Med., Anne Perkins highlights that the program is rather demanding both for registrars and the departments which train them.(11) After many discussions and consideration of the workforce the training program was extended to include diagnostic physics and nuclear medicine. As it is recognised that there is considerable overlap in these disciplines it is now possible to get certified in the second by completing the training requirements for the first followed by an additional year in the other discipline. Also a certification in Radiopharmaceutical Sciences was developed and is now up and running.

After the Baume Inquiry was implemented in 2003, the Australian and New Zealand governments recognised the shortfall of medical physicists and are funding dedicated training positions to meet the increased demand in radiotherapy services and the need for more qualified medical physicists in the diagnostic departments of radiology and nuclear medicine. These positions are hospital based and administered either through health departments or the ACPSEM. Candidates are usually employed for three years as 'registrars', often with the possibility of an extension, for example, to complete the exams. In most departments, registrars are expected to be involved in all clinical activities and often contribute significantly to the workload of the department. However, they should have some protected time and must meet regularly with their clinical supervisor(s). They are also expected to attend training days and other educational events provided by the college and its regional branches.

Enrolment in the ACPSEM TEAP program requires employment by an accredited department or organisation. The departmental accreditation process considers the number and level of qualified medical physics specialist staffing, equipment within the department and resources available to support training.

Certification is awarded following a written, an oral and a practical examination. To qualify for the written exam, all competencies must have been completed at least to level 2. Typically, candidates sit the practical exam six months later when all competencies have been completed to level 3. In addition to this, the candidate is expected to have published in a scientific journal. A lot of discussion has taken place over the years about the practical exam which involves the candidate performing typical tasks such as calibration of a radiation beam or assessment of shielding of a nuclear medicine facility in front of two examiners. ACPSEM is one of a very few medical physics organisations that provide a practical exam. It is similar to some exams for medical colleges and provides an excellent opportunity for the registrar to demonstrate ability to work in their chosen profession. However, it is costly and difficult to standardise and requires ACPSEM support and training, not only for registrars, but also for examiners.

The number of medical physics registrars enrolled in TEAP, as of May 2020, is summarised in Table 1. Approximately 88% of these registrars are employed within Australian departments, with 12% employed in New Zealand. The proportion of female registrars is growing.

Table 1 Medical physics registrars enrolled in Australia and New Zealand in 2020

Specialty	Registrars	Female	Male
Diagnostic radiology	19	9 (47%)	10 (53%)
Radiation oncology	95	41 (43%)	54 (57%)
Nuclear medicine	15	3 (20%)	12 (80%)
Total	129	53 (41%)	76 (59%)

IV. Ongoing registration

The successful completion of the clinical training program enables the graduate to be added to the ACPSEM Register of Qualified Medical Physics Specialists and Radiopharmaceutical Scientists, a recognition of current competency to practice safely and independently in their respective specialty. Admission to the register also requires candidates to abide by a code of ethics. Registration is also open to experienced medical physicists who have not completed ACPSEM TEAP, such as the graduates of recognised international clinical training programs. These experienced applicants are required to provide evidence demonstrating a level of competency at least equivalent to that of TEAP graduates and must complete a “safe to practice” structured interview.

Continuing registration requires the completion of Continuing Professional Development (CPD) activities as part of a program that has been developed in parallel with TEAP.(12, 13) This program is now a web-based system which extends over 3 year registration periods. Participants are awarded points for the completion of professional development activities, including attendance of scientific meetings, contributions to professional bodies, publications, teaching and supervision, and the attendance of training courses. Evidence of completion of these activities is audited by the ACPSEM.

The number of ACPSEM registered physicists working in Australia or New Zealand, as of September 2020, is summarised in Table 2. Approximately 95% of these physicists are employed within Australian departments, with 5% employed within New Zealand departments.

Table 2 ACPSEM Registered medical physics specialists in Australia and New Zealand

Specialty	Qualified Medical Physics Specialists	Female	Male
Diagnostic radiology	41	10 (24%)	31 (76%)
Radiation oncology	357	121 (34%)	236 (66%)
Nuclear medicine	38	8 (21%)	30 (79%)
Total	436	139 (32%)	297 (68%)

The number of medical physics specialists has increased from 335 to 436 since 2015.(14) Much of this increase can be attributed to the training of physicists through the ACPSEM TEAP, with approximately 92% of currently registered physicists certified by the ACPSEM (either through the completion of TEAP or pre-TEAP assessment of skills).

The proportion of female medical physics specialists working in Australia and New Zealand has also increased since 2015, rising from 28% (93) to 32% (139).(14, 15) This trend is expected to continue, supported by the number of women enrolled in TEAP.

V. FUTURE OPPORTUNITIES AND CHALLENGES

Since their introduction, the clinical training and professional recognition services of the ACPSEM have been continually revised. These revisions have been largely informed in consultation with members and stakeholders, and with reference to educational research and standards. There have also been several formal internal and external reviews such as a review by the Allen Consulting Group to assess TEAP and a government funded project to strengthen the Australian Medical Physics Workforce. Of particular importance was a review in 2013 when Wayne Beckham and Bruce Gerbi spent a week in Australia as representatives of the Commission for Accreditation of Medical Physics Educational Programs (CAMPEP). Based upon this review, the CAMPEP representatives found that the ACPSEM graduate and residency educational programs were comparable in content and expectations to CAMPEP requirements.

More recent projects have included the development of TEAP supervisor educational material and workshops, the introduction of a standardised schedule of periodic progress review meetings between registrars and assessors, the online testing of first-year competencies, and the development of a research support strategy to assist registrars complete the TEAP publication requirement within three years.

As clinical practices change, so must professional standards and training curricula. The ACPSEM radiation oncology medical physics clinical training guide is currently being reviewed. This will likely see the addition of new material to match future trends in radiation oncology in Australia and New Zealand (such as particle therapy and magnetic resonance image guided radiation therapy). When new material is added to the curriculum, other material must be removed. This may be achieved through sub-specialisation or the addition of elective content. For example, in recognition that not all centres could offer high level training in brachytherapy, the ACPSEM made the completion of high level learning outcomes optional in version 3.4 of the Clinical Training Guide.

ACPSEM registration is not currently a formal legal requirement to be employed as a medical physicist in Australia or New Zealand, though it does have an impact on qualifying to be licensed to use radiation sources or apparatus and award wages in some states. Registration and certification are also aspects of the safety code and the associated guidelines by the Australian Radiation Protection and Nuclear Safety Australian Radiotherapy (ARPANSA),(16, 17) the Radiation Oncology Practice Standards,(18) and feature as a common criterion when advertising medical physics positions. The ACPSEM is currently investigating enforceable national registration through regulatory agencies, which would provide a protected title and could impact potential scope of practice and the viability of the ACPSEM which is currently the organisation through which physicists are self-regulated.

Also university education is always under threat. Medical Physics is a small profession and the number of students that can be sustained make medical physics courses not overly attractive to universities. Numbers are supplemented by enrolling overseas students and making the course more flexible to attract nuclear workers and radiation protection specialists. The latter also resonates with ACPSEM which is one of the three professional organisations sponsoring the Australian Radiation Protection Accreditation Board (ARPAB).

The ACPSEM represents members separated by large distances, with the distance between Perth, in Western Australia and Auckland, in New Zealand, exceeding 5,000 km. Some physicists work in small regional hospitals and treatment centres. As such, training, for both registrars and qualified medical physics specialists, is increasingly being delivered online. The outbreak of COVID-19 resulted in practical and oral final exams being conducted remotely. These challenges also represent potential opportunities – specifically the delivery of training outside of Australia and New Zealand.

VI. CONCLUSIONS

Training and certification are key activities for professional organisations and ACPSEM in its more than 30 years of history has been actively involved in many aspects of this. Members of the ACPSEM have contributed to the delivery of training internationally, through organisations including the International Atomic Energy Agency and the International Medical Physics Certification Board.(19) The Asia-Pacific Special Interest Group (APSIG) of the ACPSEM has organised training and mentoring volunteer assignments in low-to-middle income countries in the region. Physics works the same all over the world and medical physicists in Australia and New Zealand hope to contribute to making training, education and professional recognition similarly available for everyone aspiring to this exciting career.

REFERENCES

1. Round WH, Jafari S, Kron T, Azhari HA, Chhom S, Hu Y, et al. Brief histories of medical physics in Asia-Oceania. Australas Phys Eng Sci Med. 2015;38(3):381-98.
2. Kershaw D. A History of the Australasian College of Physical Scientists and Engineers in Medicine; its Origins and the First Decade, Australasian College of Physical Scientists and Engineers in Medicine [ACPSEM]. Melbourne1998.

3. Hewson EA, Nguyen DT, O'Brien R, Poulsen PR, Booth JT, Greer P, et al. Is multileaf collimator tracking or gating a better intrafraction motion adaptation strategy? An analysis of the TROG 15.01 Stereotactic Prostate Ablative Radiotherapy with KIM (SPARK) trial. Radiother Oncol. 2020.
4. Keall PJ, Nguyen DT, O'Brien R, Caillet V, Hewson E, Poulsen PR, et al. The first clinical implementation of real-time image-guided adaptive radiotherapy using a standard linear accelerator. Radiother Oncol. 2018;127(1):6-11.
5. Ebert MA, Hardcastle N, Kron T. Future forum, Hobart, October 29, 2017: examining the role of medical physics in cancer research. Australas Phys Eng Sci Med. 2018;41(3):571-9.
6. Fox RA. A survey of therapy physics workload in Australasia. Australas Phys Eng Sci Med. 1990;13(1):42-4.
7. Oliver L, Fitchew R, Drew J. Requirements for radiation oncology physics in Australia and New Zealand. Australas Phys Eng Sci Med. 2001;24(1):1-18.
8. IAEA. Clinical Training of Medical Physicsts Specializing in Radiation Oncology. Vienna: International Atomic Energy Agency; 2009.
9. Kron T, Healy B, Ng KH. Surveying trends in radiation oncology medical physics in the Asia Pacific Region. Phys Med. 2016;32(7):883-8.
10. Round WH, Ng KH, Healy B, Rodriguez L, Thayalan K, Tang F, et al. AFOMP Policy Statement No. 3: recommendations for the education and training of medical physicists in AFOMP countries. Australas Phys Eng Sci Med. 2011;34(3):303-7.
11. Perkins A. Reflections on TEAP: training for the future of medical physics. Australas Phys Eng Sci Med. 2013;36(2):143-5.
12. Perkins A, Kron T. Continuing professional development needs of Australian radiation oncology medical physicists--an analysis of applications for CPD funding. Australas Phys Eng Sci Med. 2007;30(3):226-32.
13. Round WH, Ng KH, Healy B, Rodriguez L, Thayalan K, Tang F, et al. AFOMP policy statement no. 4: recommendations for continuing professional development systems for medical physicists in AFOMP countries. Australas Phys Eng Sci Med. 2012;35(4):393-7.
14. Crowe SB, Kairn T. Women in medical physics: a preliminary analysis of workforce and research participation in Australia and New Zealand. Australas Phys Eng Sci Med. 2016;39(2):525-32.
15. Bezak E, Suchowerska R, Claridge Mackonis E, Pillen H, Ralston A, Haworth A, et al. Women and men in the Australasian College of Physical Scientists and Engineers in Medicine: workforce survey. Australas Phys Eng Sci Med. 2019;42(1):33-41.
16. ARPANSA. Safety Guide for Radiation Protection in Radiotherapy Yallambie: Australian Radiation Protection and Nuclear Safety Agency; 2008.
17. ARPANSA. Code for Radiation Protection in Medical Exposure Yallambie: Australian Radiation Protection and Nuclear Safety Agency; 2019.
18. Kron T, Dwyer M, Smith L, MacDonald A, Pawsey M, Raik E, et al. The development of practice standards for radiation oncology in Australia: a tripartite approach. Clin Oncol (R Coll Radiol). 2015;27(6):325-9.
19. Kron T, Wu R, Caruana C, Kim S, Mustafa A, Zakaria GA, et al. The International Medical Physics Certification Board: Objectives, history and achievements in the first decade. Med Phys Internat. 2020;8:13-8.

Contact information of the corresponding author:

Author: Tomas Kron
Institute: Peter MacCallum Cancer Centre
Street: 305 Grattan Street
City: Melbourne
Country: Australia
Email: Tomas.Kron@petermac.org

MEDICAL PHYSICSIN BANGLADESH: EDUCATION, PROFESSION AND TRAINING

M. Akhtaruzzaman[1], H. A. Azhari[2, 3], G. A. Zakaria[2, 3, 4]

[1]Department of Medical Physics,Labaid Cancer Hospital, Dhaka, Bangladesh
[2]Department of Medical Physics and Biomedical Engineering, Gono Bishwabidyalay,Dhaka,Bangladesh
[3]South-Asia Centre of Medical Physics and Cancer Research, Dhaka,Bangladesh
[4]Department of Biomedical Engineering, Faculty EMW, Anhalt University of Applied Sciences, Koethen, Germany

Abstract- The commencement of medical physics in Bangladesh has started in mid 90s. Over the last two decades, there has been anencouraging development. This paper includes a narrative discussions of medical physics education, profession and clinical training.

Keywords—**Medical Physics, Education, Profession and Training**

I. INTRODUCTION

Medical Physics in Bangladesh starts its journey in the mid-90s in cooperation with the Task Group 16 "Medical Physics in the Developing Countries" of the German Society for Medical Physics (DGMP).Five seminars/workshops were organized by the Task Group between1996 and 2000 with 70-80 participants(physicists and radiation oncologists)every year at theBangladesh University of Engineering and Technology (BUET) [1].These were the beginning approach to introduce medical physics subject in Bangladesh by Bangladeshi born German Professor Dr. Golam Abu Zakaria. Since then he was trying to open a department in the public universities. However, it was not possible to open such a department in public universities for different reasons.Eventually, Gono Bishwabidyalay(GB)- a private universitycame forward to open a"Department of Medical Physics& Biomedical Engineering (MPBME)"in the collaboration with Germany in 2000. Later, Dhaka University and KhwajaYunus Ali University started their M.Sc course in 2014.

For the professional development, a society called BMPA (Bangladesh Medical Physics Association) is formed in 1998. As BMPA is nonregistered society, so during process of registration a new name (society) instead of association is suggested from the government authority. Then, Bangladesh Medical Physics Society (BMPS) is formed and registered in 2009. However, BMPA also has been continuing its activities.

Medical physicists working in clinical environment are health professionals and training is mandatory to get competency. Medical physicists in Bangladesh has been trained through vendors, International Atomic Energy Commission (IAEA), collaboration with Germany etc. South Asia Centre for Medical Physics and Cancer Research (SCMPCR) established in 2018 and has also been providing accredited hands on workshops and in-service training (2-3 per year) for the Medical Physicists.

In this article, academic programme, professional development and clinical training for Medical Physicists are discussed.

II. ACADEMIC PROGRAMME

At present, three are three universities are offering medical physics education in Bangladesh. The details of educational structuresare given in Table 1.

Table 1 Academic Programme offering by the universities

University	Course/Degree	Course Duration	Establishing Year
GonoBishwabidyalay	MSc	2 Years (120 Credit Hours)	2000
	BSc	4 Years (192 Credit Hours)	2005
Dhaka University	MSc	1 Year (32 Credit Hours)	2014
KhwajaYunus Ali University	MSc	1.5 Year (48 Credit Hours)	2014

However, the Gono Bishwabidyalay is the pioneer and playing vital role in this field. It offersM.Sc coursein medical physics and biomedical engineering since 2000. This was the first attempt to develop full- fledge master course of international standard in GB in Bangladesh. It was quite difficult to find the students in this field in M.Sc course as this is a new field and also no governmental position in the hospitals. Considering this situation, B.Sc (Hons) coursein medical physics and biomedical engineering is established in 2005. At present the total number of students is 250.The syllabus of these courses is based on the documents of DGMP, AAPM and IAEA[2]. The syllabus covered all areas of medical physics to have the possibilities for the students to work in hospitals as well as research institutes.

In the last semesterof B.Sc (8 Semesters) and M.Sc (4 Semesters) has designed as project work (15 credits, duration 6 months) and thesis (30 credits, duration 6 months) respectively which are done in the hospitals and university. Project and thesis are supervised by academic and clinical supervisors and the defense examination is held at the university by an external examiner.

The department has collaboration with multiple institutions nationally and internationally. Since the inception of the department, the main obstacle was to find the faculty member in this field. So from the beginning of this department had a fruitful cooperation with German Cancer Research Center (DKFZ), Heidelberg University and Mannheim Medical Centre of Heidelberg University,Germany [1]through teacher and student exchange program with the financial support of DAAD (2003-2006 and 2014-2021). Collaboration with different institutes are shown in Table 2.

Table 2 Collaboration with the International Institutes

Institute	Country	Period
German Cancer Research Center, Heidelberg University	Germany	2003-2006
Manheim Medical Center, Heidelberg University	Germany	2014-2021
Anhalt University	Germany	Since 2002
Saroj Gupta Center and Research Institute	India	Since 2011
North Bengal Oncology Center	India	Since 2011
Jiliang University	China	Since 2016
Zhejiang Cancer Hospital	China	Since 2016

MPBME department has own laboratories for physics, IT, electronics, medical physics and biomedical engineering.However, some practical classes are held in different government & private hospitals and nuclear medicine centers.The department is frequently arrange seminars workshop, training with Bangladesh Atomic Energy Commission (BAEC) and Bangladesh Atomic Energy Regulatory Authority.

The MPBME department has received HEQEP (Higher Education quality enhancement project) jointly funded by Government and world bank implemented by University Grant Commission (UGC) for two years (2014-2016).Through this project this is the first time in Bangladesh TreatmentPlanning System (TPS) is installed in an university for teaching purpose and Quality Control (QC) Equipment) for different imaging technique like fluoroscopy, radiography, mammography, CT are purchased in the department.Also modernization of the class room, Laboratory Room and IT Room has been established.

III. PROFESSIONAL SCOPE AND ACTIVITIES

Bangladesh, officially the People's Republic of Bangladesh, is a country in South Asia. It is the eighth-most populous country in the world, with a population exceeding 160 million people. Demographic information of Bangladesh is shown in Table 3 [3].

Table 3GDP per capita, number of MPs, population and MPs per million populations in Bangladesh

Area	GDP	Per capita income	Population in million	No. of MPs	MPs per million
148,500 km^2	$317.8 billion (2020)	$1,887.97	163 (2019)	83	0.51

The number of cancer patients equals 2000 out of 1,000,000 inhabitants per year. According to WHO, we need total 160 Centers, 320 LINACS, 600 Medical Physicists in RT sector for treatment of cancer and even more considering diagnostic centers [4]. However, the present situation is very far from the goal. The current status of medical imaging, nuclear medicine and radiation therapy equipment are illustrated in Table 4.

Table 4Medical Imaging, Nuclear Medicine and Radiation Therapy Equipment

Equipment	Total	Equipment/Million population
Co-60Teletherapy	11	0.067
Linear Accelerator	24	0.147
Brachytherapy	16	0.098
Simulator (X/CT)	19	0.116
Computed Tomography	340	2.08
Magnetic Resonance Imaging	270	1.65
Fluoroscopy/IR	530	3.25
General Radiography	1090	6.68
Mammography	9	0.055
SPECT/CT	10	0.061
Gamma Camera	50	0.306
PET-CT	8	0.049

In order to promote to establish medical physics, BMPA is formed in 1998.The main aim BMPA was to motivate physicists to become medical physicists. However, since its formation, there was no remarkable activities because of lack of medical physicist in Bangladesh at that time. Therefore, BMPS was formed and registered in 2009. Since its inception, BMPS has been playing the main role in various diversities such medical physics education, professional standard, clinical training, creation in the hospital, organization of different national and internationalorganization of different national and international scientific conferences, workshop with collaboration with different institutions and societies, awareness in public sector etc.

BMPS arranges annual conference (ACBMPS) every year.It also organizes international seminar (every two years) in Radiation oncology and Imaging (ICMPROI), which were already occurred in 2011, 2014 and 2018. In addition,BMPS celebrate 7 November in each year bypublishing e-newsletter (Voice of BMPS), rally, scientific seminar etc. Furthermore, a group of BMPS members involved in IOMP project titled" e-Encyclopaedia of Medical Physics and Multilingual Dictionary".Some examples of the international scientific events organized by the BMPS from 2011-2020 are shown in Table 5.

Table 5Examples of international scientific events organized by the BMPS from 2011 – 2020

Date	Scientific Events	No. of Delegates
11-13 March 2011	1stInternational Conference on Medical Physics in Radiation Oncology and Imaging	200
27 March 2012	International Workshop on Quality Control of CT-Simulator	20
22-26 June 2013	International Workshop on Radiation Oncology	25
20-22August 2014	2nd International Conference on Medical Physics in Radiation Oncology and Imaging	300
9 July 2015	International Seminar on Regulatory Aspects and Quality Control in Diagnostic Imaging and Radiotherapy Facilities	30
22 March 2016	International Seminar on Role of Medical Physicist in Cancer Treatment	40
28 Dec 2016-31 Jan2017	International Workshop on Radiation Therapy Treatment Planning and Quality Control of X-ray Imaging	40
10-12March2018	3rdInternational Conference on Medical Physics in Radiation Oncology and Imaging	350

At present there is no any accredited hospital/ institute for residency program in all areas of medical physics i.e. radiotherapy, nuclear medicine, and diagnostic radiology in Bangladesh. According to the requirements of IOMP guidelines and IMPCB, two years professional training is required for certification programs. There is need of establishment of a training center or recognition of existing hospital/ institute for residency program.

International Medical Physics Certification Board (IMPCB) start their journey on 23rd May 2010, which is very promising to the countries like us where MPs are in the initial stage [5]. BMPS has already been started certification program to mark the achievements of clinical medical physicists as we have sufficient candidate who have fulfilled the requirements in education and training in specific areas (RT/NM/DR). With that aim, BMPS was organized IMPCB part-I and part-II examinations on 13-14 March 2018 just after ICMPROI 2018.BMPS has accomplished the goal of the infrastructure, requirements and examination procedures for the certification of medical physicists by forming Bangladesh Medical Physics Certification Board (BMPCB) in accordance with the requirements of IMPCB guidelines.Certification programme for medical physicists will be started from 2021 with help of IMPCB.

Post creation and establishment of unified recruitment rules is a lengthy process. Post creation in the government hospitals are mandatory as newer technology radiotherapy machine, diagnostic equipment are purchased by these hospitals. In the meantime, BMPS quiet successful to make understand the present government about the importance and necessity of medical physicists in our country. Therefore, 12 positions have already been created in three different public hospitals and post creation for other public medical college and hospitals is in progress.

Public awareness can play a major role to accomplish the goal for continuous medical physics development. Regarding this many articles in newspapers, magazine are published in regular basis. Moreover, talk show, seminars are arranged in different schools, colleges for acquaintance with this subject.

IV. CLINICAL TRAINING AND CONTINUOUS PROFESSIONAL DEVELOPMENT

The MPBME department of GB has been playing a promising role for the clinical training and professional development as the medical physicists are produced mainly from here. After getting B.Scand M.Sc degree, students are placed for 3-6 months in different areas of Medical Physics at different hospitals in home and abroad. Under cooperation between Gono University, DKFZ and Heidelberg University,a considerable number of teachers, medical physicists have already been trained and more people will follow.Alternatively, 15 German teachers visited MPBME department to conduct courses.

Medical Physicists working in the hospitals are also get training through the vendors (as per contracts during procurement), IAEA etc. However, the countrystill experience a significant shortage of Qualified Medical Physicists (QMP) to run the established centers equipped with modern treatment facilities. This shortage has arisen due to the lack of structured residency program with clinical training, absence of accredited hospitals for the residency program and government policies for appointing clinical Medical Physicists.

South Asia Centre for Medical Physics and Cancer Research (SCMPCR) is acentre for Continuous Professional Development (CPD) and Training to fight against cancer in South Asia region. The main goal of SCMPCR is the capacity building of cancer professionals by the hands-on training program with the highly experienced international trainer [6].SCMPCR organizes a series of International Organization of Medical Physics (IOMP) and European Board for Accreditation in Medical Physics (EBAMP) accredited hands on workshops and in-service training (2-3 per year) in collaboration with the several national and international organization and hospitals for cancer team professionals (Doctors, Medical Physicists, Nurses, and other providers).Until now, SCMPCR was arranged five hands-on training and E-learning programs for the cancer professionals of South Asia region (4 for medical physicists, 1 for radiation oncologists) as shown in Table 6. Also SCMPCR regularly publish newsletter twice a year [7].

Table 6 Examples of scientific events organized by the SCMPCR

Date	Scientific Events	No. of Delegates
4-6 October 2018	Hands-on Training: Dosimetry and Treatment Planning	20
17 November 2018	Hands-on Training: Target Volume Definition, Treatment Planning and Evaluation	17
7-9 March 2019	Hands-on Training: Basic and Advanced Treatment Techniques of the commissioning of a Linear Accelerator	20
2 - 4 October 2019	Hands-on Training: Dosimetry of Small Fields in External Beam Therapy: Reference and Relative Dose Determination	20
June-July; October 2020	E-learning: on Radiotherapy, Radiology	70

The trainers of those training programs came from Germany, Japan, India, Canada and Taiwan and Bangladesh. The training program of SCMPCR maintains the international standard and accredited by the international organization.

V. CONCLUSION

Combination of Gono University, BMPS and SCMPCR has made a solid background for the medical physics education, profession and training in Bangladesh. However, for this highly populated country, other universities and organizations should come forward to build up more manpower and training facilities. Internal efforts supported by international cooperation, Bangladesh could attend a sustainable development in medical physics in the near future.

VI. ACKNOWLEDGEMENT

It is our great honor to have encouragement from authority of the MPBME, GB, Bangladesh; Mannheim Medical Centre and Heidelberg University, Germany for their expert guidance, cooperation and helping continuous support of medical physics study in Bangladesh.

VII. REFERENCES

[1] HasinAzhariAnupama, Golam Abu Zakaria, G. H. Hartmann (2008) Medical Physics Education in Bangladesh and Cooperation with Germany. WC IFMBE Proceedings 25/XII: 173–176.

[2] G. H. Hartmann and G. A. Zakaria (2009). Status and Perspectives of Qualification in Radiation Oncology Physics in Bangladesh. O. Dössel and (Eds.): WC 2009, IFMBE Proceedings 25/XII, pp. 162–165.

[3] www.wikipedia.org

[4] www.thedailystar.net/news-detail-205022

[5] www.impcb.org/CM140712.htm

[6] www.scmpcr.org

[7] https://scmpcr.org/scmpcr-newsletter/

Corresponding author

MdAkhtaruzzaman, PhD
General Secretary, BMPS
&
Senior Medical Physicist
Labaid Cancer Hospital
Dhaka, Bangladesh

Email: akhzam@gmail.com

MEDICAL PHYSICISTS IN JAPAN: PAST, PRESENT AND FUTURE

Naoki HAYASHI[1,2], Hideyuki Mizuno[3,4], Shigekazu FUKUDA[3,5]

[1] School of Medical Sciences, Fujita Health University, Aichi, 470-1192, Japan
[2] Chair of international affairs committee of JSMP, Tokyo, 162-0801, Japan
[3] National Institutes for Quantum and Radiological Science and technology, 263-8555, Japan
[4] Secretary general of JSMP, Tokyo, 162-0801, Japan
[5] President of JSMP, Tokyo, 162-0801, Japan

Abstract— **This paper includes an introduction of public health involving medical physics, and the status of medical physicists in Japan. The number of patients in Japan is increasing due to the aging of the population. JSMP is an academic society in this field cooperating in the education and research of medical physicists. The educational environment for medical physicists in Japan is changing day-by-day due to the development of novel medical devices and technologies in clinical practice. The number of medical physicists has increased dramatically due to the changes in the criteria for taking the medical physicist exam. Because of this situation, current activities of JSMP are expanding.**

Keywords— **Medical Physics, Education of Medical Physicists, Professional development, Training**

I. ABOUT JAPAN AND JSMP

The population of Japan is approximately 125 million (median age: 48.4 years) in 2020. The Gross Domestic Product (GDP) in Japan was worth 5081.77 billion US dollars in 2019, according to official data from the World Bank and projections from Trading Economics. The GDP value of Japan represents 4.22% of the world economy [1]. According to the report by Organization for Economic Co-operation and Development (OECD) in 2019, medical costs accounted for 10.9% of GDP, with an average annual medical cost per person was 4766 dollars. Table 1 shows the numbers of medical devices in operation in Japan at the end of 2019. The numbers of LINAC, particle therapy units, brachytherapy units, CT, MR, gamma camera, SPECT and PET was 936, 14, 55, approximately 13,000, 6500, 1500, 1500, 500, respectively. Compared to other countries, a large number of CT, MR, LINAC, and particle therapy units were installed in hospital per population. However, the number of patients in Japan is increasing due to the aging of the population. In particular, the number of patients receiving radiotherapy and/or chemotherapy have dramatically increased due to government policy on cancer treatment since mid-2000's.

Japan society of medical physics (JSMP) is an academic society for physicists in medicine as a science council of Japan. JSMP organize scientific meeting (semi-annually), summer seminar, publication of official journals, committee activities, public lecture and so on. As of June 2020, the number of JSMP members was 2508 (regular member: 2362, student member: 105, honorary member: 41, supporting member: 12). Many medical physicists are working in the therapeutic field. (Therapeutic field: 90% and Diagnostic field: 10%). JSMP has been one of the National Member Organization (NMO) of AFOMP since 2000.

Table 1 The numbers of medical devices in operation in Japan

	Medical devices	Numbers
Radiation therapy field	LINAC	936
	Particle therapy units	14
	Brachytherapy units	55
Diagnostic field	Computed tomography	Approximately 13,000
	Magnetic Resonance	Approximately 6,500
Nuclear medicine field	Gamma camera	Approximately 1,500
	SPECT	1,500
	PET	500

II. HISTORY OF JSMP AND RELATED ORGANIZATIONS

The starting point of JSMP was first founded in March 1961 as a special sub-organization of Japan Radiological Society (JRS). Figure 1 shows the history of JSMP. JRS is a science council for radiologists or radiation oncologists in Japan. The first president of the special sub-organization of JRS was Dr. Hideo Eto, the University of Tokyo. Prior to its founding, several physicists and scientists carried out their research and/or clinical practice individually in their institutions. However, the first scientific meeting of this organization was held in Hiroshima, Japan in October 1961. Subsequentially their physicists and scientists had the opportunity to share their knowledge and research status on the scientific meeting of the organization. Since the 8th scientific meeting in 1964, general researches have been presented mainly in addition to special lectures and educational lectures. In April 1965, the organization changed its name to the division of physics in JRS at the 12th scientific meeting in Tokyo. In this term, several topics such as clinical implementation of high energy radiotherapy systems and X-ray TV systems, development of anger type gamma camera were commonly focused on research reports. During this decade, the number of the member of division of physics in JRS increased from 30 to 200 due to interest in research topics and exciting discussions at meeting. By the mid-1980's, the number of organizations gradually increased to 700 members. However, the number of members was stable until 2000. In 1992, the organization name was changed to Japan association of radiological physics (JARP).

On the other hand, looking at the world, the International Organization of Medical Physics (IOMP) was established in 1963 by Canada, Sweden, the United Kingdom and the United States. IOMP hosted the first International Conference of Medical Physics (ICMP) in Harrogate, UK. In response to this situation, some members of the division of physics of JRS established Japanese Association of Medical Physicists (JAMP) in 1979 with the aim of joining Japan to IOMP. With their efforts in joining IOMP, Japan was approved as the 22nd National Organization in February 1980. Since 1984, JAMP has held meetings annually.

These two medical physics organizations continued their academic activities, but in 2000, the two organizations were integrated into one to form JSMP. This is the current form of JSMP. In addition, the number of JSMP members has increased dramatically because of the revision of the medical physicist certification procedure in Japan. Senior radiological technologists could apply for candidates for medical physicists in Japan. With this revision, the distribution of occupational background has now changed (Figure 3). Details of this revision are described at section III of this paper. In 2004, JSMP was certified as a member of Japan Radiological Council (JRC), and every April, annual scientific meeting of JSMP is held as a jointed conference with JRS and Japanese Society of Radiological Technology (JSRT).

Nowadays, the number of participants in the scientific meetings is increasing, and many topics are discussed in several sessions. In the scientific meeting, research reports are generally focused on the development of novel particle therapy systems and the dedicated machines for high precision radiation therapy, clinical implementation of artificial intelligence, big data analysis and radiation protection.

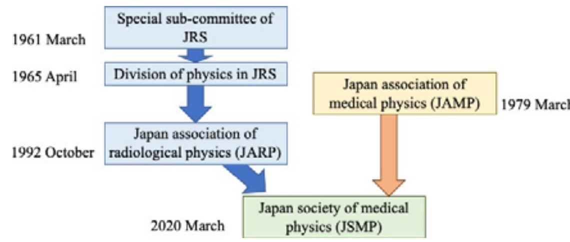


Figure 1 History of Japan society of medical physics

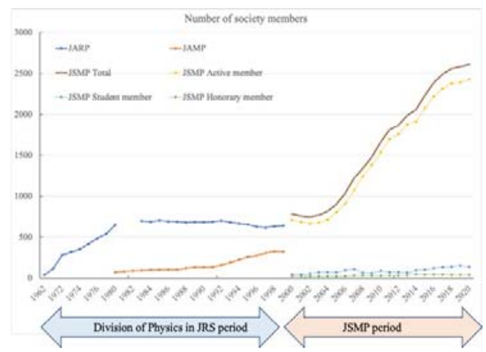


Figure 2 The transitions of number of society members

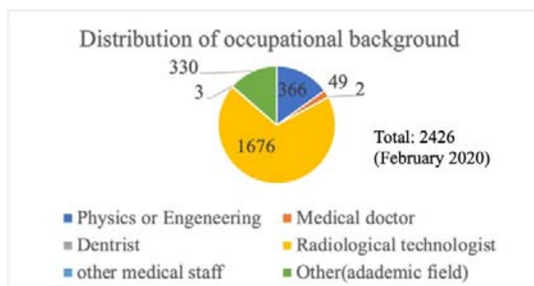


Figure 3 Distribution of occupational background of JSMP members, as of February 2020.

III. MEDICAL PHYSICISTS IN JAPAN

Japanese medical physicist certification system was established in 1987 by JRS, to ensure the person who contributes to the development and optimization of medical devices are specialists in medical physics. This system was based on specialists of radiation oncologist system. In the 10 years since the first examination, the number of medical physicists certified by JRS was only 100. This was caused by the limitation of exam criteria for occupational/academic background: those majoring in physics and engineering were only allowed to take the exam.

On the other hand, the curriculum of radiological technologist has become more complex and the minimum requirements of subjects has increased due to the needs in clinical practice for radiological technologist since mid-1990's. Because the occupational territory of Japanese radiological technologists covers from the diagnostic field including nuclear medicine to therapy and radiation dosimetry field after obtaining the national license for radiological technologist, absorbed dose measurements and quality assurance in radiation therapy were one of the tasks of senior radiological technologists in Japan. In fact, 4-year semester including clinical practice in hospitals has required for radiological technologist since mid-1990's. In addition, several graduate schools have been established to give master-degree/doctoral-degree to specialist of radiological technology in medicine. Due to these circumstances, the criteria of occupational/academic background for medical physicists were expanded to senior radiological technologist in 2003. That is, senior radiological technologists who became members of JSMP or JRS could challenge the medical physicist's examination even though there were certain requirements regarding their occupational background. As a result, the number of JSMP members (including medical physicist examinee) has increased dramatically since the early-2000's. The number of certified medical physicists was 1252 as of May 2020. Figure 4 shows the transitions of the number of certified medical physicists.

In 2009, Japanese board of medical physicist qualification (JBMP) was established to take over medical physicist certification system. The first president of JBMP was Dr. Shogo Yamada, and the current president is Dr. Hiroki Shirato. Since the establishment of JBMP, a guideline for educational curriculum of medical physicist has been proposed to ensure the educational level of medical physicists and to optimize the curriculum in accordance with the international certification system. Nowadays, there are 22 MS courses and 10 PhD courses as accredited medical physicist educational courses in graduate schools. These courses follow the JBMP guidelines. Actually 60-80 students complete the course each year.

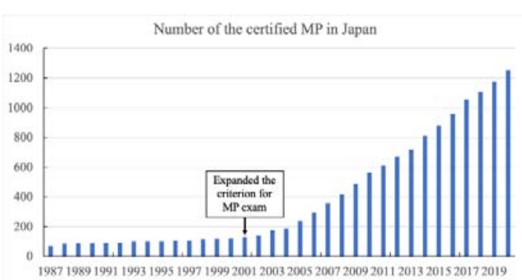


Figure 4 Changes in the numbers of medical physicists in Japan

IV. CURRENT ACTIVITIES OF MEDICAL PHYSICISTS IN JAPAN

Recent years, high precision radiation therapy techniques such as intensity modulated radiation therapy, stereotactic radiotherapy, adaptive radiation therapy and particle therapy have been widely applied to routinely clinical procedures. This technological improvement is provided not only by increased development and research, but also by the contribution of medical physicists. Actually, the number of medical physicists has increased dramatically because securing medical physicists is one of the facilities requirements to cover medical insurance for their high precision radiation therapy. Even though many medical physicists in Japan work as clinical medical physicists, the majority of their physicist's challenge to present at scientific meetings including international conference to be evaluated by foreign researchers for their research. Then they try to prepare their manuscript to submit to international journal. Two official journals of JSMP are currently published: Radiological physics and technology (RPT) published jointly with JSRT and Japanese journal of medical physics (JJMP: in Japanese). In particular, RPT journal is now the official journal of AFOMP.

V. CONCLUSION

More complex techniques are being applied to clinical practice, higher education and more medical physicists are needed worldwide. In Japan, medical physicist certification system has changed in 20 years, however, despite the increased requirements for medical physicist exams, the minimum requirements for education are stable. Recently the new coronavirus pandemic is a serious problem for implementing the actual curriculum of medical physics courses. However, it is of utmost importance for students or candidates to consider about what to do by themselves, and the faculty staff in school and the related organizations should support their activities. At least, web-based learning is available even though clinical training in hospitals is not available.

Due to new coronavirus pandemic, web-based seminars and events have widely applied in the world. As a result, Japanese medical physicists can attend several international web-based seminars even though they are in Japan. I think this is a good situation for medical physicists to perform continuing education. We, the members of international affairs committee in JSMP, would like to continue to look for ways to strengthen our relationship with AFOMP and enable us to hold a joint scientific meeting as NMO.

VI. ACKNOWLEDGEMENTS

Authors thank members of international affairs committee of JSMP for their kindly advices to prepare this manuscript.

VII. REFERENCES

1. Press material by Ministry of Health, Lovor and Welfare in 2019.
2. Endo M: History of Japan Society of Medical Physics. Jpn J Med Phys (2011), Vol.30(3); 75-90.

Author: Naoki HAYASHI, PhD. Chair of international affairs committee in JSMP. Associate Professor in Fujita Health University. hayashi@fujita-hu.ac.jp

EDUCATION TRAINING CERTIFICATION AND PROFESSIONAL DEVELOPMENT OF MEDICAL PHYSICISTS IN INDIA

S. D. Sharma[1,2] and Shobha Jayaprakash[3]

[1]Radiological Physics and Advisory Division, Bhabha Atomic Research Centre, Anushaktinagar, Mumbai 400094, India
[2]President AMPI (Association of Medical Physicists of India), RPAD, BARC, Anushaktinagar, Mumbai 400094, India
[3]Department of Radiotherapy, B.Y.L. Nair Hospital, Mumbai, India & Secretary AMPI, Mumbai, India

Abstract—

This paper describes about the medical physics education in India. The mandatory requirement for the Medical Physics course conducting institution and the entry level qualifications required by the candidate as per the requirement of Atomic Energy Regulatory Board (AERB), is also mentioned in detail. The need for medical physics internship program, after the completion of the academic course, is also discussed. The paper also includes the requirement of professional registration and recognition, professional body i.e. Association of Medical Physicists of India (AMPI) and certification program conducted by College of Medical Physics (CMPI), a scientific wing of AMPI.

Keywords— **Medical Physics, Certification, Education and Training, Professional development, Internship**

I. INTRODUCTION

Medical Physics is a new and important discipline of science which deals with the application of physical principles and methods to the diagnosis and treatment of diseases. About three decades ago, medical physics activities were restricted primarily to the dosimetry of ionizing radiation. In the recent past, this concept has changed considerably and now the medical physicists are involved in all the aspects of medical application of radiation including radiation safety and play vital roles both in diagnosis and therapy of diseases. Foreseeing the requirements of medical physicists and radiation safety officers (RSOs) well in advance, the Radiological Physics & Advisory Division (erstwhile Division of Radiological Protection), Bhabha Atomic Research Centre (BARC) started a regular training programme in Radiological Physics in 1962, in collaboration with the World Health Organization. This course was later converted as Diploma in Radiological Physics (DipRP). The DipRP course of BARC is a prestigious multidisciplinary education and training programme which is well recognised both in India and abroad. Currently, this course is conducted under the aegis of Homi Bhabha National Institute (a deemed to be university) as one year Post MSc program in Radiological Physics. The DipRP program has produced a number of world renowned medical physicists who is serving the society all over the globe.

II. INCREASE IN EDUCATIONAL INSTITUTIONS

Considering the increased demand of medical physicists/RSOs in the country, a few universities/institutions also started education and training programme in medical physics. The Anna University, Chennai was the first institution to start 2 years MSc (Medical Physics) Degree course in 1982. Currently, 22 universities/institutions are conducting courses in medical physics in India. As far as course modality is concerned, two different types of medical physics courses are conducted in India, namely (i) Post MSc Diploma in Radiological/Medical Physics (DipRP/DipMP), and (ii) MSc Degree in Medical Physics [MSc (Medical Physics)]. In DipRP/DipMP course, the entry level qualification of the candidate is MSc Degree in Physics whereas in MSc (Medical Physics) course the entry level qualification is Bachelor of Science Degree majoring in physics. As most of the medical physicists trained in India work in the discipline of radiation oncology medical physics (ROMP), the entry level qualifications are based on the eligibility criteria prescribed by the Atomic Energy Regulatory Board (AERB) for medical physicist and RSO. The curriculum of the DipRP course, conducted by BARC, has been adopted by the AERB indicating it to be one of the best courses in the country with its well-organized modality.

III. INTERNSHIP AND PROGRAM HARMONISATION

A qualified medical physicist is a professional with education and specialist training who is competent to practice unsupervised in one or more subfields of medical physics. An ROMP is involved in many clinical activities including performance evaluation of imaging and therapy equipment, physical and patient dosimetry, treatment planning, research and development, and teaching related to medical use of ionizing radiation and associated radiation protection and safety [1]. Advanced technology therapy and imaging equipments are now-a-days commonly used for treating the cancer patients by highly advanced clinical techniques such as intensity modulated radiotherapy, image guided radiotherapy, stereotactic radiosurgery/radiotherapy, and volumetric modulation arc therapy. Providing physics support in these high precision and highly conformal clinical techniques are also the routine responsibilities of the medical physicists. It will be challenging for a medical physicist without supervised clinical experience to provide physics support in such cases. Due to the complexity of recent radiotherapy equipment and clinical techniques and to ensure the effective and safe treatment for the patient, medical physics internship at a well-equipped radiotherapy centre for at least one year duration on successful completion of academic component has been incorporated in the medical physics education in India. A structured competency based medical physics internship programme was developed and implemented from July 2013. As on today, more than 100 radiotherapy centres are conducting medical physics internship in India.

IV. Program recognition and professional registration

It is a mandatory requirement for an educational institution/university to obtain the recognition of their medical physics education and training program by the Atomic Energy Regulatory Board (AERB), Mumbai. AERB has prescribed minimum requirements for conducting education and training program in medical physics which includes the course syllabus, entry level qualification of candidates, and course conducting infrastructure [2]. Minimum requirements has also been prescribed for the institutions interested of conducting medical physics internship. Successful candidates of AERB recognised education and training institutions/universities who have successfully completed their medical physics internship from AERB recognised internship institutions can apply for obtaining professional registration from AERB as medical physicst through the on-line registration system eLORA (e licensing for radiation applications). It is importnat to mention that certificate of successful completion of academic component is given by the concerned institution/university and the successful completion of internship certificate is issued by the concerned internship centre. AERB eLORA registered medical physicists are also allowed to appear for medical safety certification examination conducted by Radiological Physics and Advisory Division of Bhabha Atomic Research Centre, Mumbai.

V. Certification by professional society

The College of Medical Physics of India (CMPI, a scientific wing of Association of Medical Physicists of India) started competency certification of Radiation Oncology Medical Physicists in 2009 [3]. However, this certification is voluntary in nature and it is expected that this certification may become a mandatory requirement in future. Many qualified medical physicists have appeared in this certification examination in last ten years and received CMPI certification. The eligibility for appearing in CMPI certification examination and test pattern are available at CMPI website (www.cmpi.org.in).

VI. Professional society and professional development of medical physicists

The Association of Medical Physicists of India (AMPI) The Association of Medical Physicists of India (AMPI) was founded in 1976 with the main objective to promote the application of physics in medicine. The AMPI is a non-profit, non-trade, an all India organization primarily engaged in educational and research activities in the field of applications of Physics in Medical Sciences. In fact, it is a registered public trust which is governed by the constitution of the association (Executive Committee and the Board of Trustees). The AMPI was started with less than 100 members on record in 1976. Immediately after its formation, the association started publishing a quarterly bulletin popularly known as “AMPI Medical Physics Bulletin”. This periodical was containing a few articles of practical importance along with other scientific and technical information including regulatory and administrative requirements for medical uses of ionizing radiation. The association also started conducting annual conferences from the year of its inception where national and international experts used to share their knowledge and information for the benefit of the society.

VII. Summary and conclusions

In summary, medical physics education in India is well-structured. However, there is always scope of improving the quality of teaching and training which is being initiated by incorporating training for trainers. Now, it is required to initiate the process of revalidation of certification both for clinical competency and radiological safety.

References

1. AERB Safety Code on Radiation therapy sources, Equipments & installation (Code No. AERB/RF-MED/SC-1
2. Standing Committee on training courses & radiation professionals
3. CMPI Revised Scheme 2019 (www.cmpi.org.in)

INTRODUCTION OF KOREAN SOCIETY OF MEDICAL PHYSICS

Byungchul Cho[1,2]

[1] Dept. Radiation Oncology, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Korea
[2] President KSMP (Korean Society of Medical Physics), Seoul, Korea

Abstract— **The paper introduces the Korean society of medical Physics (KSMP) from the formation to the status. It has been formed in 1990 and currently 600+ members are participating. KSMP established its own journal, education/training guidelines and certification, and board certification as well. KSMP is actively participating international activities including IOMP, AFOMP.**

Keywords— **Medical Physics, Education and Training, Board Certification, Qualified Medical Physicist**

I. INTRODUCTION

Diagnostic X-ray machines has been introduced in Korea since 1913, just 18 years later after its discovery.

In 1960s, Radium therapy and orthovoltage radiotherapy was introduced in Korea. In 1965 Co-60 teletherapy was firstly introduced. Since then a few physicist in research institutes began to consult about radiation physics and dosimetry and the need to medical physicist was recognized. In 1970 Megavoltage linear accelerator was firstly introduced and the first medical physicist began to work for radiotherapy and medical physicist was recognized as a profession in healthcare.

Medical physicists work mainly in hospitals, but also in Universities, Research Institutions, Regulatory bodies, Industry, etc. Due to this reason it is not possible to establish the exact number of medical physicists in Korea. However, the data from various medical physics societies, collected by the Korean Society of Medical Physics (KSMP), presents a good estimate of this number. The KSMP archive data on Fig.1 shows the growth of the profession in the past 50+ years.

II. ESTABLISHMENT PERIOD 1990-2000

KSMP has been formed On September 22, 1990 by 22 medical physicists, majority of them was working for radiation treatment in hospitals. On September 22, 1990. The first President of KSMP was Prof. Sung Sil Chu at Yonsei University and the first Secretary General of KSMP was Prof. Wee-Saing Kang at Seoul National University.

Around the time of KSMP formation there had been about 30 medical physicists in Korea. During the first decade of the Organization (1990-2000) the number of medical physicists in Korea increased to about 100.

As soon as the formation KSMP started the Korean

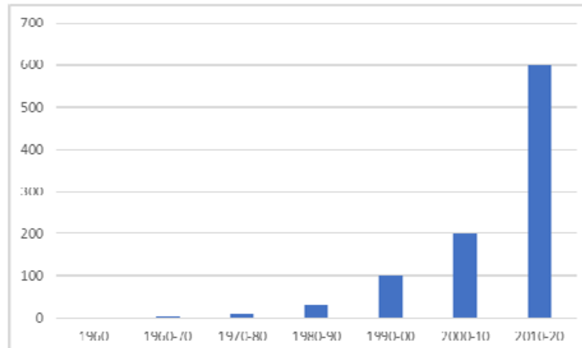


Fig.1 Growth of medical physicists of Korea in the period 1960-2020 – per decade (KSMP data)

Board of Medical Physics which is a certification for qualified medical physicist. It also began to publish the official journal of KSMP, the Korean Journal of Medical Physics. At the same time KSMP expanded international collaborations. KSMP joined the International Organization on Medical Physics in 1991 and the Asia-Oceania Federation of Organizations on Medical Physics (AFOMP) in 2000. In 1996 KSMP started a triannual joint meeting with Japan Society of Medical Physics (JSMP) to build human networks and share the knowledges. With the need to cultivate human resources the first postgraduate program focused on medical physics was established at Kyonggi University in 1996, and 50+ medical physicist graduated at this program. In 1997 Catholic University also established the MSc and PhD programs, and 100+ medical physicists graduated the program.

III. EXPANSION PERIOD 2000-2010

In the next decade 2000-2010 the number of medical physicists in Korea increased to about 200. In this period KSMP strived for recognition and legalization of medical physicist as a health profession in Korea. For this purpose in 2005 KSMP established guidelines for clinical training program which meets International Standards and certified two institutes. In 2006 KSMP hosted World Congress on Medical Physics and Biomedical Engineering. In 2005 Korean Journal of Medical Physics was indexed in Korean Citation Index and further indexed in KoreaMed [1].

IV. MATURITY PERIOD 2010-2020

In the period 2010-2020 the number of medical physicists in Korea reached about 600. This period also continued development of medical physics education and training. In 2013 KSMP established guidelines for postgraduate education program and certified 5 Universities for their MSc and PhD Medical Physics courses. In 2015 as an independent board certification organization Korean Medical Physics Certification Board (KMPCB) was established for efforts to acquire more objectiveness and transparency in board certification with the help of other organizations including Korean Society of Radiation Oncology and Korean Society of Nuclear Medicine. KMPCB acquired accreditation from International Medical Physics Certification Board (IMPCB) [2]. There are 22+ certified members and 80+ equivalent board members.

As an effort to transfer the official journal from domestic journal into international, Korean Journal of Medical Physics was renamed as Progress in Medical Physics in 2012 and actively working for PubMed Central indexing.[3]

V. CURRENT STUTUS

The population and GDP of Korea is currently about 52 million and 1.6 trillion dollars. There are 260+ radiotherapy machines, 90,000 X-ray imaging devices, 1,000 MRIs, 30,000+ Ultrasounds for diagnostic imaging, and 500+ SPECT, 300+ PET systems for nuclear medicine. Around 300+ medical physicists are working actively. Among them 80% works in radiotherapy, 10% works for diagnostic imaging, and 10% for nuclear medicine. 70% of them are men and the other 305 are women. Except RT most MPs in diagnostic imaging and nuclear medicine works in Universities and research institutes. Therefore, most of QA in diagnostic imaging and nuclear medicine is done by radiation technologies. Increasing MP workforce working in diagnostic imaging and nuclear medicine is needed in Korea.

At the same time, there are 260+ radiotherapy machines, but only ~200 medical physicists and ~100 qualified medical physicist are only available which is less than 50% of recommend workforce.

In 2013 postgraduate program, following IAEA TC56 [4] and CAMPEP program [5], has established to be certified by KSMP, and 5 Universities are certified. There are 3 Universities also certified from IOMP postgraduate program. Around 8-10 students are graduated from these courses each year.

In 2005 KSMP started the certification of clinical training program and certified 2 institutes. MP training is not mandatory but recommended for working as a clinical medical physicist.

KSMP is organizing two scientific meetings every year and continuing education courses for certified board members two times a year also.

There are several issues that KSMP must deal with. Firstly, legalization of medical physicist as a health profession is still long way to go. It needs more recognition of medical physicists from relevant societies including physicians, nurses, radiological technologists, and public as well. It must also overcome the opposition of radiation technologists who are thinking MP maybe limits their job opportunities. For this purpose, well-organized education/training program and board certification are also very critical. As for journal and research, the recognition and quality improvement of the official journal is also urgent issue. The huge challenge for KSMP, shown in the previous paragraph, will need special attention and actions necessary a lot of energy and endless concentrations.

VI. CONCLUSION

Currently, the field of medical physics is undergoing a major turning point. Advances in computing technologies such as artificial intelligence is changing the landscape of global healthcare. It is also forcing the change of conventional role of medical physicist. However, there will be a chance to contribute more to the development of global healthcare as medical physicists.

At such a big turning point, medical physicists constantly learn emerging technologies and play the role of steppingstones for application in the clinical field.

In this purpose, global collaboration and harmonization is necessary and KSMP is willing to take a role in developing global healthcare.

VII. REFERENCES

1. Taejin Choi, Aeran Yoon, Sung-Soo Seol (2113) "Korea Citation Index and Its Macro Bibliometrics. Asian Journal of Innovation and Policy [Internet]. Vol. 1, No.2, 2013, p.194–211 (Available from: https://doi.org/10.7545/AJIP.2013.2.2.194)
2. L.D. Oliver (2013) "International Medical Physics Certification: But what else is needed for International acceptance?". In: Long M. (eds) World Congress on Medical Physics and Biomedical Engineering May 26-31, 2012, Beijing, China. IFMBE Proceedings, vol 39. Springer, Berlin, Heidelberg.
3. Hyun Do Huh, Seonghoon Kim (2020) "History of Radiation Therapy Technology" Progress in Medical Physics, vol. 31. No. 2. P.124-134.
4. INTERNATIONAL ATOMIC ENERGY AGENCY (2014) Postgraduate Medical Physics Academic Programmes, Training Course Series No. 56, IAEA, Vienna.
5. C Kleefeld, M Alaswad, and M Foley (2019) J. Phys.: Conf. Ser. 1248 012074.

Author: Byungchul Cho, PhD, President KSMP, Institute: Asan Medical Center, University of Ulsan College of Medicine, Seoul, Korea, cho.byungchul@gmail.com

MEDICAL PHYSICS DEVELOPMENT IN MALAYSIA

J.H.D. Wong[1,2], C.H. Yeong [3], H. M. Zin[4], M Pawanchek[5], N Jamal[3], K.H. Ng[1,2]

[1] Department of Biomedical Imaging, Faculty of Medicine, University of Malaya, Kuala Lumpur 50603, Malaysia
[2] University of Malaya Research Imaging Centre, Faculty of Medicine, University of Malaya, Kuala Lumpur 50603, Malaysia
[3] School of Medicine, Faculty of Health and Medical Science, Taylor's University, 47500 Subang Jaya, Malaysia
[4] Advanced Medical and Dental Institute, Universiti Sains Malaysia, Bertam 13200 Kepala Batas, Penang, Malaysia
[5] Department of Radiotherapy and Oncology, National Cancer Institute, 62250 Putrajaya, Malaysia

Abstract — **Medical physics is a relatively young profession in Malaysia, but we have seen encouraging development in the past 20 years. There are currently 349 medical physicists in Malaysia, making a ratio of 1 medical physicist for every 100,000 people. This ratio ranked the second among the South East Asia countries. 41% of the medical physicists are working in the regulatory/licencing bodies and academic/research institution, followed by 36% in radiation oncology, 15% in diagnostic radiology and 8% in nuclear medicine. In 2016, the Malaysian parliament gazetted the Allied Health Profession Act (ACT 774) that governs that all practising allied health professionals including medical physicists must obtain a practising certificate and compulsory Continuous Professional Development (CPD) of 30 points per year. Malaysia has two affiliate National Member Organizations (NMOs) of AFOMP, namely Medical Physics Division (MPD) under the umbrella of Institute of Physics Malaysia (IFM) and Malaysia Association of Medical Physics (MAMP). Malaysia currently offers two postgraduate medical physics programme at two public universities. The Master of Medical Physics programme at the University of Malaya is accredited by the Institute of Physics and Engineering in Medicine (IPEM) since 2002. There is currently no medical physics residency programme in Malaysia. However, the country adapts the International Atomic Energy Agency (IAEA) RAS6038 Clinical Training programme in three sub-disciplines (i.e. ROMP, DRMP and NMMP).**

Keywords — **medical physics, Malaysia, IFM, MAMP**

I. INTRODUCTION

Malaysia has a population of 32.7 million, with a total area of 329,847 km^2 [1]. The country currently has 71,041 medical doctors working in both public and private sectors, making a ratio of one doctor for every 454 people [2]. Malaysian has an average life expectancy at birth of 77.3 years for females and 72.2 years for male [3].

As of 1st January 2020, the total number of medical physicists in the country is 349 [4]. Hence the ratio of medical physicists is 1:100,000 people. This ratio ranked the second among the South East Asia countries [5]. 36% of the medical physicists in the country are working in the sub-discipline of radiation oncology, 15% in diagnostic radiology, 8% in nuclear medicine, and the remaining 41% are serving in either the regulatory bodies, licensing companies, or academic/research institutions. The number of medical physicists in Malaysia, according to different sub-disciplines is given in Table 1 [5].

Table 1 Distribution of medical physicists according to sub-disciplines in Malaysia (as of 1 January 2020)

Sub-Discipline	Total
Radiotherapy	126
Nuclear Medicine	53
Radiology	28
Other Sub-Discipline	142
Total	**349**

II. INFRASTRUCTURE

As of 31st December 2018, Malaysia has 135 public hospitals, nine special medical institutions and 210 private hospitals [6]. On top of that, there are more than 228 medical clinics and 487 dental clinics that are registered for the use of X-ray equipment. The number of radiological facilities/equipment in the country is given in Table 2 [5].

Table 2 Number of radiological facilities/equipment in Malaysia (as of 1 January 2020)

Facilities/Equipment	Number
Radiation Oncology	
EBRT (including LINAC, IMRT, IGRT, Cyberknife, Gamma Knife)	67
Brachytherapy systems	19
Nuclear Medicine	
Gamma Camera (including SPECT Camera)	23
SPECT/CT scanners	13
PET/CT scanners	21
Medical Cyclotron	3
Diagnostic Radiology	
CT scanners	3,427
Fluoroscopy and angiography systems	711
Mammography	279
General X-ray systems	3,629
Dental X-ray Equipment	257
MRI systems	104

Abbreviations:
EBRT: External beam radiotherapy
LINAC: Linear accelerator
IMRT: Intensity-modulated radiotherapy
IGRT: Image-guided radiotherapy
SPECT: Single photon emission computed tomography

CT: Computed tomography
PET: Positron emission tomography
MRI: Magnetic resonance imaging

III. Regulation of medical physics

In 2016, the Malaysian parliament gazetted the Allied Health Professions Act (Act 774) [7]. This Act governs medical physicist, along with 22 other allied health professions. All the practising professionals must obtain a practising certificate and compulsory Continuous Professional Development (CPD) of 30 points per year. The Act is effective from 1st July 2020 onwards [7].

IV. Professional organizations

Malaysia currently has two medical physics professional organizations, namely Medical Physics Division (MPD) under the umbrella of Institute of Physics Malaysia (IFM) [8] and Malaysia Association of Medical Physics (MAMP) [9]. MPD, IFM are the National Member Organization (NMO) of the Asia-Oceania Federation of Organizations for Medical Physics (AFOMP) and the International Organization for Medical Physics (IOMP); while MAMP is the affiliate member of AFOMP. Table 3 lists the current executive committee members of both organizations. Both MDP, IFM and MAMP have actively involved in organizing professional activities related to medical physics such as regional conferences, workshops and seminars. The organizations are also responsible for the annual celebration of the International Day of Medical Physics (IDMP) and International Medical Physics Week (IMPW). On the 7th of November 2017, IFM organized a global webcast in conjunction with the 150th birthday of Marie Sklodowska-Curie [10]. MAMP also organized bi-annual national scientific meetings on medical physics known as "International Seminar on Medical Physics" that typically attracts 100-200 participants from the region. Some examples of the important scientific events organized by the organizations from 2015-2020 are shown in Table 4.

Table 3 Executive committee members of the NMOs

Name of NMO	MPD, IFM	MAMP
Chair:	Prof. Dr. Kwan Hoong Ng	Dr. Hafiz Mohd Zin
Vice Chair:	Dr. Noriah Jamal	Dr. Rafidah Zainon
Secretary:	Dr. Jeannie Wong	Dr. Noramaliza Mohd Noor
Assistant Secretary:	Dr. Hafiz Mohd Zin	Dr. Rozilawati Ahmad
Treasurer:	Dr. Chai Hong Yeong	Dr. Husaini Salleh
Assistant Treasurer:	Dr. Ngie Min Ung	-

Table 4 Some examples of important scientific events organized by the Malaysian NMOs from 2015 – 2020

Date	Scientific Events	Theme	No. of Delegates
11 - 14 Nov 2015	AAPM/IOMP/ISEP Imaging Physics Workshop	Building Foundations for Sound Clinical Practice	214
10 Dec 2015	Workshop on Digital Radiography	To review the basic principles, image quality and artifacts, as well as some routine quality control (QC) tests in digital radiography	40-50
5-6 Aug 2016	Interventional Radiology: Safety, Optimization, Dosimetry and Quality Control	To provide the latest updates on radiological safety, optimization, dosimetry and quality assurance related aspects in the field of interventional radiology	64
27-28 Aug 2016	10th International Seminar on Medical Physics (ISMP)	Fostering Medical Physics Research and Clinical Practice for Better Healthcare	200
6 Dec 2017	Workshop on Radiation Dosimetry II - Solid-State and OSL Dosimetry: Physics & Applications	To provide a basic understanding of physics of semiconductor and optically stimulated luminescence dosimetry.	38
11 – 14 Nov 2018	18th Asia-Oceania Congress of Medical Physics (AOCMP) & 16th South-East Asia Congress of Medical Physics (SEACOMP)	A Sustainable Future For Medical Physics	529
4 Jul 2019	Updates in Radiobiology	-	50
7-8 Nov 2019	11th International Seminar on Medical Physics (ISMP)	Medical Physics: Together We Make an Impact	112

V. Education and training

Malaysia currently offers two postgraduate programmes of medical physics (Master's and doctorate degrees). One is offered by the University of Malaya (UM) in Kuala Lumpur (started in 1999), and the other is offered by the University of Science Malaysia (USM) in the northern region of the peninsular of Malaysia (started in 1995) [11]. The universities have produced more than 400 medical physicists for the country and the region since 1996.

The Master of Medical Physics programme offered by UM is accredited by the Institute of Physics and Engineering in Medicine (IPEM) of the United Kingdom since 2002, is the only university outside of the British Isles to receive such recognition [7,11,12]. UM is also recognized as a regional education and training centre for postgraduate medical physics by the International Atomic Energy Agency (IAEA). Since 2012, the IAEA has been sponsoring fellows from less developed countries to undergo the Master's programme and clinical training at UM. To date, the programme has successfully trained four IAEA fellows from Cambodia and Vietnam, with two more candidates in the pipeline. Three of them are currently medical physics leaders and educators in their respective countries and one currently pursuing a doctorate at UM.

There is currently no medical physics residency programme in Malaysia. Most of the clinical medical physicists were trained on-the-job after obtaining their postgraduate degrees. However, under the IAEA RAS6038 programme, Malaysia has completed clinical medical physics training for six Radiation Oncology Medical Physicists (ROMPs) and two Diagnostic Radiology Medical Physicists (DRMPs). The latest cohort of the ROMP, DRMP and Nuclear Medicine Medical Physicists (NMMP) clinical training kick-started in 2018 and expected to complete in 2021 [5].

VI. Adwards and recognitions

Malaysia has been actively involved in the development of medical physics profession in the Asia-Oceania region through strong collaborations with numerous international organizations, such as the IAEA, IOMP, AAPM, IPEM, AFOMP, SEAFOMP and ACOMP. In 2018-2021, Malaysia is leading a non-agreement project under the IAEA Technical Cooperation project (RAS6088) on "Strengthening Education and Clinical Training Programmes for Medical Physicists in the Asia Pacific region". This project provides budget to support capacity building and training for medical physicists in the region. Under the project, 12 workshops in the field of radiotherapy, diagnostic radiology and nuclear medicine physics have been planned [5].

On individual level, a number of medical physicists from Malaysia have been awarded for their significant contributions in the development of medical physics at the international level. These include Prof. Dr. Kwan Hoong Ng for the prestigious Marie Sklodowska-Curie Award 2018 as well as the Top 50 Medical Physicists who have made an outstanding contribution to the advancement of medical physics over the last 50 years by the IOMP in 2013; Assoc. Prof. Dr. Chai Hong Yeong, Dr. Hafiz Mohd Zin and Assoc. Prof. Dr. Jeannie Wong Hsiu Ding for the Young Leader Awards by SEAFOMP for the year of 2017, 2018 and 2019, respectively; Dr Noriah Jamal and Prof. Dr. Wan Kamil for the Top 21 Outstanding Medical Physicists from the AFOMP region in 2020; and etc.

VII. Conclusion

Medical physics profession has seen steady development over the past 20 years in Malaysia. The demand for medical physicists in both quantity and quality increased by year in line with the rapid development in healthcare services. Malaysia is listed in the Top 10 Medical Tourism Destinations in the World by Patients Beyond Borders [13] due to its strategic location, technology orientated, friendly environment, proficient English speaking healthcare professionals, excellent public and private healthcare services at very affordable price. Malaysia's strength lies in having accredited postgraduate medical physics programmes, structured clinical training~~s~~ supported by the IAEA, professional certification under the allied health professional act, as well as active and leading roles of the medical physics associations. The continuing challenges faced by the medical physics community in the country, however, is outward migration of experienced medical physicists and sustainable research funding.

Acknowledgment

We acknowledge the contributions of the IAEA in strengthening the education and clinical training of medical physicists in the region through Technical Cooperation (TC) programme. We would also like to thank the IOMP, AFOMP and SEAFOMP for their supports in multiple Continuous Professional Development activities in Malaysia. Finally, we thank the radiology, oncology, nuclear medicine and radiography communities in Malaysia for their continual congenial supports and collaborations throughout the years.

References

[1] Department of Statistics Malaysia. Department of Statistics Malaysia Official Portal. 2020 2020. https://www.dosm.gov.my/v1/index.php?r=column/ctwoByCat&parent_id=115&menu_id=L0pheU43NWJwRWVSZklWdzQ4TlhUUT09 (accessed September 11, 2020).
[2] Malay Mail. Malaysia's doctor-population ratio surpasses WHO recommendation, says health minister 2020.
[3] Department of Statistics Malaysia. Abridged Life Tables, Malaysia, 2017-2019. 2019.
[4] Wong J, Zin H, Pawanchek M, Medica KN-P, 2019 U. Medical physicists in Malaysia: A national workforce survey 2019. Elsevier 2019;67:40–9.
[5] Ng KH, Krisanachinda A, Tabakov S, Peralta A, Pawiro S, Lee JCL, et al. Medical Physics Development in South-East Asian Federation of Organizations for Medical Physics (SEACOMP): 2000-2020. Med Phys Int Journal, Spec Issue, Hist Med Phys 2020;4:387–98.
[6] Ministry of Health Malaysia. Health Facts 2019 - Reference Data for 2018. 2019.
[7] Wong J, Ng KH, Haryanto F, Krisanachinda A, Lee J, Nguyen TC, et al. South-East Asian Federation of Organizations for Medical Physics (SEAFOMP)-Celebrating 20 th Anniversary of formation.

vol. 8. 2020.
[8] IFM. Malaysian Institute of Physics 2020. http://ifm.org.my/.
[9] MAMP. Malaysian Association of Medical Physics 2020. https://www.mamp.org.my/.
[10] University of Malaya. Medical Physics University of Malaya Past Events 2020. https://medicalphysics.um.edu.my/past-events.
[11] Wong J, Ng K, Medica SS-P, 2019 U. Survey of postgraduate medical physics programmes in the Asia-Oceania region. Elsevier 2019.
[12] Wong J, Ng KH. Medical Physics Education in Malaysia - With The Example of the Master of Medical Physics Programme at the University of Malaya. vol. 3. 2015.
[13] Patients Beyond Borders. Top 10 Medical Tourism Destinations in the World. Patients Beyond Borders 2020. https://www.patientsbeyondborders.com/media.

Contacts of the corresponding author:

Author: Dr Chai Hong Yeong
Institute: Taylor's University
Street: Subang Jaya
City, Country: Selangor, Malaysia
Email: yeongchaihong@gmail.com

MEDICAL PHYSICS IN MONGOLIA

Tserendavaa, Oyunchimeg [1]

[1] Secretary of Mongolian Society of Medical Physics & Informatics

Mongolia is a large, landlocked and sparsely populated country in the northern part of Central Asia, located between Russia on the north and China on east, south and west. Its total land area of 1.5 million square kilometers, but contains only 3.2 million population or 1.3 people per square kilometer.

Mongolia, as a peace-loving country, has a strong commitment to the nonproliferation of nuclear weapons and the peaceful use of nuclear energy.

Mongolia has been cooperating with the International Atomic Energy Agency on such projects as manpower development and development of nuclear analytical techniques, the introduction of nuclear techniques in health, and upgrading nuclear medicine services.

Mongolia has been working together with other countries in making with using gamma rays treating patients with radiation and in the early detection of genetic disorders in infants, of cancer, heart disease and other ailments.

In the 1960s, two X-ray machines and the most advanced technology of the time, the Cobalt-60 generator, were installed to treat cancer patients with radiation and to use nuclear technology in the medical field.

Cardiovascular diseases and cancer are among the leading causes of death in Mongolia. Nuclear Medicine in Mongolia-1975-1981 Beginning First Medical Application of radioisotopes - First Rectilinear scanner, 1972.

Single and dual scintillation detectors system, Thyroid Uptake Test; 1982-1999 Settlement, IAEA TC Project since 1982, Thematic Program on Health Care (RAS) since 1997, First Gamma Camera since 1997, Radio immunological Laboratory and first Radioiodine treatment since 1982,

First SPECT and Quantitative Measurement in 2000 Second Gamma Camera, New Thyroid Uptake System-Atom lab 950 PC Spectrometer Radio immunological Laboratory replacement, Myocardial Perfusion Scintigraphy, Liver Cancer Treatment with Re-188, Radiosynovectomy with Re-188.

The National Cancer Center Mongolia has a long history in cancer care, with treatments dating back to 1961 with radiotherapy in Mongolia going back even further. Currently, the National Cancer Center Mongolia provides nation-wide services in cancer treatment. This includes surgery, chemotherapy and radiotherapy. In Mongolia, the number of total high energy radiotherapy machines per million people is 0.7.

Radiotherapy services in Mongolia have been improved, and two Linacs became operational in June 2019. Quality assurance systems for ensuring that patients receive the correct radiation doses were upgraded and new technologies and a radiation safety system for radiotherapy services were also introduced. In addition, donors provided support in 2016 for a state-of-the-art cancer diagnosis and treatment system, and training through IAEA assistance helped to introduce highly accurate 3D radiation therapy and other modern technologies to the country.

IAEA support has been crucial for Mongolia in the acquisition of a gamma beam radiation protection system and an X-ray calibration system to support the country's cancer control, diagnosis and treatment program.

The IAEA is also assisting Mongolia in upgrading a computed tomography (CT) and single-photon emission computed tomography (SPECT) medical imaging system at the First General Hospital.

Combined PET-CT imaging technology, which is mainly used in the diagnosis of cancer, cardiac disease and nervous disorder, is to be introduced in the State Central Second Hospital.

Mongolian Society of Medical Physics & Informatics (MSMPI) - a member of (IOMP) & (AFOMP), the professional organization was founded in 2003, current 25 members.

Medical physicists (MPs) working in the clinical environment are health professionals, with education and specialist training in the concepts and techniques of applying physics in medicine, competent to practice independently in one or more of the subfields (specialties) of medical physics.

Preparation of Medical Technical Engineers in Mongolia:

Before the 1990s, there were 3 ways:

- Mostly educated in the former the Soviet Union
- graduated at Mongolian National Technical University under an Electrical Engineering
- graduated at Mongolian Medical College under a Radiology technician

Present, there are 3 ways:

- Mongolian National University of Medical Science offers BS in Health Information Technology
- Mongolian University of Science and Technology offers BS in Medical Equipment Engineering
- National University of Mongolia offers BS in Nuclear Engineering

The purposes of the MSMPI are as follows:

- To advance and safeguard the profession of Medical Physics in all its aspects;
- To unite and promote cooperation and understanding among medical physicists and workers in the medical allied professions; and
- To promote the welfare and professional development of medical physicists of Mongolia.

The MSMPI shall undertake the following activities to achieve its primary goal:

- To initiate a Master's Degree Program in Medical Physics at Mongolian National University of Medical Sciences in collaboration with AFOMP and other organizations.
- To develop and disseminate scientific and technical information in medical physics and related fields;
- To organize and sponsor conventions, scientific meetings, clinical residency training programs, training courses, workshops, and seminars in medical physics, and courses related to the roles, responsibilities, and development of medical physicists;
- To send our specialists to developing countries, especially member countries of Asia-Oceania Federation of Organizations for Medical Physics, to gain an experience
- To invite professionals to Mongolia to teach and give a lecture to our specialists
- To collaborate with Nuclear Energy Agency Government of Mongolia and other scientific organizations;

Medical Physics in Nepal: A Narrative on its Development

Adhikari, K.P.[1,2]

[1]Associate Professor & Chief Medical Physicist, National Academy of Medical Sciences, Bir Hospital, Katmandu, Nepal
[2]Secretary General, Nepalese Association of Medical Physicist (NAMP)

Abstract — **As mentioned by International Organization of Medical Physics, Medical physicists are professionals with education and specialist training in the concepts and techniques of applying physics in medicine. Medical physicists working in clinical environment are health professionals, with education and specialist training in the concepts and techniques of applying physics in medicine, competent to practice independently. The ratio of medical physicist in Nepal is less than 0.65 per million inhabitants and still does not have medical physics education and training program. Since 2008, after obtaining a membership of IAEA, the turning point of recognition of role and responsibilities of medical physicists ensued in Nepal. The main accomplishments include Radioactive Materials Uses and Regulatory Act has materialized effective as of July 2020. This has created a path for recognition, role and responsibilities of medical physicists in Nepal.**

Keywords— **Act, Medical Physicist, Radioactive Materials,**

I. INTRODUCTION

Federal Democratic Republic of Nepal, is landlocked, and borders with China in the north and India in the south, east and west, a country in South Asia. It is also known as a country of Himalayas. Demographic information of Nepal is shown in Table 1.

Table 1. GDP per capita, number of MPs, population and MPs per million populations in Nepal

Area	GDP	Per Capita income	Population in million	No. of MPs	MPs per million
1,47,516 Sq km	$29.813 billion (in 2019)	USD 1,048.00	29.0	19	0.65

In Nepal, radiological services with first X-ray was started way back in 1923. Similarly, first radiation therapy was started in 1976 with Brachytherapy service (Radium Needle). In 1988, CT scan and Nuclear Medicine as the first such technology of its kind was introduced at the NAMS, Bir Hospital. That was the beginning of introduction of medical physicists in Nepal. History of Radiation emanating used in Nepal is shown in Table 2.

Table 2. History of Radiation Equipment in Nepal

Year	Equipment	Center
1923	First X-ray	Tri-ChandraElectroMedical.
1976	First Brachytherapy(Radium)	Paropakar MaternityHospital.
1988	First CT scan	NAMS, Bir Hospital
1988	First Nuclear Medicine	NAMS, Bir Hospital
1991	First Radiotherapy(Cobalt60)	NAMS, Bir Hospital
2002	First Linear Accelerator	B.P.K.M. Cancer Hospital
2002	First HDR Brachytherapy	B.P.K.M. Cancer Hospital
2015	First Blood Irradiator	Civil Servent Hospital

In 1987, Dr. Gauri Shanker Pant, medical physicist from All India Institute of Medical Sciences (AIIMS), Delhi was sent to Nepal to start and run the nuclear medicine imaging service at NAMS, Bir hospital by the Indian government. Later Dr. Pant was also volunteered in establishing Cobalt-60 and trained Nepal's first medical physicist Mr. P.P Chaurasia, who was recruited for the job of Medical Physicist. In 1989, first medical physicist post was created at Bir Hospital, just before introducing first radiation therapy service unit with a Tele Cobalt-60 machine in Nepal. This means, we are celebrating thirty years of medical physics in Nepal.

In 2002, B.P. Koirala Memorial Cancer Hospital introduced first Linear Accelerator and HDR Brachytherapy service in the country, which has paved the way for more medical physicist positions in the country. In 2004, 2005 & 2006 NAMS, Bir hospital, has been assigned different projects to find out status of radiation protection and inventory of radioactive sources being used in Nepal by then Ministry of Science & Technology of Nepal, under the secretary-ship of Dr. Kanchan P Adhikari, medical physicist. Final report of those projects has recommend to the government of Nepal to acquire a membership of International Atomic Energy Agency (IAEA) and to establish radiation regulatory system in the country.

In, 2009, Nepalese Association of Medical Physicist (NAMP) was established to improve medical physics practice with a goal of patient safety for the medical use of radiation in radiology, nuclear medicine and radiation therapy. Since then, NAMP was affiliated to International Organization for Medical Physics (IOMP) and Asia-Oceania

Federation of Organizations for Medical Physics (AFOMP). In 2010, NAMP became one of a charter member organizations of the International Medical Physics Certification Board (IMPCB). Members of NAMP have been involved as a committee member of AFOMP's and IMPCB's various committees. Around ten members of NAMP has been awarded travel grants from IOMP/AFOMP to attend IOMP/AFOMP conferences or seminars till date. Current executive committee members of the Nepalese Association of Medical Physicists (NAMP) is shown in table 3.

Table 3. Professional Society Establishments

Year Established	First President	First Secretary General	Members Male/Female
2009	Pradhuman Pd. Chaurasia	Dr. Kanchan P Adhikari	18 Male 0 Female

II. Present status & issues

The ratio of medical physicist in Nepal is less than 0.65 per million inhabitants. At present, Nepal has seven radiotherapy centers; three public, one semi-public and three private that accommodate almost all the physicists.

Table 4. Distribution of Medical Physicists

Discipline	Total
Radiotherapy	17*
Nuclear Medicine	0
Radiology /Academic	1
Private Company	1
Total	**19**

**including three physicists from India, working at two private centers.*

Nepal has yet to have any official data regarding the number of radiation emanating equipment being used at different facilities in the country. Reliable records of the number of the radiological facilities in operation were lacking, until a few years ago, when the Ministry of Education, Science & Technology (MoEST) provided an opportunity to a few professionals including this scribe to make an inventory of radiation emanating equipment being used in Nepal. The number of diagnostic and therapeutic equipment being used in Nepal are shown in Table 5.

Table 5. Medical Imaging and Radiation Therapy Equipment

Equipment	Total	Equipment Per million inhabitants
Cobalt-60	2	0.07
Linear Accelerator	5 (+1)	0.21
HDR Brachytherapy	6 (-2)	0.14
X-ray	1000 +	35.60
CT Scan/ CT Simulator	100 +	3.56
MRI	46	1.59
Mammogram	15 +	0.53
Gamma Camera	3	0.11
PET/CT	2	0.07
Blood Irradiator	1	0.03

In Nepal, medical physics professional is yet to be regulated by government/competent authority. We still do not have licensing and registration system for medical physicist. There is also lack of medical physics position in government system. Ministry of Health & Population of Nepal has yet to create medical physics positions. Though Medical physicists are one of the key components in radiation oncology and plays a vital role in improving cancer cure through technology, the rules and regulation regarding medical physics services are still lacking. About 60% of the cancer cases worldwide occur in low and middle income countries but however, the existing infrastructure is far behind to cope successfully with the increasing threat not only to public health but also national economies. Modern radiation therapy treatments require trained and qualified professionals and big capital investment. However, Nepal does not benefit from this advancement due to lack of sufficient number of radiotherapy machines and insufficient number of specialized medical physicists.

III. Education and training

Nepal still does not have medical physics education and training program. Efforts have been done to start post graduate course in medical physics in Nepal but the desired result is yet to be seen. One IAEA expert mission was conducted in Nepal under IAEA / RAS project entitled RAS6088 Non-Agreement Project - Strengthening Education and Clinical Training Programmes for Medical Physicists. Prof. Kwan Hoon Ng was the expert and visited Nepal on June 2019 to recommend the further steps to be taken to materialize proposed academic program in Nepal. NAMS, Bir Hospital is the counterpart institution with a MD Program in Diagnostic Radiology and Radiation Oncology. NAMS, Bir Hospital also runs graduate and post graduate program in medical imaging technology for radiological technology. SWOT analysis was carried out to give balanced perspective of this initiative. Physicists from government centers have been participating in fellowship and education and training program in various IAEA/RCA projects which includes strengthening education and training program of medical physics. Nepal is Participating various on IAEA/RCA Regional Projects which is focused on Medical Physics in the Asia Pacific Region which includes

1. RAS6077 RCA Project - Strengthening the effectiveness and extent of medical physics education and training
2. RAS6087 RCA Project - Enhancing Medical Physics Services in Developing Standards, Education and Training through Regional Cooperation
3. RAS6088 Non-Agreement Project - Strengthening Education and Clinical Training Programmes for Medical Physicists

In the meantime, IAEA is also supporting Nepalese candidates to peruse Post Graduate course on Advanced studies in medical physics program from International Center for Theoretical Physics (ICTP), Trieste, Italy. Until now, four candidates have been graduated and currently one candidate is studying at ICTP under IAEA fellowship program. Currently, one medical physicist is pursing PhD in medial physics through sandwich program.

IV. Way forward

Since 2008, after obtaining a membership of IAEA, the turning point of recognition of role and responsibilities of medical physicists ensued in Nepal. The main accomplishments include Radioactive Materials Uses and Regulatory Act has materialized effective as of July 2020. The finalized draft for minimum standards required for operating diagnostic radiology and nuclear medicine facility has already been completed through Ministry of Education Science & Technology (MoEST) with an active participation of medical physicist. Once it is carried out, role and responsibilities of medical physicists and NAMP will be increased. Since 2012, Nepal has been involved in various Technical Cooperation (TC) projects associated with the IAEA with an active involvement of medical physicist from project designing to successful implementation of project as a national project counterpart (NPC). Therefore, the future of role and responsibilities of medical physicist as well as NAMP in Nepal mainly depends on the infrastructure of a strong regulatory system and sustainable safety culture of radiation users. Despite all the challenges inherent, the author remains confident that recognition, role and responsibilities of medical physicists in Nepal will be enhanced and NAMP could play its active role in promoting this field.

Acknowledgement

I would like to thank Nepalese Association of Medical Physicist (NAMP) including all medical physicists working in Nepal for their dedication and contribution in the field of medical physics.

References

1. World Bank, Central Bureau of Statistics, Nepal; retrieved on August, 2020.
2. ADHIKARI K.P., A Medical Physicists Perspective: Radiation Therapy in Nepal, Medical Physics International Journal, Vol **6** 1 (2018) 145-147.
3. ADHIKARI K.P., Radiation Regulation in Nepal: A challenging Journey, Radiation Regulator 1 (2013):7-10
4. Adhikari, K.P., Jha, L.N. and Montenegro, P.G. 2012. Status of Radiation Protection at different Hospitals in Nepal. J. Med Phys (Pub Med India) 37: 240-244.
5. Final Report on "Present Status of Nuclear Materials used in Nepal." Ministry of Environment, Science & Technology, June 2006.
6. Status of Radioisotopes in Nepal – A Survey for the Preparation of Inventory, Ministry of Science & Technology, 2010.
7. Final Report on finding out current status of X-ray being used in medical field in Kathmandu Valley, Ministry of Science & Technology, 2017.

Author: Kanchan P. Adhikari, PhD
Institute: National Academy of Medical Sciences, Bir Hospital.
Street: Mahabouddha, Ratnapark
City: Kathmandu
Country: Nepal
Email: kanchanadhikari@gmail.com

SMPRP-AFOMP: FOOTPRINTS IN THE LAST 20 YEARS

Cruzpero, Ramon Carlo [1]

[1] Public Relations, SMPRP, Philippines

The Society of Medical Physicists in the Republic of the Philippines (SMPRP) joins the 20th anniversary celebration of the Asia-Oceania Federation of Organizations for Medical Physics (AFOMP). Looking back at the timeline of our community 20 years ago will take us to the footprints of our collaborations through education, training, and professional development in our field.

In 2000, the SMPRP was still named as the Philippine Organization of Medical Physicists (POMP). This was the year where our society joined in the inception of the AFOMP, thus, becoming one of its founding member organizations. From there, AFOMP has always been our support through activities and events where we share best and standard practices of the medical physics profession.

The Philippines participated in the International Atomic Energy Agency- Regional Cooperative Agreement (IAEA RCA) RAS 6038 project, *Strengthening Medical Physics through Education and Training*, in 2002. A series of short-term workshops then followed which were hosted by various institutions from both local and international organizations, including AFOMP, to further enhance the knowledge and skills through structured clinical programs in radiation oncology medical physics (ROMP), diagnostic radiology medical physics (DRMP), and nuclear medicine medical physics (NMMP).

It was in 2008 that our community applied to participate in piloting the two-year clinical Radiation Oncology Residency Training Program. The said training program ended in 2010 through a two-part examination conducted by Dr. Brendan Healy, from Australia, as the external examiner and Prof. Lilian Rodriguez as the local examiner. The first wave of the residency training programme produced 11 board certified ROMPs who now serve as mentors to the succeeding generation of ROMPs in the country. Currently, the Philippines has produced 20 board certified ROMPs.

Also, our community participated in the two-year clinical Diagnostic Radiology Residency Training Program in 2010. However, due to some unforced circumstances, it was only in 2019 that the certification examination was conducted. Dr. Ian Donald McLean, also from Australia, was the external examiner while Prof. Agnette Peralta, Engr. Bayani San Juan, and Ms. Aida Lobriguito served as the local examiners. Now, our community has produced 13 board certified DRMPs.

On the other hand, through the IAEA RCA RAS 6077 project, *Strengthening the Effectiveness and Extent of Medical Physics Education and Training*, the Advanced Medical Physics Learning Environment (AMPLE) orientation was conducted in 2016. The platform provided budding medical physicists with aided learning materials and remote mentorships to further enhance their clinical skills. In 2019, IAEA, together with the University of the Philippines- Philippine General Hospital (UP-PGH), sponsored a national training course on Radiation Safety: Safety is not an Accident. One of the key speakers was Prof. Tomas Kron from Australia.

This year, our community joined in the celebration of the International Medical Physics Week through a series of webinars. Apart from our locally produced webinars, we incorporated two from AFOMP. These were the Medical Physicists and Clinical Trials: Evidence in Times of Uncertainty with Prof. Tomas Kron as the speaker while Prof. S.D. Sharma as the moderator and How to Nurture the Next Generation of Medical Physics Leaders with Dr. Kwan Hoong Ng as the speaker and Dr. Eva Bezak as the moderator.

Since the inception of AFOMP, a number of Filipino medical physicists have been recipients of the AFOMP travel grants, which helped them to attend in international conferences. These events mentioned are just few but are the milestones that clearly manifested that SMPRP and AFOMP are working together in the last 20 years. They are clear testaments that both have achieved the AFOMP's objectives. These are:

1. to promote the cooperation and communication between medical physics organizations in the region;
2. to promote medical physics and related activities in the region;
3. to promote the advancement in status and standard of practice of the medical physics profession;
4. to organize and/or sponsor international conferences, regional and other meeting of courses; and

5. to collaborate or affiliate with other scientific organizations.

Starting 2020, SMPRP is devoted to hold our annual gathering called Philippine Congress of Medical Physics (PCMP). Other milestones and developments in the medical physics community here in the Philippines can be found on earlier articles such as Medical Physics in the Republic of the Philippines by Prof. Agnette Peralta, Engr. Bayani San Juan, and Prof. Lilian Rodriguez and South East Asian Federation of Organizations for Medical Physics (SEAFOMP)- Celebrating 20th Anniversary of Formation. Both articles were published in the Medical Physics International Journal, Volume 8, No. 2, 2020 (http://mpijournal.org/pdf/2020-02/MPI-2020-02.pdf).

We, the Filipino medical physicist community, are one in your 20th anniversary celebration. We are hoping to more collaborations in promoting and strengthening the medical physics profession. Let's imprint more footprints together in our future stories. Mabuhay, AFOMP!

References

1. BJ, Thomas (2011). Education and training of medical physicists in South East Asia: accomplishments and challenges. *Biomedical Imaging and Intervention Journal.* doi: 10.2349/biij.7.3.e23
2. Chougule, A (2020). Twentieth anniversary of Asia-Oceania Federation of Organizations for Medical Physics (AFOMP)- Are we near to achievements of our goals?. *AFOMP Newsletter 12(2): 24-36.* https://efomp.org/uploads/d5a2c488-b923-4ddf-a4e1-dde38550615f/AFOMP-Newsletter-Special-Issue-June-2020.pdf
3. Peralta, A., Rodriguez, L., San Juan, B. (2020). Medical physics in the republic of the philippines. *The Journal of the International Organization for Medical Physics* 8(2): 51-54. http://mpijournal.org/pdf/2020-02/MPI-2020-02.pdf
4. Wong, JHD., Ng, KH, et.al (2020). South East Asian Federation of Organizations for Medical Physics (SEAFOMP)- Celebrating 20th Anniversary of Formation. *The Journal of the International Organization for Medical Physics* 8(2): 32-38. http://mpijournal.org/pdf/2020-02/MPI-2020-02.pdf
5. Foster, W. (2017). *Improving Medical Physics in Asia and the Pacific through Education and Training.* https://www.iaea.org/newscenter/news/improving-medical-physics-in-asia-and-the-pacific-through-education-and-training

Contacts of the corresponding author:

Author: Ramon Carlo Cruzpero
Institute: Public Relations, SMPRP
Street:
City:
Country: Philippines
Email:

SOCIETY OF MEDICAL PHYSICISTS (SINGAPORE) 1998-2020

James C. L. Lee[1,2]

[1] Division of Radiation Oncology, National Cancer Centre Singapore, Singapore
[2] President, Society of Medical Physicists (Singapore)

Abstract— **This paper presents a brief write-up of the Society of Medical Physicists (Singapore) or SMPS. It traces the motivation and progress of the SMPS from its inception till 2020.**

Keywords— **Medical Physics, Singapore, history, progress**

I. INTRODUCTION

The Society of Medical Physicists (SMPS) of Singapore was founded in 1998 with the following objectives to:

1. Foster a closer working relationship among those working in the various fields of Medical Physics.
2. Create public awareness of the Medical Physics profession in Singapore and to project and maintain the image of Medical Physics professionals.
3. Represent and promote the interests and views of members in the local Medical Physics profession at international organisations like SEAFOMP, AFOMP and IOMP.
4. Promote research, training and education in Medical Physics.

II. PROGRESS OF SMPS 1998-2020

Our membership has grown from a handful of less than 10 to 44 members today. We have diverse representations from various sub-fields, majority of whom are from Radiotherapy and the many others from Nuclear Medicine, Diagnostic Radiology, Health Physics and academia.

Singapore's healthcare sector continues to grow and advance with new technologies for diagnosis and treatment, especially for an aging population. The demand for more Medical Physicists will increase in tandem for clinical-scientific services and research.

Being a small country with limited resources, we were dependent on external academic Medical Physics programs to educate our members. Since 2011, we have also introduced Medical Physics as a minor subject within the Physics/Applied Physics programs at two of our local universities. We have since established a PhD program in Medical Physics at one university. We have also established residency programs in Radiotherapy and Nuclear Medicine as part of the clinical training and career of Medical Physicists based on the IAEA syllabus.

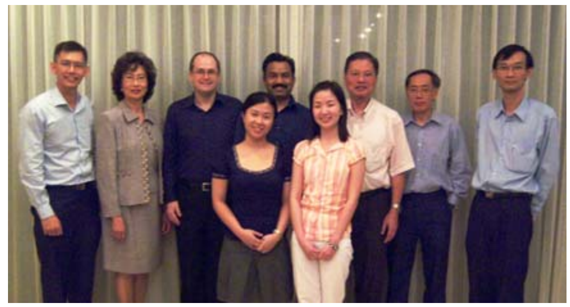


Fig.1 Some of our SMPS members a. past and b. (below) present.

Some of the key activities and contributions of SMPS recently and through the years are:

1. Local symposiums on advances in Medical Physics of up to a few times a year.
2. Promoting members to participate and support regional congresses like SEACOMP and AOCMP.
3. Representation in the SEAFOMP executive committee.
4. Represented in the committee of the Singapore Accreditation Council on establishing standards for Medical Imaging.
5. Organizing the AOCMP/SEACOMP in December 2013

Fig.2 AOCMP/SEACOMP 2013 organized by SMPS

6. Organizing the World Congress on Medical Physics and Biomedical Engineering 2021, Singapore. Due to the current Covid pandemic, the congress has been postponed to June 2022.
7. Support of local and regional meetings of related professional groups like the Singapore Society of Radiographers, Singapore Radiological Society and ESTRO meets Asia.

III. CONCLUSION

Since its inception in 1998, Singapore's Medical Physics community has grown fairly quickly especially in the last few years, with more to join the society. The increase is a result of the expanding growth of healthcare and the improving recognition of the important role of a Medical Physicist, especially in areas of Radiotherapy, Nuclear Medicine and Diagnostic Radiology. Singapore looks forward to the healthy growth and recognition of Medical Physicists in the years to come.

IV. REFERENCES

1. None

Author: James C L Lee, PhD, President of Society of Medical Physicists (Singapore), Singapore, trdjas@nccs.com.sg

MEDICAL PHYSICS DEVELOPMENTS IN ASIA – OCEANIA FEDERATION OF ORGANIZATIONS FOR MEDICAL PHYSICS (AFOMP): 2000-2020

THAILAND

A. Krisanachinda

Department of Radiology, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand

I. INTRODUCTION AND TWENTY YEARS AFOMP

Thailand is situated in the South-East Asia, with the land area of 513, 120 Sq. meters and the population of 66,413,969 in 2018. The neighbors are People's Republic of China (PROC) in the north, Lao PDR, and Cambodia in the east, Malaysia in the south and Myanmar in the west. Kingdom of Thailand was established about 800 years ago. Thailand is a founding member of Association of South East Asian Nations (ASEAN). Medical Physics was started at Division of Radiotherapy, Department of Radiology, Siriraj Hospital, Mahidol University, Bangkok in the year 1964. Medical Physics education was started in the year 1974 after the author graduated from The University of London UK and worked at School of Medical Physics, Ramathibodi Hospital, Mahidol University. Currently, there are 6 M.Sc. Programs in Medical Physics and 1 Ph.D.Program in Medical Physics in Thailand. As AFOMP was formed during the World Congress of Medical Physics in Chicago in 2000, the author was one of the founding members together with Dr.K.Y.Cheung from Hong Kong, Prof.Barry A.Allen from Australia. Dr.KY Cheung was voted as the first AFOMP President and Prof. BA Allen was Vice President, the author was the first AFOMP Treasurer. The author had also proposed to host the first AFOMP Congress in Bangkok in 2001. At the AOCMP 2018 held in Kuala Lumpur, Malaysia, the author proposed to host the AOCMP 2020 in Phuket Thailand with the popular vote pouring to Thailand. During 20 years of AFOMP, Thailand has the great opportunities to organize another 3 congresses in 2009, 2012 in Chiang Mai and 2016 in Bangkok.

II. POPULATION AND GDP OF AFOMP COUNTRIES

Population of Thai people was 69,979,988 on June 1, 2020 estimated by the UN. GDP nominal per capita estimated in 2019 was USD 7,791. Number of Thai Medical Physicist was 450 results in 6.4 medical physicists per million populations.

COUNTRY	LAND AREA sq.km	GDP NOMINAL PER CAPITA(USD)	MP (2020)	POPULATION (M)	MP PER MILLION
THAILAND	513,120	7791	450	69.9	6.4

III. .RADIATION MEDICINE IN AFOMP DIAGNOSTIC RADIOLOGY EQUIPMENT IN THAILAND

COUNTRY	CT	FLU	MAMMO	DENTAL	GENERAL	MRI
THAILAND	1505	1846	456	8226	6422	208

RADIOTHERAPY EQUIPMENT

COUNTRY	EBRT	BRACHYTHERAPY	SIMULATOR
THAILAND	123	33	99

NUCLEAR MEDICINE EQUIPMENT

COUNTRY	SPECT	SPECT/CT	PET/CT	PET/MR	CYCLOTRON
THAILAND	24	31	15	1	6

IV. MEDICAL PHYSICISTS IN THAILAND

COUNTRY	DIAGNOSTIC RADIOLOGY	RADIATION ONCOLOGY	NUCLEAR MEDICINE
THAILAND	100	295	55

PROFESSIONAL SOCIETY DEVELOPMENT

COUNTRY	YEAR ESTABLISHED	FIRST PRESIDENT	PERCENT MALE	PERCENT FEMALE
THAILAND	2001	Dr.A.Krisanachinda	41	59

V. EDUCATIONAL DEVELOPMENT

COUNTRY	UNIVERSITY	CURRICULUM	ACADEMIC PROGRAM	YEAR ESTABLISHED	GRADUATE PER YEAR
THAILAND	MAHIDOL	MEDICAL PHYSICS	M.Sc.	1972	6
	MAHIDOL	MEDICAL PHYSICS	M.Sc.	1980	4
	CHIANG MAI	MEDICAL PHYSICS	M.Sc.	2001	6
	CHULALONGKORN	MEDICAL PHYSICS	M.Sc.	2002	6
	CHULALONGKORN	MEDICAL PHYSICS	Ph.D.	2015	-
	NARESUAN	MEDICAL PHYSICS	M.Sc.	2014	4
	CHULABHON ROYAL ACADEMY	MEDICAL PHYSICS	M.Sc.	2019	9

VI. CLINICAL TRAINING COURSE

COUNTRY	HOSPITAL	CURRICULUM	YEAR	RESIDENTS	NO. OF GRADUATES
THAILAND	KCMH	ROMP	2006-2008	10	8
	Siriraj				
	Ramathibodi				
	Chiang Mai				
THAILAND	KCMH	DRMP	2008-2010	5	4
	Bumrungrad				
	KCMH	NMMP	2011-2013	12	10
	Siriraj				
	Ramathibodi				
	Chiang Mai				
	KCMH	AMPLE RT DR	2016-2018	RT 15 DR4 NM3	14
	Siriraj	AMPLE RT NM			5
	Ramathibodi	AMPLE RT DR			3
	Chiang Mai	AMPLE RT NM			
	PSU	AMPLE RT			
	Chulabhorn	AMPLE RT			
	Pinlon	AMPLE RT			
MYANMAR	Yangon GH	AMPLE NM			
THAILAND	KCMH	AMPLE RT	2018-2020	RT 14 DR5 NM3	
	Siriraj	AMPLE RT			
	Ramathibodi	AMPLE RT			
	Chiang Mai	AMPLE RT			
	PSU	AMPLE RT DR NM			
	Chulabhorn	AMPLE RT			
	Udonthani	AMPLE RT			
	Suratthani	AMPLE RT			
Myanmar	Pinlon	AMPLE RT			
LaoPDR	Mittaphap	AMPLE RT			

VII. AFOMP Conferences hosted in Thailand

COUNTRY	YEAR	2001	2009	2012	2016	2020
THAILAND	Conference Venue	BANGKOK	CHIANG MAI	CHIANG MAI	BANGKOK	PHUKET

VIII. IAEA regional projects

Thailand had participated an IAEA Regional Project RAS 6038 in Medical Physics Education and Clinical Training for Asia and Pacific region. Thailand was a pilot country trial an IAEA Training Course Series, TCS 37 on Radiation Oncology Medical Physics (ROMP) in 2006, TCS 47 Diagnostic Radiology Medical Physics (DRMP) in 2008 and TCS 50 Nuclear Medicine Medical Physics (NMMP) in 2011. In 2016, Thailand participated RAS 6077 "Strengthening the Effectiveness and Extent of Medical Physics Education and Training" and piloted Online clinical training IAEA AMPLE RT, DR and NM with 15 residents in RT- 2 residents from Myanmar shared Thai Clinical Supervisors, 5 residents in diagnostic radiology and 3 residents in nuclear medicine which one of them was a Myanmar resident working at Yangon General Hospital, sharing Thai clinical supervisor. Two year clinical training completed after the written exam arranged by local assessors, the practical and oral assessments were conducted under IAEA Expert team for RT, DR and NM. Certification was offered to success residents at the Annual Meeting of TMPS. They became a clinically qualified medical physicist. The third clinical training program for medical physicists started in August 2018 with 14 residents AMPLE RT of 13 Thai and 1 Lao PDR residents, 5 DR and 3 NM with 2 Myanmar and 1 Thai residents. Final assessment for 14 RT will be arranged in November 2020 and the certification will be offered at AOCMP SEACOMP 2020 in Phuket Thailand.

IX. CONCLUSION

Even though the education of medical physicist is strengthened by several leading universities with full resources and the clinical training has been supported by IAEA since 2005 till now, Thailand struggled on the position of medical physicist in governmental hospitals as the Ministry of Public Health requires the professional license. Thai Medical Physicist Society took the major role in processing the Medical Physicist National License since 2008. Finally in September 2020 the Minister of Public Health signed for the approval of the National License of Medical Physicist and will be announced in the Royal Gazette of Thailand. Then the structure of medical physicist position will be allowed in the MOPH and Cancer centers. The problem on the lack of medical physicists at the MOPH could be solved in the next five years. This will be one pattern of the standard of medical physics profession taken care by the Department of National License of Thailand.

X. ACKNOWLEDGEMENTS

The author would like to acknowledge Mrs.Pradub Atthakorn the first Thai Medical Physicist, Mrs. Ratana Pirabul, Ms. Jongjin Patramontri, and Mr.Surat Vivijsorn senior medical physicists who worked so hard and contributed to medical physic activities in Thailand Unfortunately, three of them passed away of cancer.

XI. REFERENCES

1. International Atomic Energy Agency. Clinical training of medical physicist specializing in radiation oncology, Training Course Series 37, IAEA Vienna 2009.

2. International Atomic Energy Agency. Clinical training of medical physicist specializing in diagnostic radiology, Training Course Series 47, IAEA Vienna 2010.

3. International Atomic Energy Agency. Clinical training of medical physicist specializing in nuclear medicine, Training Course Series 50, IAEA Vienna 2011.

IMPACT OF COVID-19 PANDEMIC ON MEDICAL PHYSICIST'S WORK IN ASIA & OCEANIA REGION

Adhikari K.P[1], Nyaichyai K.S[2]

Associate Professor Medical Physics, National Academy of Medical Sciences, Bir Hospital, Kathmandu, Nepal
Medical Physicist, National Academy of Medical Sciences, Bir Hospital, Kathmandu, Nepal

Abstract—**Medical physicists and their respective workplace across the Asia and Oceania region has been dramatic because of the impact of COVID-19. Medical Physicists are under varying levels of stress and burn out during the ongoing COVID-19 pandemic and this is adversely affecting their working conditions in clinical practices. We present a broad review to evaluate the impact of COVID-19 in their respective work and changes in work practices among the medical physics community in Asia and Oceania countries. All together 186 medical physicists from twenty-two countries in the Asia & Pacific region have participated from Asia and Pacific region which consists of Low-income countries to High-Income Countries. Irrespective of the economies of the countries the overall responses were found similar. Due to COVID-19 pandemic, it is found that the treatment of cancer patients was somehow affected in their regular treatment, the most affected part was overall treatment time and five fraction regimens. It is found that almost all responder medical physicists who work in a hospital, have continued their work despite the pandemic. A regular supply of radiopharmaceutical and source used for brachytherapy was an issue in some countries because of lockdown and closure of international flight. COVID-19 pandemic adversely affecting the working environment of the overall hospital, but it has not adversely affected the work of medical physicists in the Asia Pacific region.**

Keywords— **Asia & Oceania, COVID-19, diagnostic radiology, nuclear medicine, medical physics, radiation therapy**

I. INTRODUCTION

The spread of COVID-19 has created difficult as well as fundamental challenges for both employees and employers across the world. In medical physics world, populations of safety measures and shutdown have affected medical physicists work and turned overnight into different working practices. Given the uncertainty of the COVID-19 shock, institution and work urgently need to apply the field's current knowledge to help individual workers and institutions to manage risks by developing and applying solutions. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) or Coronavirus disease 2019 (COVID-19) was first detected in Wuhan City in December 2019 [1]. After causing significant morbidity and mortality in China, by February 2020, COVID-19 had spread to other countries [2]. As of October 11, COVID-19 has spread to 214 countries, infecting 3.6 million people and causing almost 1.5 million deaths across the world and is therefore considered a global pandemic [3,4]. The phenomenal increase in the number of COVID-19 cases has put tremendous pressures on health care systems in most countries across the world. Healthcare workers (HCWs) are amongst the high-risk group to acquire this infection [5,6]. Given the high burden, there is a growing demand and focus on protecting HCWs across the world through the provision of personal protective equipment (PPE), training and countering the psychosocial consequences [7,8]. The COVID-19 pandemic has impacted cancer care services provided by all hospitals especially so due to the restrictions imposed by the nation-wide lockdown in majority of countires aimed at impeding the spread of the contagion. Under such circumstances, the timely implementation of various administrative policies to enable the continuation of cancer care along with preparations for effectively handling this medical emergency is of paramount importance. Notably, both patient-directed and employee-directed measures that minimize the risk of contracting COVID-19 should be adopted. However, the escalating trend in the number of positive cases, social stigma and fear of family members contracting the disease adds to the psychological and social trauma which has a demoralizing effect on the mental health of the cancer care providers. These are important problems that have to be addressed and comprehended for effective medical management of the pandemic.

Medical Physics is a branch of Applied Physics, pursued by medical physicists, that uses physics principles, methods and techniques in practice and research for the prevention, diagnosis and treatment of human diseases with a specific goal of improving human health and well-being. Medical physics may further be classified into several sub-fields (specialities), including Radiation Oncology Physics, Medical Imaging Physics, Nuclear Medicine Physics, Medical Health Physics (Radiation Protection in Medicine), Non-ionizing Medical Radiation Physics, and Physiological Measurement. It is also closely linked to neighbouring sciences such as Biophysics, Biological Physics, and Health Physics [9,10]

1.1. Impacts of COVID-19 in Health Sector in Nepal

Nepal government issued a nationwide lockdown as a preventive measure from 24th March to 21st July 2020, prohibiting domestic and international travels by closing its airports and international borders. The government had also prohibited non-essential services including transportation and offices. The lockdown has ~~affected the health of individuals and~~ disrupted regular healthcare services including radiation therapy, diagnostic radiology and nuclear medicine. This pandemic crisis has significantly transformed the working environment in the medical field. Frontline health workers, including doctors, nurses, allied health workers, technologists with inadequate supplies of PPE, have provided their best healthcare services. [11]. In the Wuhan outbreak as reported, 63% of health care workers became infected, and 14.8% of cases in healthcare personnel were severe or critical [12].

1.2. Impact of COVID-19 in Radiation Therapy

The COVID-19 positive patient in a radiation therapy creates significant challenges to the physicians, nurses, staffs, radiation therapy technologists and also medical physicists who are charged with not only that patient's care but also the care and well-being of other patients and the HCW in the clinic/institute. Patients who test positive for the novel coronavirus, at a minimum, require a 14-day quarantine per CDC recommendations has created additional significant challenges in treatment interruptions, planning and patient QA.

II. OBJECTIVE

The study aimed to understand the effects of the pandemic on medical physicist's perceptions and performance during a pandemic and the lockdown. It was also conducted to determine if statistically significant differences are still present between the perceptions before and during the pandemic.

III. MATERIALS AND METHODS

After the Nepal Health Research Council (NHRC) ethic board permission for the survey, data were collected from 2nd September to 15th October 2020. Eligibility criteria were selected only for medical physicists working in Asia and Oceania region countries.

3.1. Study participants and Sampling

We conducted a cross-sectional study using an online questionnaire, among medical physicists in Asia & Pacific (APAC) region in accord with the checklist for reporting results of internet surveys [13]. The study targeted specifically clinical medical physicists working on their different capacities in their respective institutes. The research questionnaire was distributed to medical physicist of the APAC countries through the Asia-Oceania Federation of Organizations for Medical Physics (AFOMP) network and also through personal contact. Google form was created for questionnaire and responses were recorded for analysis. Before participation, informed consent was obtained from all responders. Participants were requested to fill the questionnaires assuring confidentiality of the provided information. Word document was used for those who do not have access to Google forms. For literature search strategies, we have done an online search on health and workplace impact due to COVID-19, PubMed or other medical literature and google scholar for relevant articles from June to August 2020.

3.2 Data Sources and processing

The online questionnaire included a total of 49 questions including sub-questions on socio-demographic characteristics, medical physicists' perception on COVID-19, and perception toward corresponding institute response and preparedness to COVID-19. The responses were to be selected from binary variables of "Yes" and "No", scaled 1 and 0 for analysis, and 4-tier scales of "Very much", "Quite a bit", "A little", and "Not at all", scaled 1 to 4 respectively. Before conducting the survey, we have conducted pretest of the questionnaire to the medical physicists of Nepal to assess the reliability of the questionnaire items. The analysis revealed an overall Cronbach's alpha score of 0.803, indicating higher internal consistency [14].

IV. RESULTS

A total of 203 medical physicists working in different capacities from twenty-two countries responded to the questionnaire from Asia and the Pacific region. During data processing, out of 203, only 186 responds were accepted. Eighteen responses were discarded citing the duplicacy and blank responses during the final evaluation process. It was seen that almost 81% of the study participants were radiation oncology medical physicist followed by around 11% diagnostic radiology medical physicist around 7% Nuclear medicine medical physicist and rest were academics, specialists etc. Country wise responses are shown in figure 1 which is denoted by a numerical number.

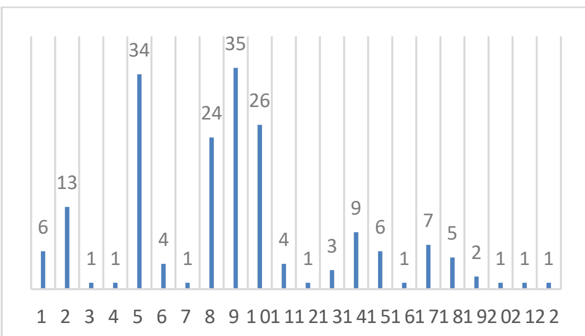


Fig: 1 Country wise responses

4.1. Socio-demographic characteristics

A total of 186 medical physicists working in different capacities from twenty-two countries out of forty-eight in the Asia Pacific (APAC) region [15] participated in the study as shown in Figure 1. The majority responses 143 (76.88 %) were male and 43 (23.12%) were female. Highest responses were from a HIC with 18.9% of the total responses followed consecutively by LICs and LMICs. Maximum of the respondents, 42.7%, were in the age group of 30-40 years. Work experiences of the respondents were mostly less than 5 years, between 5-10 years (27.4%). Almost half, around 48.9% of the respondents working as a medical physicist had completed Post Graduate studies followed by PhD scholars around 38.2%. Most of the respondents reside quite near to hospital having to travel between 5 km (n= 71, 38.2%) and 6-10 km (n = 41, 22.0%) of the hospital. A maximum number of respondents around 71.0% use their vehicle, 20.4% use public transportation and 8.6% use hospital vehicles for travel to their respective institutes. The demographic profile is shown in Figure 2.

Demographic Profile		N=186	
		N	%
Gender	Male	143	76.88
	Female	43	23.12
Marital Status	Single	59	31.72
	Married	127	68.28
Occupation	ROMP	157	84.41
	DOMP	13	6.99
	NMMP	7	3.76
	Others	9	4.84
History of smoking or tobacco use	No	141	75.81
	Yes	45	24.19
Experience (years)	<5	61	32.8
	5-10	51	27.4
	>11	74	9.8
Education	Graduate	24	12.9
	Post Graduate	91	48.9
	PhD	71	38.2

Figure 2: Demographic Profile

More than half of the respondents (52.2%) reported that they do not have any elderly people in their residence. Regardless of this, 40.3% of the respondents were "very much" worried about their family members getting COVID-19 infection while a maximum number of family member above the age of 60 years residing together with them was eight.

Regarding self-evaluation of overall health condition, 60.2% of the respondents considered themselves to have a "Good" overall health condition, similarly, 25.8% consider themselves to have an "Excellent" condition but one paticipant reported to have a poor health condition and still working in active duty. Most of the respondents (76.8%) after considering the missing responses had no serious medical histories that the COVID-19 infection could make more severe.

The main source of information was from the internet (83.6%), television (88%) and socialmedia (50.8%). Most of the responding medical physicists (75.8%) have continued their work in the hospital despite the pandemic while the rest had the pleasure of special leave due to the perceived high risk of contracting COVID-19. As the work of medical physicists, do not include frequent contact or interaction with the cancer patient, our study also found that 50% of the respondents “rarely” interact/contact with a cancer patient. Only 29% of the respondents (n= 54) tested for COVID-19 of which six were hospitalized with COVID-19 infection. 10.8% of the respondents (n=20) had the close contact with confirmed COVID-19 positive cases during work while 17.7% of the respondents were quarantined and 6 respondents, 3.2% of the respondents were hospitalized for COVID-19. Majority of the respondents reported to have changed their lifestyle because of COVID-19 in their habits like washing hand regularly (93.5%), cough etiquettes (81.7%), social distancing and avoiding unnecessary visits (97.3%), wearing the mask (97.8%), workplace sanitizing (85%), avoid leaving personal belongings to the workplace (67.6%), sanitizing accessories (74.9%) and using appropriate PPE (70.3%) as shown in figure 3.

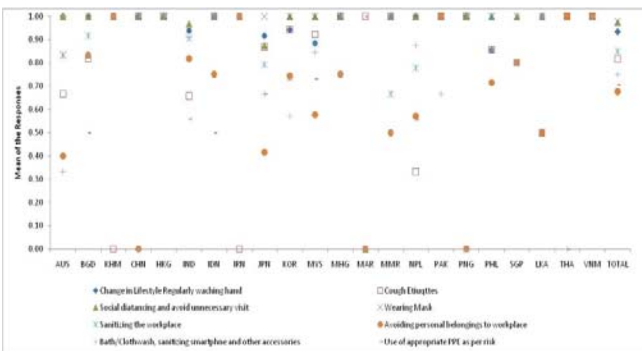


Figure 3: Mean responses to the change in lifestyle and etiquettes because of COVID-19 pandemic.

Regarding personal concern on the likelihood of contracting COVID-19 during the outbreak, 8.7% responded to not have any concern showing that 91.3% of the respondents were concerned at least a little. Accordingly, 93.5% responded that they are worried about their family members getting COVID-19 infection.

Half of the respondents (n=94, 50.5%) were involved in academic activities like teaching and training the graduates or the trainees. 79.8% of the academically involved respondents (n=75) had the option to work remotely. 54.8% of the respondents agreed that the COVID-19 pandemic has affected the residency/training program in their hospital.
The medical physicists who were also active in the academic field and have an option to work remotely put out three major problems during their remote work as problems with internet connectivity, harder communication with co-workers, and harder to keep a regular schedule. Correlations for the dependent variables were established with the predictor (constant) variables of country.

4.2. Effect on the working environment of medical physicist due to COVID-19 Pandemic:

Half of the respondents (51.1%) were satisfied with their institution preparedness for a safe working environment while 10.3% responded that they were not satisfied with institutional preparedness for a safe working environment. Regarding new patient planning, around 21.1% responded “Very Much”, 24.3% responded “Quite a bit”, 25.4% “A little” while 19.5% felt that there was no effect at all due to the COVID-19 pandemic. The mean score was 2.48 (95% CI 2.31-2.64). No significant differences were observed among the responses from different countries. Pearson correlation value was -0.003 with the approximate significance of 0.965 which is quite less. ANOVA test shows an F value of 1.226 with a significance value of 0.238 which is greater than 0.05 hence responses were statistically not significantly different with different countries. Also, a test of homogeneity of variances has a significance value of 0.376 (>0.05) which shows the variance within countries is statistically not different from each other. Eta squared value is 0.150 that means 15.0% of the variability in response in Effect on new treatment planning is accounted for by country. As shown in Figure 4.

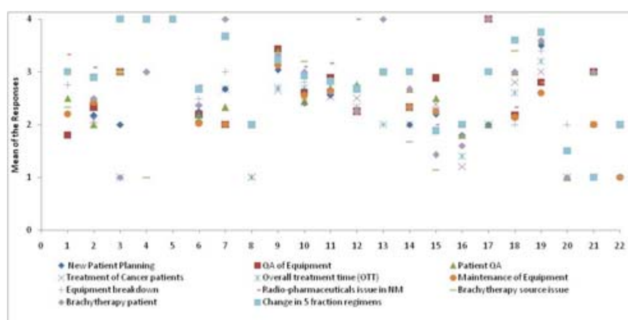


Figure 4: Mean responses of effects on the working environment differentiated according to countries

4.3. Effect on QA Equipment

30.2% of the respondents reported that the pandemic has affected QA of Equipment as “Quite a bit” while 19.8% felt the pandemic has “Very much” affected. Another 30.2% responded that it has not affected at all and the remaining 19.8% felt it has affected “A little”. Pearson correlation was found to be -0.057. ANOVA test shows an F value of 1.807

with a significance value of 0.022 which is less than 0.05 hence responses were statistically significantly different with different countries. Test of homogeneity of variances has a significance value of 0.000 (>0.05) which shows the variance within the group is statistically not different from each other. Eta squared value is 0.201 that means 20.1% of the variability in response in Effect in QA of Equipment is accounted for by country. As shown in Figure 4.

4.4. Patient QA

21.6% responded "Very Much", 25.7% "Quite a bit", 24.6% "A little" and 28.1% "Not at all". The Mean value for the score of effect on Patient QA was 2.59 with 95% CI 2.42-2.76. Pearson correlation of the Effect of Patient QA with Country is 0.093 and significance with the country is 0.104. ANOVA test shows an F value of 2.023 with a significance value of 0.008 which is less than 0.05, hence responses were statistically significantly different with different countries. Test of homogeneity of variances has a significance value of 0.101 (>0.05) which shows the variance within different countries is statistically not different from each other. Eta squared value is 0.221 that means 22.1% of the variability in response in Effect in Patient QA is accounted for by country. As shown in Figure 4.

4.5. Treatment of Cancer Patient

23.7% responded "Very Much", 30.2% "Quite a bit", 29.6% "A little" and 16.6% "Not at all".
The mean value for the score of effect on the treatment of cancer patient was 2.39 with 95% CI 2.23-2.55. ANOVA test shows an F value of 1.403 with a significance value of 0.126 which is greater than 0.05, hence responses were statistically not significantly different with different countries. However, the test of homogeneity of variances has a significance value of 0.009 (<0.05) which shows the variance within countries is statistically different from each other. Eta squared value is 0.166 that means 16.6% of the variability in response in Treatment of Cancer patientsaccounted for by country. As shown in Figure 4.

4.6. Overall Treatment Time (OTT)

19.0% responded "Very Much", 33.9% "Quite a bit", 28.0% "A little" and 19.0% "Not at all". The mean value for the score of effect on overall treatment time was 2.47 with 95% CI 2.32-2.62. Pearson correlation of the Effect on overall treatment time with Country is -0.031 and significance with the country is 0.340. ANOVA test shows an F value of 1.523 with a significance value of 0.078 which is greater than 0.05 hence responses were statistically not significantly different with different countries. Test of homogeneity of variances has a significance value of 0.036 (<0.05) which shows the variance within countries is statistically different from each other. Eta squared value is 0.179 that means 17.9% of the variability in response in Treatment of Cancer patients accounted for by country. As shown in Figure 4.

4.7. Maintenance of Equipment

21.4% responded "Very Much", 32.4% "Quite a bit", 24.9% "A little" and 21.4% "Not at all". The mean value for the score of effect on Maintenance of Equipment was 2.46 with 95% CI 2.30-2.62. Pearson correlation of the effect on Maintenance of equipment with the country is -0.024 and significance with the country is 0.371. ANOVA test shows an F value of 1.513 with a significance value of 0.081 which is greater than 0.05 hence responses were statistically not significantly different with different countries. Test of homogeneity of variances has a significance value of 0.052 (>0.05) which shows the variance within countries is notstatistically different from each other.Eta squared value is 0.173 that means 17.3% of the variability in response in Effect on Maintenance of equipment is accounted for by country. As shown in Figure 4.

4.8. Effect on when Equipment breaks down

12.9% responded "Very Much", 30.4% "Quite a bit", 30.4% "A little" and 26.3% "Not at all". The mean value for the score of effect on when equipment breaks down was 2.70 with CI 2.55-2.85. Pearson correlation of the Effect on when Equipment breaks down with Country is -0.116 and significance (1-tailed) with the country is 0.057. ANOVA test shows F value of 1.693 with a significance value of 0.037 which is less than 0.05 hence significant. Test of homogeneity of variances has significance value of 0.099 (>0.05) which shows the variance within countries is notstatistically different from each other. Eta squared value is 0.192 that means 19.2% of the variability in response in effect on when equipment breaks down is accounted for by country. As shown in Figure 4.

4.9. Radiopharmaceutical Issues in Nuclear Medicine

10.6% responded "Very Much", 23.2% "Quite a bit", 28.9% "A little" and 37.3% "Not at all". The mean value for the score of Radiopharmaceutical Issues in Nuclear Medicine was 2.93 with 95% CI 2.76-3.10. Pearson correlation of the

Radiopharmaceutical Issues in Nuclear Medicine with Country is -0.205 significance (1-tailed) with the country is 0.003. ANOVA test shows an F value of 2.319 with a significance value of 0.003 which is less than 0.05 hence responses were statistically significantly different with different countries. Test of homogeneity of variances has a significance value of 0.004 (<0.05) which shows the variance within countries is statistically different from each other. Eta squared value is 0.275 that means 27.5% of the variability in response in effect on radiopharmaceutical issues in Nuclear Medicine is accounted for by country. As shown in Figure 4.

4.10. Brachytherapy source issues

20.0% responded “Very Much”, 18.1% “Quite a bit”, 25.8% “A little” and **36.1%** “Not at all”. The mean value for the score of Brachytherapy source issues was 2.78 with CI 2.60-2.96. Pearson correlation of the Brachytherapy source issues with Country is -0.060 and significance with the country is 0.208. ANOVA test shows an F value of 3.242 with a significance value of 0.000 which is less than 0.05 hence responses were statistically significantly different with different countries. Test of homogeneity of variances has a significance value of 0.007 (<0.05) which shows the variance within countries is statistically different from each other. Eta squared value is 0.337 that means 33.7% of the variability in response in effect on brachytherapy source issue is accounted for by country. As shown in Figure 4.

4.11. Effects on Brachytherapy patient

19.0% responded “Very Much”, 22.8% “Quite a bit”, 23.4% “A little” and 34.8% “Not at all”. The mean value for the score of Effects on Brachytherapy patients was 2.74 with CI 2.56-2.92. Pearson correlation of the Effects on Brachytherapy patients with Country is -0.040 and significance with the country is 0.294. ANOVA test shows an F value of 2.533 with a significance value of 0.001 which is less than 0.05 hence responses were statistically significantly different with different countries. Test of homogeneity of variances has a significance value of 0.006 (<0.05) which shows the variance within countries is statistically different from each other. Eta squared value is 0.280 that means 28.0% of the variability in response in effect on brachytherapy patient is accounted for by country.As shown in Figure 4.

4.12.Effects on 5 fraction regimen

11.0% responded “Very Much”, 27.1% “Quite a bit”, 28.4% “A little” and 33.5% “Not at all”. The mean value for the score of Effects on 5 fraction regimen was 2.85 with CI 2.68-3.01. Pearson correlation of the Effects on 5 fraction regimen with Country is -0.095 and significance with the country is 0.100. ANOVA test shows an F value of 1.885 with a significance value of 0.017 which is less than 0.05 hence responses were statistically significantly different with different countries. Test of homogeneity of variances has a significance value of 0.013 (<0.05) which shows the variance within countries is statistically different from each other. Eta squared value is 0.228 that means2 2.8% of the variability in response in Effect on Brachytherapy patient is accounted for by country.As shown in Figure 4

Twenty-three responders had provided comments and additional information regarding COVID-19, which on were very positive and encouraging.

V. Discussion

The COVID-19 pandemic has drastically transformed the day to day life of every individual. The most affected area was among the health sector, its staffs and their working environment. Increased risk of exposure to the COVID-19 with the addition of precautionary measures during work potentially exacerbates the fear, anxiety and distress among medical physicists. Immune-suppressive state in cancer patients poses themselves an increased risk of COVID-19, which results inthe threat of exposure to the health workers in radiation therapy.

All together 186 medical physicists from twenty-two countries in the Asia & Pacific region have participated in this study. Asia and the Pacific region consists of Low-income countries (LIC) to High-Income Countries (HIC) and the responses received in this study, medical physicists from HIC which made out 38.1% of the responses. Irrespective of the economies of the countries the overall responses were found similar.

It’s well-known fact that most number of medical physicists is working in radiation oncology hence most of the respondents are working in radiation oncology followed by diagnostic radiology and nuclear medicine.

Highest respondents, almost 85%, falls in young to middle age group and with a post-graduate and PhD degree in the field of medical physicists inferring that most of the medical physicists are well qualified and have good experience in their respective field. It is also found that most of the physicists are residing very near to their respective institute and use their mode of transportation.

More than half of the respondents mentioned that they are living without an elderly family member which means they are staying in a nucleus family. Those who have elderly family members are worried about their family members getting COVID-19 infection. Irrespective of them residing with or without an elderly family, the respondents were equally worried about their family members contracting COVID-19.

Regarding self-evaluation of overall health condition, it is noticed that most of the respondents have a good health condition without any serious medical historiesthat the COVID-19 infection could make more severe. Some respondents indicated to have hypertension and diabetes,and few haveindicated to have thyroid and bronchial asthma.

It is found that almost all responding medical physicists who work in a hospital, have continued their work in the hospital despite the pandemic but some radiation therapy departments were closed for a few days during the lockdown. After a few days, they had started again with adequate safety measures to treat the growing number of cancer patients. While some had the pleasure of special leave due to the perceived high risk of contracting COVID-19.

As the work of medical physicists, do not include frequent contact or interaction with the cancer patient, our study also found that half of the respondents have rare interaction/contact with a cancer patient. That is why it is also noticed that most of the medical physicists were not given special leave because of the perceived high risk of contracting COVID-19.

Regarding COVID-19 contact history, only some of the respondents tested for COVID-19 of which few were quarantined and few were hospitalized with COVID-19 infection. It is found that COVID-19 has highly impacted a change of lifestyle of the majority of the respondents. Day to day lifestyle has been changed because of COVID-19 with regularly washing hand, cough etiquettes, social distancing and unnecessarily using and bringing personal belongings to the workplace.

Questionnaire regarding institutional preparedness to provide secure and safe working environment during COVID-19 outbreak, responses were almost the same for both satisfied and not satisfied. Most of the positive responses from HIC and MIC countries and those who were not satisfied are formed LMIC and LICs.

Around half of the respondents were also involved in academic activities and only academically involved respondents had the option to work remotely. It is found that working from home is still a challenge in LIC. More than half of the respondents mentioned that the COVID-19 pandemic has affected academic activities, training and residency program. Those who are active in the academic field and have an option to work remotely, have raised internet connectivity, difficulty in communication with co-workers, and keeping the regular schedule as the major problems they facedduring their remote work. But it is found that of COVID-19 pandemic has increased the e-learning platform in those institutions having academic program [16].

Due to COVID-19 pandemic, it is found that the treatment of cancer patients was somehow affected in their regular treatment; the most affected part was overall treatment timeand five fraction regimens. The study has found that COVID-19 pandemic had affected in new patient planning and brachytherapy treatment in radiation therapy. The study found that the impact of COVID-19 was less in QA of equipment and was not much affected while patient QA has been affected a bit during the pandemic. It is found that equipment breakdown and maintenance of the equipment has some issues in LIC countries but it has not an issue in HIC or MIC. A regular supply of radiopharmaceutical and source used for brachytherapy was an issue in some countries because of lockdown and closure of international flights. It is also found that in some HIC there is no effect in radiation therapy, diagnostic radiology and nuclear medicine. All the above-mentioned issues have not affected them.

VI. Conclusion

This study has provided a situational analysis of the state of medical physicist due to the impact of the COVID-19 in their routine work. It has analyzed the impacts the pandemic has had on medical physicists work in the field of radiation oncology, diagnostic radiology and nuclear medicine. All together 186 medical physicists from twenty-two countries in the Asia &Pacific region have participated from Asia and Pacific region consists of Low-income countries (LIC) to High-Income Countries (HIC). Irrespective of the economies of the countries the overall responses were found similar. Due to COVID-19 pandemic, it is found that the treatment of cancer patients was somehow affected in their regular treatment, the most affected part was overall treatment time and five fraction regimens. It is found that almost all responding medical physicists who work in a hospital, have continued their work in the hospital despite the pandemic. A regular supply of radiopharmaceutical and source used for brachytherapy was an issue in some countries because of lockdown and closure of international flights. COVID-19 pandemic adversely affecting the working environment of the overall hospital, but it has not adversely affected the work of medical physicists in the Asia Pacific Region.

VII. Acknowledgement

The authors acknowledge the support of all the medical physicists working in Asia and the Oceania region and the Asia-Oceania Federation of Organizations for Medical Physics (AFOMP) through which this work was produced.

VIII. Funding

The authors received no financial support for the research and publication of this article.

IX. References

1.https://www.who.int/news-room/detail/29-06-2020-covidtimeline, accessed on 11th September, 2020.
2.Rothan HA, Byrareddy SN. The epidemiology and pathogenesis of coronavirus disease (COVID-19) outbreak. Journal of Autoimmun. Academic Press; 2020. p. 102433.
3.Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. Lancet Infect Dis. 2020.https://doi.org/10.1016/ S1473-3099(20)30120-1.
4. Situation update worldwide, as of 12th September 2020. https://qap.ecdc.europa.eu/public/extensions/COVID-19/COVID-19-mobile.html#global-overview-tab
5. Cavallo JJ, Donoho DA, Forman HP. Hospital capacity and operations in the coronavirus disease 2019 (COVID-19) pandemic—planning for the nth patient. JAMA Health Forum. 2020;1(3):e200345.
6. Chen Q, Liang M, Li Y, Guo J, Fei D, Wang L, et al. Mental health care for medical staff in China during the COVID-19 outbreak. Lancet Psychiatry. 2020;7(4):e15–6.
7. Wang X, Zhang X, He J. Challenges to the system of reserve medical supplies for public health emergencies: reflections on the outbreak of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) epidemic in China. Biosci Trends. 2020;14(1):3–8.
8. Cavallo JJ, Donoho DA, Forman HP. Hospital capacity and operations in the coronavirus disease 2019 (COVID-19) pandemic—planning for the nth patient. JAMA Health Forum. 2020;1(3):e200345.
9.IOMP Policy Statement No. 1, The Medical Physicist: Role and Responsibilities https://www.iomp.org/medical-physics/ accessed on 24th October, 2020.
10. INTERNATIONAL ATOMIC ENERGY AGENCY (2013) Roles and Responsibilities, and Education and Training Requirements for Clinically Qualified Medical Physicists, IAEA Human Health Series No. 25. IAEA, Vienna
11. Sharma K, Banstola A., Parajul R.R., Assessment of COVID-19 Pandemic in Nepal: A Lockdown Scenario Analysis
12. Wu Z, McGoogan JM. Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72 314 Cases From the Chinese Center for Disease Control and Prevention. JAMA. 2020.
13. Eysenbach G. Improving the quality of Web surveys: the Checklist for Reporting Results of Internet E-Surveys (CHERRIES). J Med Internet Res. 2004 Sep 29;6(3):e34.
14. George, D., &Mallery, P. (2003). SPSS for Windows step by step: A simple guide and reference. 11.0 update (4th ed.). Boston: Allyn & Bacon.
15.https://blogs.worldbank.org/opendata/new-country-classifications-income-level-2019-2020 accessed on 13th November, 2020.
16. Che Ahmad Azlan et al. Teaching and learning of postgraduate medical physics using Internet-based e-learning during the COVID-19 pandemic – A case study from Malaysia. Physica Med 2020;80:10-16

Contacts of Corresponding author

Author: Kanchan P. Adhikari, PhD
Institute: National Academy of Medical Sciences, Bir Hospital.
Street: Mahabouddha, Ratnapark
City: Kathmandu
Country: Nepal
Email: kanchanadhikari@gmail.com

EDUCATIONAL TOPICS

EMERGENCY REMOTE TEACHING DURING THE COVID-19 OUTBREAK – THE EXPERIENCE OF THE ICTP AND UNIVERSITY OF TRIESTE MASTER PROGRAMME IN MEDICAL PHYSICS

S. Renato Padovani[1], Slavik Tabakov[2], Vassilka Tabakova[2],Renata Longo[3]
[1]*ICTP, Italy,* [2]*King's College, London UK,* [3]*Trieste University, Italy*

Abstract— **The paper describes the ad-hoc use of e-learning at the Master programme of ICTP and the University of Trieste – an emergency response of the Covid-19 pandemic. The paper shows results from a questionnaire with students from 21 countries and draws conclusions that this experience has been effective and useful and has saved the programme delivery, but e-learning should be blended with classical one**

Keywords— **eLearning, LMS, VLE, Emergency Remote Teaching, Covid-19, pandemic, Medical Physics education**

I. INTRODUCTION

The COVID-19 pandemic in spring 2020 required the immediate suspension of educational activities in presence at ICTP and University of Trieste for a period of 4 months. Many papers have been recently published analysing the effectiveness of the online educational methods adopted during the pandemic for single institutions (1) up to national scale (2) and for different school levels.

The event has required an immediate switch from in-presence class to e-learning - online distance learning (ODL) of courses, tutorials and exams of the first academic year of the Advanced Master (Post-master) in medical physics (MMP), a joint ICTP and Trieste University 2-year post-graduate programme (3,4).

Because the change of the educational method was not planned, this experience can be better identified as Emergency Remote Teaching (ERT) (5). Teachers had to immediately convert their educational method and material for the ODL using the Zoom platform for teaching and the ICTP Learning Management System (LMS), a Moodle platform, as the repository for the education material, exercises, assignments, and for the online exams.

After this experience with e-learning, a survey has been conducted on the 25 Master's students to understand acceptance, views and to get recommendations. In order to try to assess the effectiveness of the ERT experience, a comparison of the marks on the courses affected by the ODL with the marks received, by other MMP students of the past years is made.

This paper is reporting the results of the survey on the students and the comparison of the marks.

II. MATERIALS AND METHOD

A Google form has been developed for the 25 MMP students of the first academic year that began in January 2020 (the annual programme is delivered in 3 trimesters). From these, 23 students (92%) submitted answers on the Goggle form. These 23 students were from 21 Low-and-Middle Income (LMI) countries. None of them had previous experience with ODL using LMS.

From March to June 2020, courses and exams were delivered using Zoom and the ICTP LMS, based on a Moodle platform, in a form of emergency remote teaching. Existing teaching material with minor changes, due to the restricted time, was used. In particular, the 10 courses/modules of the first term January-April 2020 were delivered online for half of the lectures and with online exams, while the 11 courses of the second term April-July had online lectures and in-presence exams.

The questionnaire, aiming to explore the acceptance and the effectiveness of the ERT, was designed to include questions on the online accessing mode, the teaching methodology and material, the online exams, the ICTP learning management system (LMS) and on the overall ERT experience, asking also for comments and advices. Table 1 reports the questions, included in the Google form together with multiple choice or graded possible answers.

Table 1. The online questionnaire addressed to the Master of advanced studies in medical physics students.

Question	Answers
On the mode of accessing to ODL	
On the equipment of accessing to ODL	Mobile phone, tablet, laptop, desktop
On the quality of internet connection	Poor, sufficient, good, excellent
Rate the equipment and facilities to participate to online lectures	1 – insufficient to 5 - excellent
Rate the guidelines provided to follow online lectures and LMS (Learning Management System) platform (Moodle)	1 – insufficient to 5 - excellent
The teaching material	
Rate the quality of the online teaching	1 –

material (lectures)	Insufficient, to 5 - Excellent
Give a franc evaluation of the lecture material. For which course the material was insufficient, not appropriate for an online lecturing, not sufficient for the study of the topic. Give recommendations	(open text)
On the quality of the online exercises (exercises on Moodle)	1 – Insufficient, to 5 - Excellent
Give a franc evaluation of the exercise material. For which course was not sufficient/useful for the study. Give recommendations	(open text)
The online exams	
Give your evaluation of the online exam method taken via Moodle or Zoom for the assessment of your knowledge - Multiple choice question (MCS) - Numerical exercise - Assay question - Oral	Easy, Optimal, Acceptable, Difficult
Weakness of the online exam methodology	(open text)
Recommendations for online exams	(open text)
The ICTP LMS (Moodle platform)	
The Learning Management System (LMS): ICTP Moodle platform. - The LMS is fundamental for ODL - [The LMS is containing all the necessary material to study and prepare the exam - The LMS was always used by teachers - The LMS was used to address questions to teachers - The present content of the LMS can be proposed in the future by ICTP for distance learning - The LMS should contain video registration of all lectures - The LMS should contain video registration of some important topic - The LMS together with online lectures allow to reach the same educational efficacy of conventional (in presence) lecturing	1 - Strongly disagree, 2 - Disagree, 3 - Neither agree or disagree, 4 - Agree, 5 - Strongly agree
Do you think that you have gained experience with the ODL, which you could use in your own country?	Yes, No, Maybe
Give recommendations to improve the LMS	(open text)
Give a franc evaluation of the experience with the LMS	(open text)
The ODL experience	
Your evaluation of the ODL experience. : - It was possible and easy to submit questions to lecturers - Personal attention of lecturers was useful to overcome communication difficulties - The interaction with other students was sufficient - Online lectures are effective than traditional - Frustration and lack of interest due to the lockdown situation - Was an occasion to gain a new experience of learning method - Online lectures can be a better accepted method for learning in normal conditions - A pre-recorded video would improve learning effectiveness giving more flexibility - Online lectures should shorter and a lot of short breaks are necessary	1 - Strongly disagree, 2 - Disagree, 3 - Neither agree or disagree, 4 - Agree, 5 - Strongly agree
On the environment: - Home environment is suitable for participation to online lectures - Home distractions is affecting the effectiveness of online lectures - Higher motivation is required to follow online lectures - After the lectures it was easy to discuss the lecture topic with other students	1 - Strongly disagree, 2 - Disagree, 3 - Neither agree or disagree, 4 - Agree, 5 - Strongly agree
Any comment, suggestions and recommendations	(open text)
After the lockdown experience, any comment and recommendations for the improvement of the online distance learning efficacy	(open text)

Apart from the information from the Questionnaire, one of the indicators for the effectiveness of the ODL teaching was the comparison of the mean marks of the exams of this group of students with the mean marks of the same courses delivered by the same teachers in the past 4 cycles, from 2016 to 2019.

III. RESULTS AND DISCUSSION

The first group of questions are related to the technology and environment supporting the online learning. In some cases internet connection and personal equipment was rated as insufficient to a remote activity as expected (figure 1).

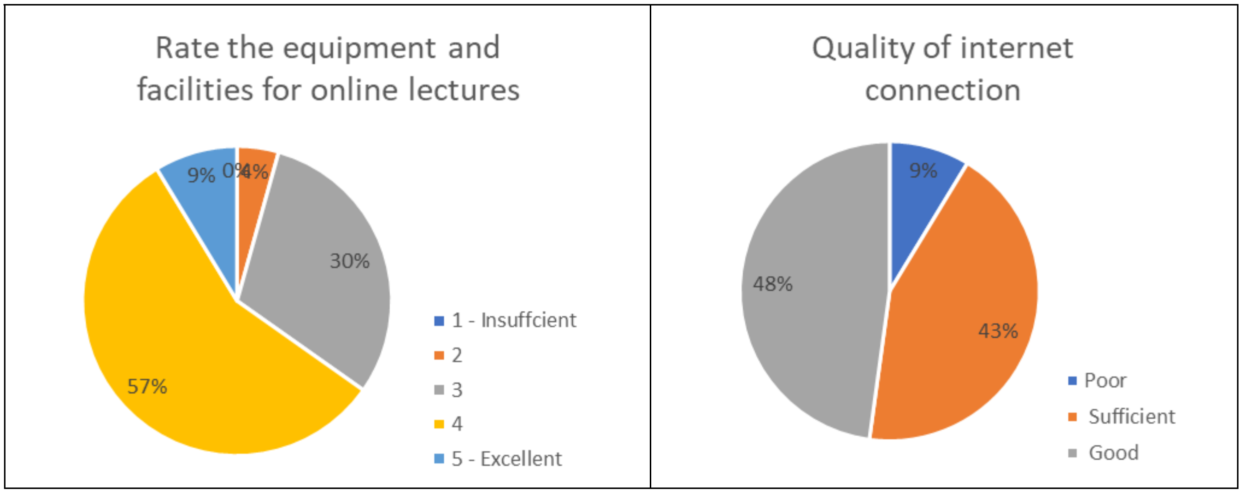


Fig. 1. Equipment, facilities and internet connection qualities as rates by the MMP students.

Students were following remote teaching at home, usually shared flats where students where working at the same time. Distractions, motivation and limited students and teacher interactions are frequently rated as limiting factors for an optimal ODL experience while home environment is frequently considered a favourable condition (figure 2).

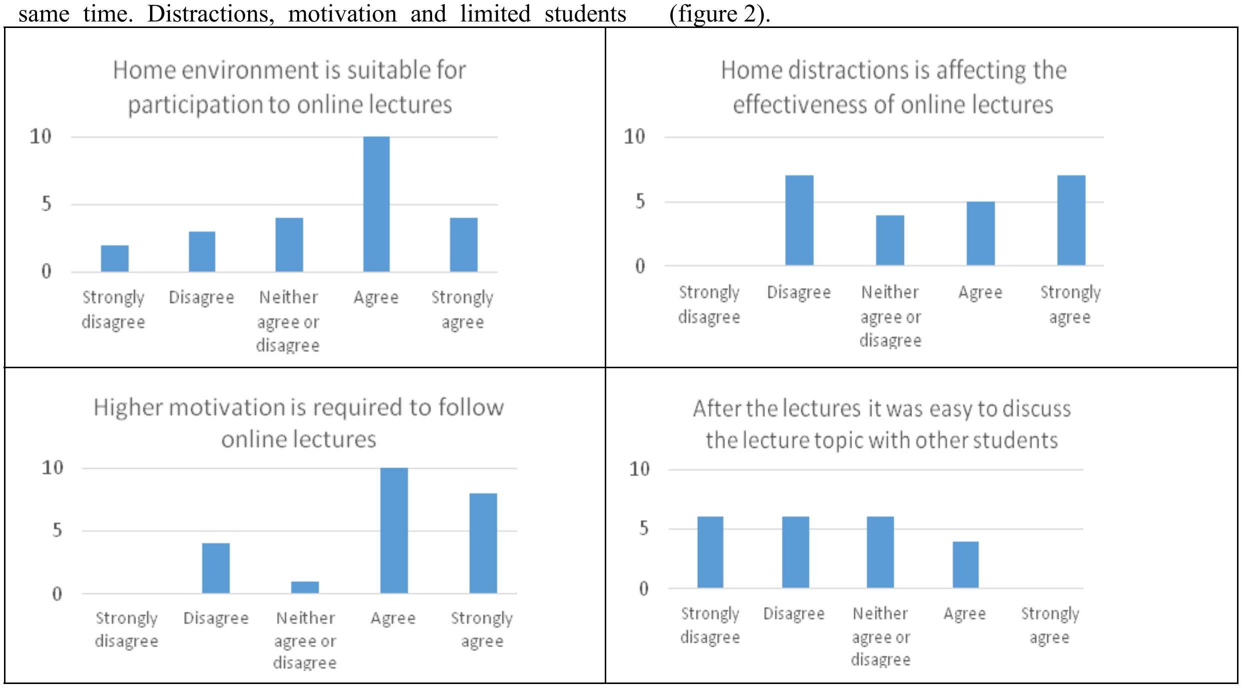


Fig. 2. Home environment and distractions, motivation and limited interactions are frequently limiting factors for an optimal ODL experience.

Teaching material on the LMS (ICTP Moodle), developed for the 26 course of the first year and for the clinical training of the second year of the programme, consists of slides for the online lectures, with voice over only for a module, exercises in form of multiple choice questions (MCQ), essay and numerical exercises, sometimes for each lecture topic, assignments in the form of short lecture to prepare and deliver online. This last activity is requested only for extensive courses. Educational material, in fact, has not been changed from the material delivered in conventional lecturing to the immediate shift to online lecturing. Each course material is complemented with additional teaching materials delivered to the students:

literature in form of book chapters, guidelines, exercises from the past exams. Students have assessed the teaching materials and exercises as Good (4), even when these materials have not been designed specifically for ODL but they are coming from several years of experience and updates based on the feedback from the previous alumni (Figure 3).

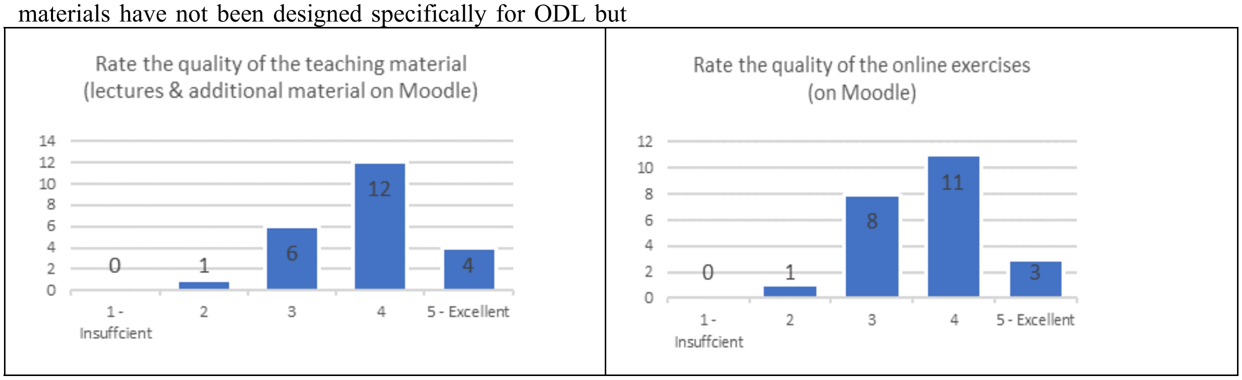


Fig.3. Overall quality of teaching material.

In some cases students have used communication services provided by our website LMS like the chat, newsroom, etc.

Students have also provided individual comments on the lecture material, summarised in Table 2 below, where limitations on ODL are expressed mainly for practical topics, like measurements, QC tasks.

Table 2. Specific comments from students

- Lecture material was perfect but prefer to learn in person when the subject is new - I wish to have lecture recorded, especially for measurements or other practical tasks - Sometimes the teacher needed to explain additional things on a whiteboard - It was not sufficient for some of the courses requiring practicals, where only procedures were discussed. - Some courses are hands on tasks, so through online the students had no any chance to see, observe as well as perform the activities - I did chat meeting, like questions and discussions, with some classmates that was helpful.

The examinations with LMS were specifically discussed with the Faculty of the programme. There were concerns related to the supervision during the exam and the possibility students to exchange information via smartphones or other means. The request to have web camera and microphone ON all the time during the exam could help, but would not be able to solve in principle the problem of students' supervision. The online written exams (paper exams) have been adopted due to the constraints of the period, but probably it would be more appropriate to have individual online oral exams - a methodology which was used by two of the teachers. The online exams have used some of the Moodle quiz types: multiple choice questions (MCS) with 3-5 answers provided in random order; numerical questions that allow a numerical response with units that is graded by comparing against various answers with tolerances; calculative questions that are like numerical questions but with the constants used selected randomly from a set when the quiz is taken; and, essay questions. In many exams, questions have been submitted in a random order to each student and also in sequential order, the last impeding to the student to go back to check or correct previous submitted answers.

Students have evaluated the type of questions included in the different exams, e.g. online written or online oral exam. In general, all type of modes are considered acceptable, with a larger preference for the MCQs and the oral form (figure 4). Many students complained for the short time allowed, typically 1-2 minutes for MCQ and 5-10 minutes for essay and numerical tests, for the randomly proved questions that are not following a typical flow of the questions following course and topics development. Again, students complained that in some exams there was a sequential delivery of the random questions without giving the opportunity to review the answers or to have an overview of all exam that allows to identifying easy and difficult questions. Some students recommend using more assignments during the course.

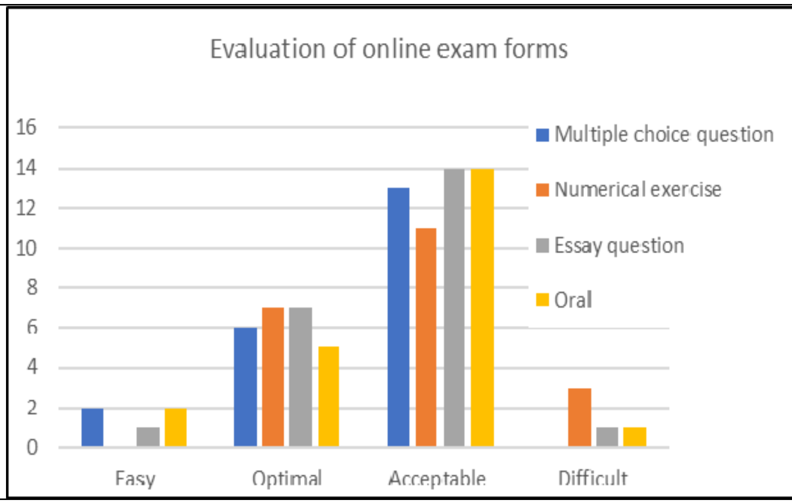


Fig. 4. Students' evaluation of the different forms of the online exams via LMS, with different type of questions or in oral online modality.

The LMS, based on the ICTP Moodle platform, is used for the MMP and the development began in September 2019 thanks to the support and the advices of one of the authors that shared her long experience at the King's College (London, UK) developing and maintaining the LMS for medical physics and engineering and other programmes (6).

Figure 5 shows that students have considered the LMS fundamental for the ODL - collecting all the necessary material and allowing to communicate with teachers and students, e.g. via chats. They consider the present development almost ready for the ODL in the future, but with lectures with more video recording or PPT with voice over. 19 of the 23 students (82%) are considering the LMS ready to provide ODL compared to 4 students (17%) that disagree (figure 5). It is important to note that 78% of the students give marks Agree and Strongly agree to the question 2 from this set – i.e. they have received through ODL the materials which are necessary for their studies.

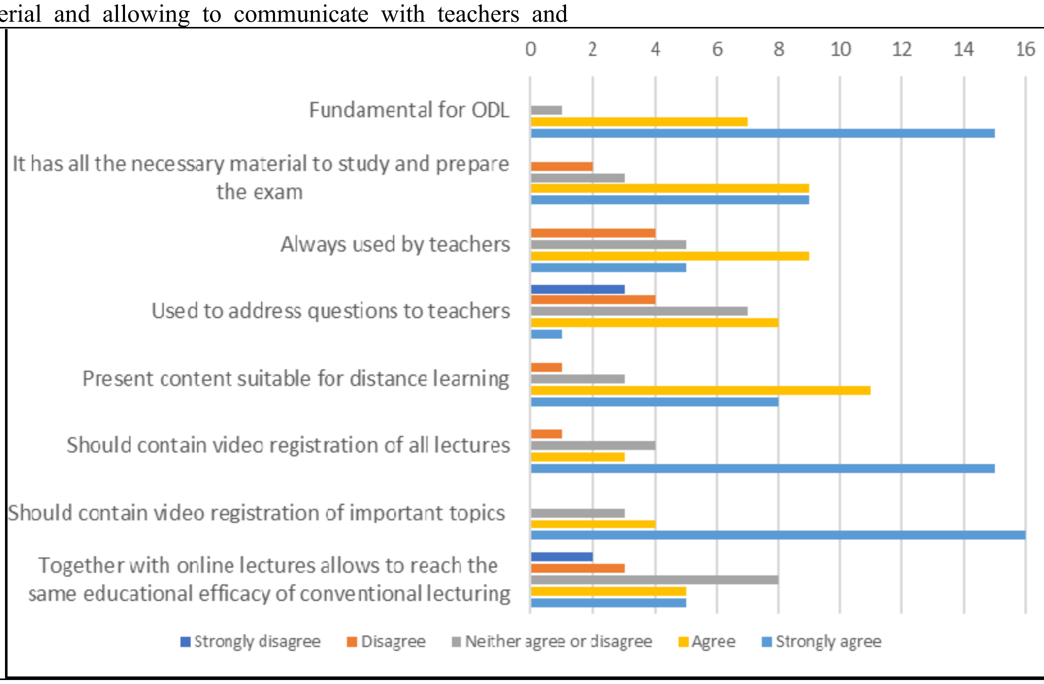


Fig. 5. The evaluation of the ICTP LMS developed for the MMP able to support a programme based on ODL.

Students have been asked to give an overall assessment of the ODL experience. Figure 6a illustrates that 25% of the students do not find this experience useful (what is mainly due to equipment, internet connection and home environment), however 75% of the students find the ODL experience very useful. On the contrary, figure 6b reports that only 17% evaluate ODL equivalent to conventional teaching, however communication with teachers and classmates have been evaluated acceptable for the 60% and the 78%, respectively.

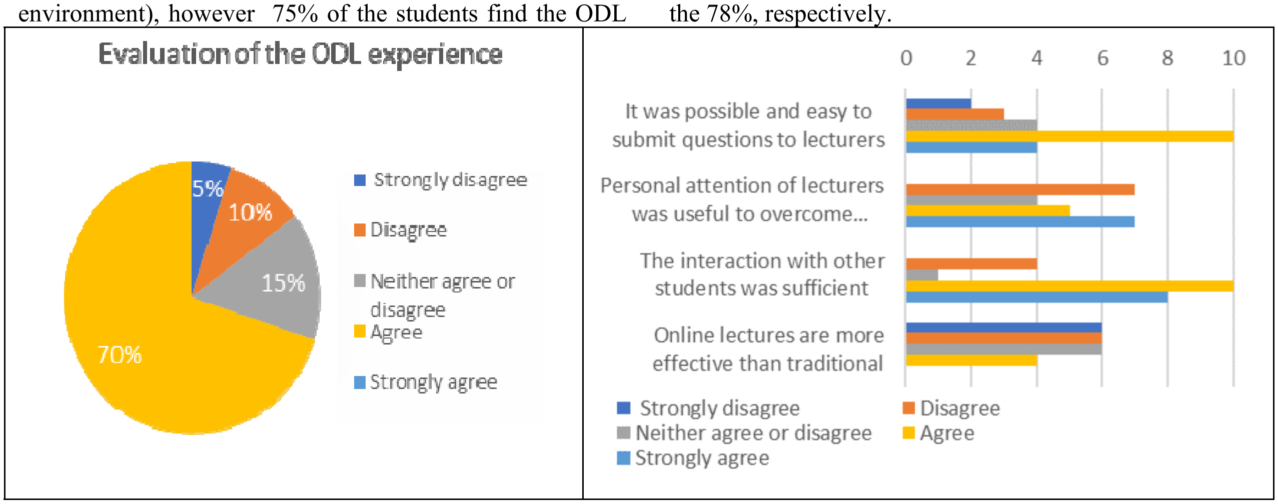


Fig. 6. a) Overall evaluation of the ODL experience. b) Evaluation of effectiveness of ODL and inter-communication level with classmates and teachers.

Effectiveness of the teaching has been evaluated on 17 of the 21 courses/modules of the 1st and 2nd terms (these courses had the same teacher as the past years). The average difference of the mean marks of each course for 24 students interested by the ODL, compared with the 64 students of 4 past cycles (2016, 2017, 2018 and 2019) is -0.6±1.7. In the Italian university scoring system, the range of positive marks in an exam is from 18 to 30 (*with laude*) and -0.6 marks correspond to a percentage difference of 4%. This minor difference in the marks of the exams of the students using ODL during the lockdown, compared with students from the previous years with classical teaching, shows that the use of the e-learning has been very effective. However we have to indicate that this results is only based on the theoretical part of the courses. Medical physics education requires extensive practice, including clinical experience, which can only be delivered in classical way.

IV. Conclusion

The Covid-19 lockdown was a period of mixed emotions during which we tried to find an equilibrium between the frustration of the pandemic and the quality of the education delivery at the MMP programme. All teachers/lectures in the Faculty delivered extra work in order to adapt their existing materials for the LMS delivery. Significant additional work was also associated with the administration of the LMS delivery.

The majority of the students expressed their appreciation of the ODL opportunity that has opened a window on a different way to teach and learn and on the great potentiality that these methods and technologies can represent, in particular, in low and medium income (LMI) countries where knowledge can be spread across a country, as well as in nearby countries. In fact, online education is more economical and convenient, but it requires extra preparation up-front. Probably it is effective only if the number of participants is reduced and when students have active communication with the teacher.

We realised that teachers have to learn ODL methods and instruments and adjust the teaching methods and educational material. We understood that the assessment of the gained competencies has to be made in a more complex form, for example with more assignments using the LMS but also with an oral online exam. We also have to underline that the full educational package of the each student has to include the practical exercises in clinical setting – i.e. the education has to be hybrid – a mix of e-learning and classical learning.

Finally, with this experience we, as teachers, learned a lot about the ODL methods, the only and useful option during the lockdown, allowing us to continue the delivery of the annual academic programme. It was also a great experience for the students and for their future as clinical medical physicists, trainers and teachers in their countries to support the development of the medical physics.

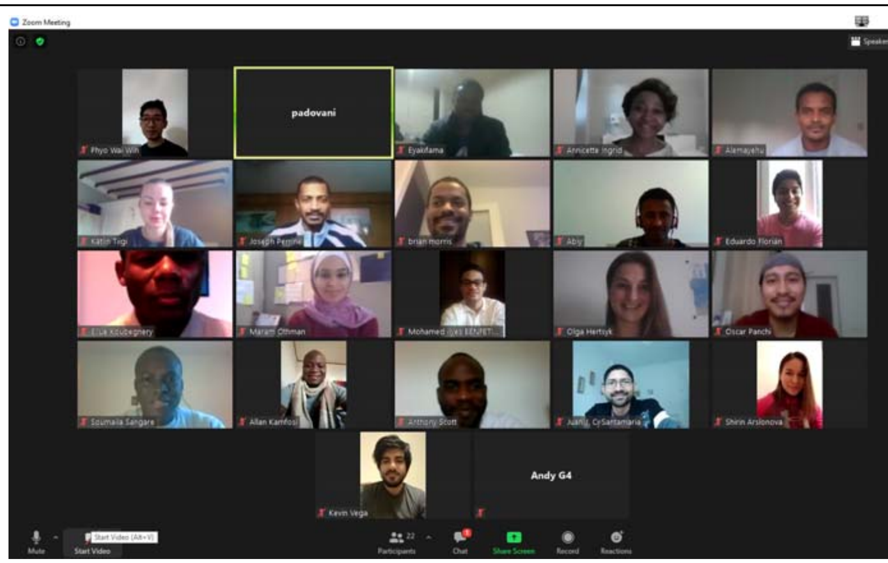
Acknowledgements

We thank Hossein Aslian for the initial development of the LMS for the Master in medical physics programme. Many thanks also to the Master's students for their contribution to the survey and for the advices useful to improve our instruments and methods for remote teaching: Anberbir Andualem, Arslonova Shirin, Benfetima Mohamed Ilyes, Beshah Abiy Tamiru, Calderon Santamaria Juan Junior, Diarra Adama, Florián Ché Eduardo, Hazou Eyakifama, Hertsyk Volha, Kamfosi Allan, Kouadio Landji Dibert, Luna Cambronero Joselin De Los Angeles, Morris Brian, Noumbi Domgouo Annicette Ingrid, Othman Maram S. K, Panchi Oscar, Perrine Joseph, Sangare Soumaila, Scott Anthony, Silue Koubegnery Aly, Telila Alemayehu, Thinn Aye, Tiigi Kätlin, Vega Mena Kevin Ulises, Win Phyo Wai.

References

1. L. Czerniewicz. What we learnt from going online during university shutdown in South Africa. https://philonedtech.com/what-we-learnt-from-going-online-during-university-shutdowns-in-south-africa/
2. Suddenly online: A national survey of undergraduates during the COvid-19 pandemic. Digital Promise and Langer Research. 2020. https://www.everylearnersolve.org/asset/h22tgaXzW18yQImzAsdR
3. The ICTP and Trieste University Master of advanced studies in medical physics, https://www.ictp.it/programmes/mmp.aspx http://df.units.it/en/graduate-schools/advanced-master-programmes
4. Loreti G et al, " Evaluation of the Impact of an International Master of Advanced Studies in Medical Physics" IFMBE Proceedings 68/1, p 873-876 (2019) doi.org/10.1007/978-981-10-9035-6_162
5. Hodges et al., "The Difference Between Emergency Remote Teaching and Online Learning" in Educause Review, March 27, 2020.
6. V. Tabakova, e-Learning in Medical Physics and Engineering, Building Educational Modules with Moodle. CRC Press, 2020

Corresponding Author: Renato Padovani, ICTP Trieste, Italy
rpadovan@ictp.it



Part of the students and colleagues who took part in the ICTP-University of Trieste Master programme survey

NURTURING A GLOBAL INITIATIVE IN MEDICAL PHYSICS LEADERSHIP AND MENTORING

A. H. Ng[1], A. C. A. Sirico[2], A. H. Lopez[3], A. T. Hoang[4], D. D. Chi[5], H. Prasetio[6], I. B. Uwadiae[7], J. C. Santos[8], K. Chhoeurt[9], L. A. Thomas[10], L. Giansante[11], L. Goulart[12], L. J. Rojas[13], L. E. Lubis[14], M. Y. Yeh[15], N. T. Pham[4], P. M. Trejo-Garcia[16], S. C. S. Cheng[17], S. Dang Quoc[18], T. Sanghangthum[19], V. Ath[9], V. H. Guerra[2], Y. H. Lin[20], E. Bezak[21], R. Jeraj[22], T. Kron[23], K. H. Ng[24].

[1] Department of Radiotherapy and Oncology, National Cancer Institute, Putrajaya, Malaysia.
[2] Department of Physics, Institute of Physics, University of São Paulo, São Paulo Brazil.
[3] Department of Physics, National University of San Agustin of Arequipa, Arequipa, Peru.
[4] Department of Biomedical Physics, Nguyen Tat Thanh University, Ho Chi Minh, Vietnam.
[5] Department of Radiation Oncology and Radiosurgery, 108 Central Military Hospital, Hanoi, Vietnam.
[6] Center for Technology of Radiation Safety and Metrology, National Nuclear Energy Agency of Indonesia, Jakarta, Indonesia.
[7] Department of Radiation Oncology, University College Hospital, Ibadan, Nigeria.
[8] Institute of Physics, Federal University of Rio de Janeiro, Rio de Janeiro, RJ, Brazil.
[9] National Cancer Center, Calmette Hospital, Phnom Penh, Cambodia.
[10] Transmedic Healthcare Sdn. Bhd., Kuala Lumpur, Malaysia.
[11] Department of Physics, The Royal Marsden NHS Foundation Trust, London, United Kingdom.
[12] Department of Radiotherapy, Santa Casa de Irmandade of Porto Alegre, Santa Rita Hospital, Rio Grande do Sul, Brazil.
[13] Department of Basic Sciences, University Santo Tomas, Bucaramanga, Colombia.
[14] Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Indonesia, Depok, Indonesia.
[15] Department of Physics, National Tsing Hua University. Hsinchu City, Taiwan.
[16] Department of Physics, Benemérita Universidad Autónoma de Puebla, Puebla, Mexico.
[17] Department of Health, Government of Hong Kong Special Administrative Region, Hong Kong, China.
[18] Medical Physics Division, Hanoi Oncology Hospital, Hanoi, Vietnam.
[19] Division of Radiation Oncology, Department of Radiology, Chulalongkorn University, Bangkok, Thailand.
[20] Division of Radiation Oncology, National Cancer Center, Singapore.
[21] Cancer Research Institute and School of Health Sciences, University of South Australia, Adelaide, SA, Australia
[22] Department of Medical Physics, University of Wisconsin, Madison, WI, United States of America.
[23] Department of Radiation Oncology, Sir Peter MacCallum Institute, University of Melbourne, Victoria, Australia.
[24] Department of Biomedical Imaging, Faculty of Medicine, University of Malaya, Kuala Lumpur, Malaysia.

Abstract— **This paper aims to present on the establishment of the "Medical Physics: Leadership and Mentoring Programme" and its achievements to date. The objectives of the programme are to develop leadership roles among young medical physicists and to provide guidance and support for young medical physicists by creating an atmosphere of openness where meaningful communication and trust can exist. Since its formation in 2016, the programme has expanded and kept growing to offer a platform for the young medical physicists to equip with leadership values. The group applies an e-mentoring method, which offers an innovative way of mentoring despite geographic constraint. Tele-mentoring sessions have also been organised to enable the mentors to share their experiences with mentees. Throughout its 4 years of operation, the group has accomplished four important achievements: worldwide professional network establishment, tele-mentoring sessions with guest mentors, scientific collaborations and publications as well as information dissemination. A questionnaire survey to study the key impacts of the programme on mentees shows that the majority of the mentees agreed that this programme has been beneficial in their career pathway. There is a need to further strengthen and expand the programme to become a more structured programme. It is envisaged that the programme could be considered as a training model for other medical physics groups in future.**

Keywords— **Mentoring, leadership, medical physics, professional development, personal development.**

I. Introduction

The word mentoring originated with the character of Mentor in Homer's Odyssey in Ancient Greek mythology. When Odysseus, the king of Ithaca, was away fighting at the Trojan War, he entrusted the care of his young son Telemachus to his trusted friend named Mentor [1]. According to the Cambridge dictionary, mentoring is the activity of supporting and advising someone with less experience to help them develop in their works [2]. It is the relationship between a mentor and a mentee. A mentor is a person who has the expertise, experience or knowledge and has the role of providing guidance, motivation, encouragement, support, and education to a mentee. On the other hand, the mentee has the role of learning from the mentor's knowledge, asking for help when needed, maintaining the contact and learning new things from mentors to achieve the goals [3-5]. However, it is important to note that mentors can also benefit significantly from the relationship through fresh ideas and questions that can bring out new aspects of known relations.

The high quality of the mentor-mentee relationship is one of the key factors to establish successfully in their professional career. For traditional mentoring, the mentor and mentee are typically working at the same organisation, however, the e-mentoring or online mentoring is the new way occurring due to the globalisation that is easier to communicate from the e-mail, online chats with different platforms, or virtual meeting conferences [6-7]. The mentor and mentee from different institutes or even countries can bring new perspectives and ideas free from obligations and direct professional relations.

Mentoring has become highly popular nowadays in several professions including medical physics. Mentoring and leadership have been discussed in several studies on training, education and research in medical physics. For example, the European Federation of Organisations for Medical Physics (EFOMP) introduced the Mentoring in Research Programme to support early-career medical physicists in setting up a research project [8]. Woods et al. described a multimodal mentoring model by integrating medical professional competencies into bio-engineering and medical physics graduate training [9]. The American Association of Physicists in Medicine (AAPM) announced the Diversity Recruitment through Education and Mentoring (DREAM) programme to increase the number of underrepresented groups in Medical Physics [10]. Caruana et al. applied a ‘strength-weakness-opportunity-threat (SWOT)’ analysis method in a medical physics leadership training programme through EFOMP-EUTEMPE collaboration, known as mini MBA for medical physicists [11-13]. Medical Physics for World Benefit, a not-for-profit organisation is also formalising a mentoring partnership programme recently to support medical physicists in need [14].

Medical Physics: Leadership and Mentoring Programme is a newly established platform that connects regional young medical physicists to the global mentoring group. This mentoring community is a system under which senior or experienced medical physicists support, inspire, advise, guide, assist or lead the juniors in medical physics work environment to achieve the goals [15]. This paper aims to report on the establishment of this programme and its achievements to date. It also reports the mentees’ experiences with regards to online conferences participation, bridging the gap and foster international ties beyond local medical physics communities.

II. History of development

The Medical Physics: Leadership and Mentoring Programme was formed in late 2016, led by Professor Dr. Kwan Hoong Ng (Professor Ng, University of Malaya, Malaysia). The objectives of this programme are (i) to develop leadership roles among the young medical physicists, and (ii) to provide guidance and support for young medical physicists by creating an atmosphere of openness where meaningful communication and trust can exist. The pioneer mentee group consisted of 12 mentees and currently, it has expanded to 23 members, who are involved in the medical physics area such as clinical medical physicists (44%), postgraduate students (26%) or young academic (17%) and research staff (13%) from Asia, Latin America and Africa. Most of them are graduated with a master degree (57%), followed by a PhD (30%) and bachelor degree (13%). The mentees were mostly recruited during scientific events (Fig. 1) or scientific visits of the mentor to the research groups at universities.

As a mentor, Professor Ng is strongly motivated by his desire to encourage young people to succeed in their studies, career, or life choices by providing support and guidance. His work was inspired in a great experience he had as a mentee, having the late Professor John Cameron from the University of Wisconsin USA as a mentor. Professor Ng reported the desire of continuing the legacy of his mentor John Cameron: “It's time to initiate a programme that will allow young medical physicists to benefit from more organised, conducive interaction and mutual support from mentors” [16].

Fig. 1 Photographs of the mentee-mentor meetings in scientific conferences. Top: South East Asia Congress of Medical Physics 2018 (Kuala Lumpur, Malaysia); Middle & bottom: Brazilian Congress on Medical Physics (Florianopolis, SC, Brazil)

III. Operations and practices

Coordinating and engaging members from different time zones with variable cultural and working background pose a practical challenge. Hence, the e-mentoring method which connects mentor-mentee electronically offers an innovative way of mentoring to ease the communication between the mentors and mentees despite geographic constraint. The group has utilised mobile instant messaging application (WhatsApp), Voice over Internet Protocol (VoIP) technologies (Skype or Zoom) to communicate. These free-of-charge applications enable real-time group communications, information sharing as well as a teleconference. Other online applications such as Google Classroom (Google, California, USA) and Asana (Asana, California, USA) have been utilised to collaborate in ad-hoc projects among volunteers and to archive related data.

Teleconferences have been organised periodically to enabling the mentors to share their experiences with mentees in an hour's online meeting. A volunteered mentee will organise and moderate the sessions under a mutual agreement with the guest mentor. During the session, active participation and two-way communications are highly encouraged. The first online meeting was held on 14th February 2017 to kick-off the programme, 'ice-breaking' amongst mentor-mentees as well as to mutually set the scene for the programme, under the guidance of Professor Ng and Professor Robert Jeraj (University of Wisconsin, USA). Since then, multiple online meetings took place to provide motivation, encouragement, aimed in nurturing leadership skills among the mentees. Nowadays, in addition to the meetings, the group is a space to explore and cultivate new ideas and possibilities to work and learn together (e.g. writing papers, planning activities, managing website and preparing and sharing educative materials in social media).

IV. Group achievements

Medical Physics: Leadership and Mentoring group throughout its four years of the foundation has reached four important achievements:

A. Worldwide professional network

A worldwide network of professionals in the area of medical physics with different levels of expertise has been formed. This has been achieved by gathering young medical physicists from several Latin American and Asian countries, and most recently from the African continent, in academic events and connecting them with more experienced professionals. The invited mentors consisted of world top researchers to leaders in professional and clinical medical physics. The group also invited non-medical physicist to share with the leadership values from other perspectives. The list of mentors is tabulated in Table 1.

Table 1 List of mentors

Mentor	Affiliation
Prof. Dr. Kwan-Hoong Ng (KHN)	University of Malaya, Kuala Lumpur, Malaysia
Prof. Dr. Robert Jeraj (RJ)	University of Wisconsin, Madison, USA
Prof. Dr. Tomas Kron (TK)	University of Melbourne, Victoria, AUS
Prof. Dr. Eva Bezak (EB)	University of South Australia, Adelaide, AUS
Prof. Dr. John M. Boone (JMB)	University of California, Davis, USA
Prof. Dr. Marialuisa Aliotta (MA)	University of Edinburgh, Edinburgh, UK
Prof. Dr. Virginia Tsapaki (VT)	General Hospital of Athens, Athens, Greece
Prof. Dr. Perry Sprawls (PS)	Emory University, Atlanta, USA
Prof. Dr. Emico Okuno (EO)	University of São Paulo, São Paulo, Brazil
Prof. Dr. Ho-Ling Liu (HLL)	The University of Texas MD Anderson Cancer Center, Texas, USA
Prof. Dr. Slavik Tabakov (ST)	King's College London, London, UK
Prof. Carmel J. Caruana (CJC)	University of Malta, Malta
Prof. Renato Padovani (RP)	International Centre of Theoretical Physics, ICTP
Associate Prof. Jamie Trapp (JT)	Queensland University of Technology, AUS
Dr. David Yoong (DY)	DYLiberated Learning Resources, Malaysia

Fig. 2 shows the distribution of both mentors and mentees around the world. The climate of trust and cooperation has been built amongst the group members, which offers positive synergy to enhance leadership skills, teamwork and personal growth. Fig. 3 illustrates the core values of leadership that, in the opinion of the mentees, a leader should possess. An interesting aspect of the programme is that it also helps to promote gender equity. While male colleagues are more represented amongst the mentors, there is gender balance within the mentees. This has the potential to create an even better leadership group for the future.

B. Tele-mentoring

Online mentoring sessions have been organised with guest mentors to learn about their experiences, listen to their advice and provide guidance (Fig. 4). These meetings cover topics such as personal experiences of the mentors, advice to develop leadership skills and updating on topics of interest in particular medical physics and leadership. Fig. 5 shows the list of guest mentors and their topic of talks.

Fig. 2 Distribution of the mentors and mentees around the world

Fig. 3 Core values of leadership

Fig. 4 Online mentoring session

C. Scientific collaborations and publications

One of the major accomplishment through this mentoring programme is the joint effort in article writing and conference presentations. Two peer-reviewed articles were published [15,17] and several presentations have been carried out to report the formation and activities of the group in the regional or international conferences such as IUPESM World Congress of Medical Physics and Biomedical Engineering 2018, XXVI Brazilian Congress of Medical Physics 2019 and AFOMP Monthly Webinar 2020. These exercises provide a platform for the current mentor-mentee to share their experiences in the mentoring programme as well as outreach to more prospective young medical physicists and potential mentors to join in this programme. It also highlights the mutual benefits through the creation of the mentor-mentee relationship.

D. Information dissemination

To bring programme information to the group members, young professionals and the general public, a website and several social media accounts were created. They have been designed to share the information about the online meetings, scientific materials and relevant video productions [18] of mentees throughout this mentorship. According to the Pew Research Center for Journalism and Media, 68% of Americans stay informed about world news through social media [19]. The mentoring group has been made visible in social media platforms to allow publicity of the group at no cost and to engage potential ‘followers’ in the different topic of interests.

Fig. 5 List of guest mentors and topics of discussion during the online mentoring sessions between 2017 and August 2020

For instance, the group has created a simple animation to educate the public about the digital infrared thermometer and its health effects on the human body during the Covid-19 pandemic [16]. The animated infographic was published on the website and social media (Fig. 6) where the operation of the digital thermometer was explained simply in 25 commonly spoken languages around the world population, to reduce the fear of general public about the myth of harmfulness of digital infrared thermometers. The Physics World has also recently featured the global mentoring programme in its weekly research update [20]. This has further publicised the latest development of the programme.

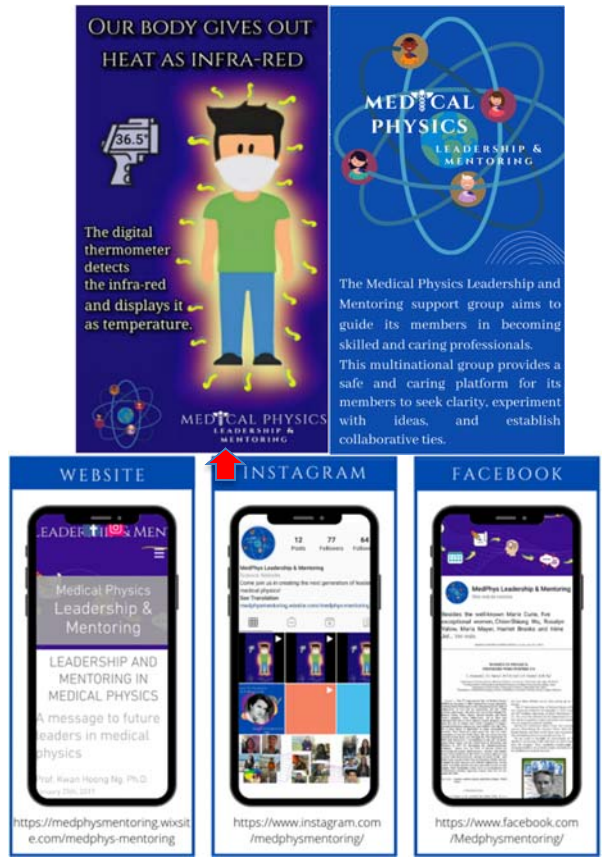


Fig. 6 (Top)Animation about the digital infrared thermometer and its health effects published on the (bottom) website and in social media

V. The key impact of the programme

It is of particular interest to quantify and briefly analyse the impact of the on-going leadership and mentoring programme. A questionnaire survey was carried out to study the initial impacts and experiences of mentees who joined the programme. On the mentoring side, the survey allows mentees to express how they feel about the need for mentorship and enlist the aspects they feel the need to consult about as early-career medical physicists.

According to the survey results, all mentees have gained experience in leading various scientific activities as shown in Fig. 7. They also reveal that there was a variety of activities, across which their leadership experience has spanned. Majority of the mentees (73.4%) considered themselves to be good leaders, while 66.7% thought that they needed improvement. Most of the mentees (93%) stated that joining the group changed their perspective on leadership, while all of them unanimously claimed that joining the group changed the way they lead a team/project in their daily professional activities.

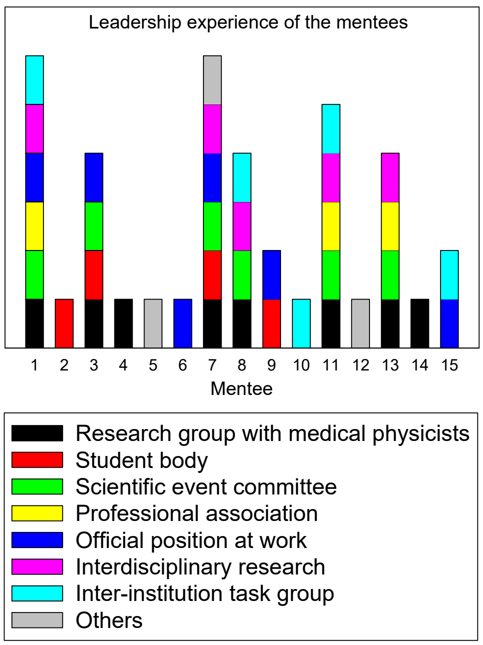


Fig. 7 Mentees' leadership experiences

In this study, all mentees have expressed the importance of a mentor in their career pathway. According to Table 2, of the three top aspects having the most need to be discussed with a mentor(s) are (1) organisational skills (including leadership), (2) technical/scientific aspects, and (3) paper writing. The discussed information was useful not only to reflect the impact or success of the group activities but also to plan for the future by addressing the mentee's need to fulfil the aims of the programme and ensure the beneficial nature of the activities.

While no similar survey has been performed amongst the mentors, it has been generally acknowledged that the preparation for lectures, the opportunity to communicate and particularly the questions of the mentees provided significant stimulation and benefits to the mentors as well. For instance, the general comment from one of the mentor mentioned: "I am grateful to have the opportunity to chat with young and talented medical physicists like you and others in the group. I think this programme is an excellent platform for students, trainees and young faculty in medical physics to broaden their views by interacting with more senior ones with varied experience and practice in different regions and institutions".

Table 2 Mentoring aspect required by mentees

Aspects	Overall Percentage (%)
Organisational skills	80
Technical/scientific	60
Paper writing	47
Career choice	40
Office politics	40
Teaching	28
Personal life	12

VI. Challenges and opportunities

These achievements would not be accomplished without the cooperation and dedication of the mentees and mentors, who voluntarily support and guide each other along with this collaboration. The programme provides insightful advice and 'real-time' support whenever needed. Topical group discussions via online meetings guided by some of the world medical physics leaders were inspirational and offered a global view of the profession. Recently, we have carried out a SWOT analysis to examine the current status of the programme as shown in Table 3 [15].

Table 3 SWOT analysis of the programme

Strengths

- Mutual agreement of programme establishment and implementation
- Virtual programme with no cost involvement
- Mentors are world leaders or experienced practitioners in the field
- Lively group meetings or discussions in real-time using an online platform

Weaknesses

- Limited 'meeting' time creates virtual 'barrier' among the mentee-mentee and mentee-mentor
- Different time zones (from GMT +10 to GMT -5)
- Extra work in addition to the existing workload
- Heterogeneity of the group and different working background and style
- Not a structured or time-specific training programme
- Mentees only from several countries of different continents
- A low number of mentors compared to mentees

Opportunities

- Able to expand networks and scientific collaborations
- Current market needs of medical physicists in leadership development
- Able to learn in diverse ways collectively and excel in career

Threats
• Large time gaps between group meetings
• Medical physics roles take over by other professions

In general, medical physics proved to be a good field for the set-up of an international mentoring programme as there are a shared purpose and common terminology. Being science-based, it also allows building on a common culture with problems, tools and solutions similar all over the world. Use of mathematics, diagrams and graphs further enables communication even if most of the participants (mentors and mentees) did not share the same mother tongue.

VII. Plans

No doubt nurturing leadership values among the professionals could offer added values to healthcare services. Based on the SWOT analysis, this programme could be considered a training model, which is flexible enough to be adopted and adapted locally, regionally or globally, to create the critical mass of high-quality medical physics leaders in the future job market. With that in view, there is a need to further strengthen and develop the programme to maintain its relevancy and to expand its functionality.

Firstly, it is important to expand the network of the group by recruiting more mentees from different part of the world such as Africa and Europe and engage more medical physics leaders as mentors. The wider the range of group members, the wider the variety of knowledge and experience sharing, enabling thus resource sharing and complementing each other, especially when it comes to limitations such as language barriers and skills. Collaboration with international organisations such as the International Organization for Medical Physics (IOMP) and the Medical Physics for World Benefit may be considered to establish the mentoring partnership programme. Individual mentoring may be considered for developing one-on-one relationships between mentor-mentee and tailor the mentee’s need along with the mentoring programme.

Secondly, the programme should be enhanced to become a systematic and structural training programme for optimising its efficiency and sustainability. Related professional associations, agencies or individuals should be approached to widen its network and build potential collaborations. More research work and scientific publications which could benefit the services can be achieved. Further publicity and information dissemination could be carried out.

VIII. Conclusion

The initiative of global medical physics leadership and mentoring programme offers a new platform to nurture the future leaders of medical physics. This voluntary programme gathers worldwide enthusiastically medical physicists to communicate and collaborate, as well as excel their leadership skills through interaction with the mentees and mentors. Positive impacts have been witnessed among the mentees were several early achievements have been accomplished and created added values to the field of medical physics. With that in view, it is hoped that the programme can be outreached across the globe and expanded locally to build up the capacity of medical physics leaders to fill the gap of the evolving healthcare industries.

Acknowledgement

The authors would like to thank all mentors and mentees not explicitly mentioned in the paper for their time and enthusiasm contributing to the mentoring programme. We also acknowledge the support of local, regional and international organisations, in particular, the IOMP.

References

1. Wikipedia (2020) Mentorship. Available from: https://en.wikipedia.org/wiki/Mentorship
2. Cambridge Dictionary (2020) Mentoring. Available from: https://dictionary.cambridge.org/dictionary/english/mentoring
3. Haggard DL, Dougherty TW, Turban DB, et al. (2010) Who is mentor? A review of evolving definitions and implications for research. Journal of Management, 37(1): 280-304.
4. Jacobi M (1991) Mentoring and undergraduate academic success: a literature review. Review of Educational Research, 61(4): 505-532.
5. Sorcinelli MD, Yun J (2007) From mentor to mentoring networks: mentoring in the new academy. Change: The Magazine of Higher Learning, 39(6): 58-61.
6. Adams G, Crews BT (2004) Telementoring: a viable tool. Journal of Applied Research for Business Instruction, 2(3): 1-5.
7. Rowland KN (2012) E-Mentoring: an innovative twist to traditional mentoring. Journal of Technology Management & Innovation, 7(1): 228-237.
8. EFOMP (2020) Introduction to the "EFOMP Mentoring in Research programme". Available from: https://www.efomp.org/index.php?r=pages&id=mentoring-about
9. Woods KV, Peek KE, Richards-Kortum R (2014) Mentoring by design: integrating medical professional competencies into bioengineering and medical physics graduate training. J Cancer Educ. 29(4): 680-688.
10. AAPM (2015) Fellowships for Diversity Recruitment through Education and Mentoring (DREAM) in Medical Physics Mentor Application. Available from: https://www.aapm.org/education/grantsfellowships/docs/MentorTemp_2015%20DREAM.pdf
11. Caruana CJ, Cunha JAM, Orton CG (2017) Subjects such as strategic planning, extra-disciplinary communication, and management have become crucial to medical physics clinical practice and should become an integral part of the medical physics curriculum. Medical Physics. 44(8): 3885-3887.
12. Caruana CJ (2020) Leadership and challenges in medical physics - a strategic and robust approach: A EUTEMPE network book. IOP Publishing Ltd, Bristol.

13. Caruana CJ, Vano E, Bosmans H (2015) EUTEMPE-RX module MPE01: Developments in the profession and challenges for the medical physics expert (D&IR) in Europe – a first in international medical physics education and training. Medical Physics International Journal. 3(2): 69-71.
14. Medical Physics for World Benefit (2020). Mentoring Partnerships. Benefit exchange, 5(2). Available from: https://www.mpwb.org/resources/Newsletters/2020-2.pdf
15. Santos JC, Goulart LF, Giansante L, et al. (2020) Leadership and mentoring in medical physics: The experience of a medical physics international mentoring programme. Physica Medica. 76: 337-344.
16. Medical Physics Leadership and Mentoring (2020). Available from: https://medphysmentoring.wixsite.com/medphys-mentoring
17. Giansante L. Santos JC, Lin YH, et al. (2018) Women in Physics: Pioneers Who Inspire Us. Medical Physics International Journal, 6.
18. Medical Physics Leadership and Mentoring (2020). The Life Before and During COVID 19: Crown of Victory in Dawn. Available from: https://youtu.be/jaET1NbBd9I
19. Shearer E, Matsa KE (2018) News Use Across Social Media Platforms 2018, Pew Research Center. Available from: https://www.journalism.org/2018/09/10/news-use-across-social-media-platforms-2018/.
20. Freeman T (2020) Global mentoring scheme fosters future leaders in medical physics. Available from: https://physicsworld.com/a/global-mentoring-scheme-fosters-future-leaders-in-medical-physics/

Contacts of the corresponding author:

Author: Aik Hao Ng
Institute: Department of Radiotherapy and Oncology, National Cancer Institute, Malaysia
Street: No. 4, Jalan P7, Precinct 7,
City: Putrajaya
Country: Malaysia
Email: hao06051982@yahoo.co.uk

AN INTRODUCTION TO THE SOCIETY OF DIRECTORS OF ACADEMIC MEDICAL PHYSICS PROGRAMS (SDAMPP)

H.A. Al-Hallaq[1,8], S.G. Armato III[2,8], E.I. Parsai[3,8], W.D. Newhauser[4,5,8], B.A. Schueler[6,8], and R.E. Wendt III[7,8]

[1] Dept. of Radiation and Cellular Oncology, The University of Chicago, Chicago, IL USA
[2] Dept. of Radiology, The University of Chicago, Chicago, IL USA
[3] Dept. of Radiation Oncology, University of Toledo Health Sciences Campus, Toledo, OH USA
[4] Dept. of Physics, Louisiana State University, Baton Rouge, LA USA
[5] Dept. of Physics, Mary Bird Perkins Cancer Center, Baton Rouge, LA USA
[6] Dept. of Radiology, The Mayo Clinic, Rochester, MN USA
[7] Dept. of Imaging Physics, The University of Texas MD Anderson Cancer Center, Houston, TX USA
[8] SDAMPP, Alexandria, VA USA

Abstract— **The paper introduces the Society of Directors of Academic Medical Physics Programs, which is dedicated to advancing medical physics education worldwide. We describe the Society's mission, focus areas, selected activities and resources, and organizational structure. The Society is a volunteer organization that fosters collaboration, cooperation, and coordination on a wide variety of topics in medical physics education. We describe several membership options and benefits, as well as ways for non-members to participate in many activities. The Society, which originated in the United States, has always welcomed international participation and membership, and with increased prevalence of online access, we anticipate this will increase in future.**

Keywords— **medical physics education, professional society, international, graduate, residency, clinical training, research training**

I. INTRODUCTION

The Society of Directors of Academic Medical Physics Programs (SDAMPP) is a volunteer organization whose prime objective is the advancement of education in the applied scientific field of medical physics. This objective is pursued through discussions, meetings, collaboration, and the sharing of perspectives of those engaged in academic medical physics programs. The Society:

1. Promotes advancement of medical physics education worldwide;
2. Encourages coordination among academic medical physics programs;
3. Fosters establishment of best practices in medical physics education;
4. Monitors production of medical physics trainees relative to the job market;
5. Assists new academic medical physics programs;
6. Fosters coordination of the graduate and residency elements of medical physics training;
7. Provides a forum for discussion among leaders of academic medical physics programs;
8. Serves as a voice for leaders of academic medical physics programs;
9. Engages leaders of academic medical physics programs around the world to provide better and more consistent training.

After beginning as a task group within the American Association of Physicists in Medicine (AAPM), SDAMPP was formed in 2008 as a non-profit organization. It is governed by elected officers and an elected board of directors according to its By-laws and Rules. Most of the Society's activities are member-initiated and conducted under the auspices of its 10 standing committees. The Society relies on volunteers for the vast majority of its operation. Additional information is provided on the Society's website (www.sdampp.org), and a word cloud pictorially reveals the main emphasis areas (Fig. 1).

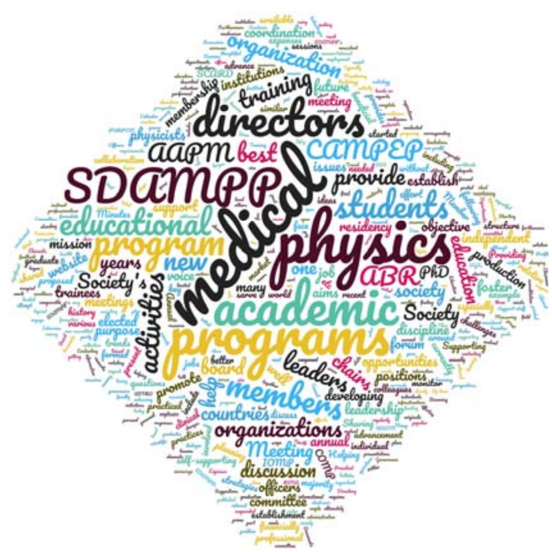


Fig. 1. A word cloud created in wordclouds.com using text from the "Home," "Purpose/Vision," and "History" pages of the SDAMPP website reveals the major focus areas in medical physics education.

The Society's activities continue to evolve in response to the needs of our members, our discipline [1] and our sister organizations, including the AAPM (www.aapm.org), the Commission on Accreditation of Medical Physics Education Programs, Inc. (CAMPEP) (www.campep.org), and the American Board of Radiology (ABR) (www.abr.org), with which SDAMPP has developed integrated, complementary relationships (Fig. 2). CAMPEP defines medical physics accreditation standards for education programs, the AAPM establishes standards and definitions of best practices for the medical physics profession, ABR provides professional certification of clinical medical physicists, and SDAMPP works with these and other societies to advance medical physics education. In the early years, the Society's activities mainly focused on its Annual Meeting. In recent years, the Society has expanded the scope of benefits to its members and increased access through the website and other online platforms. Specifically, SDAMPP has published reports [2], hosted topical webinars, hosted a discussion forum using an electronic bulletin board, liaised and cooperated with other organizations, served as a clearinghouse for electronic resources, co-sponsored surveys [3], and performed various other activities in support of our members. To facilitate responsiveness and rapid communication, AAPM, CAMPEP, and ABR appoint liaisons to SDAMPP and vice versa.

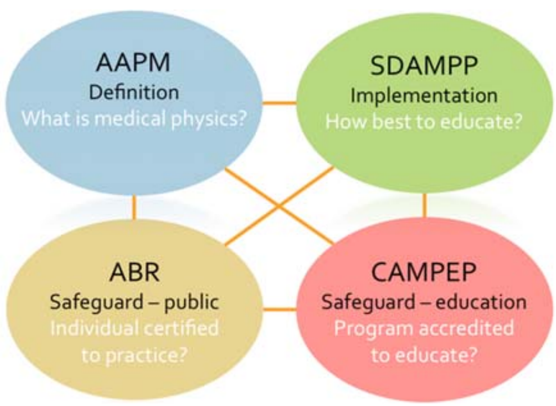


Fig. 2. The organizational interfaces among SDAMPP and the three societies with which it collaborates (SDAMPP 2016).

II. Uniqueness among medical physics organizations

SDAMPP is unique among its sister organizations in several ways. First, it is the only organization that advocates for the interests of medical physics education programs, including the interests of both students and faculty. It is also broadly inclusive and representative of medical physics education programs, as ensured by its rules on voting membership and Board membership. Its members hail predominantly from North America (Fig. 3); international participation has been limited by travel constraints. Because the Society does not accredit programs, certify individuals, or regulate any aspect of medical physics education (Fig. 2), it remains impartial and free from conflicts-of-interest while advocating on behalf of its members for important issues in medical physics education. For example, SDAMPP frequently provides feedback to CAMPEP and AAPM on curriculum matters and to ABR on issues pertaining to board certification. The Society has played a leadership role in helping program directors navigate the potential impacts of COVID-imposed restrictions on instruction, accreditation, and recruiting. The Society has also effectively identified emerging and latent issues in medical physics education, a topic receiving increased attention [4].

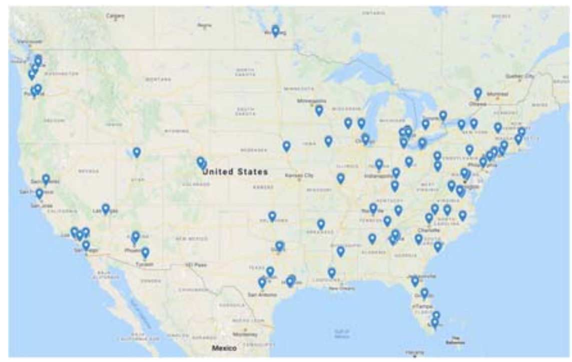


Fig. 3. Geographic distribution of all SDAMPP members as of November 1, 2020. Map data copyright 2020 Google, INEGI

The Society is well suited to connect educators with resources and to move urgent efforts forward quickly. One recent example is the publication in 2019 of an open-access scheduling calendar to facilitate coordination of residency programs' interview dates. Voluntary use of this resource by programs and applicants has been substantial, with 38% of therapy residency programs and 49% of imaging residency programs using it during its inaugural year.

III. Membership

The state of the Society is strong. Membership has steadily grown each year since 2013, reaching 180 in 2020 (Fig. 4).

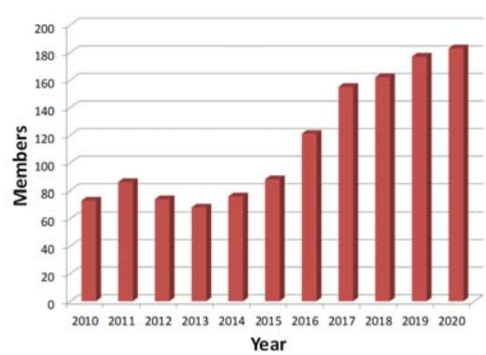


Fig. 4. SDAMPP membership numbers over the past 10 years.

There are ample opportunities for aspiring members to assume roles on committees that are active in their area of interest. Elected offices and appointments have terms of one to three years. Prospective volunteers typically contact a committee chair or vice versa to explore opportunities. The Society welcomes participation from educators from around the world. The Society affords its members the opportunity to network and share knowledge, which in turn opens opportunities for career development, program enhancement, and ultimately improved education of students and trainees (Table 1). One recent example occurred within the Outreach Committee when a residency program director inquired about how others remediate struggling residents and discovered that many other program directors were interested in this same issue. It became apparent that there are well-developed frameworks for remediating residents within medical residency programs, and a medical physics program director had attended a lecture on this topic at her institution. With involvement from a knowledgeable and experienced speaker, these program directors developed a webinar on this topic that was recorded and is available to members through the website.

"SDAMPP is a 'connecting' not a 'commanding' body."
"SDAMPP is a very nimble organization that is focused solely on medical physics education."
"SDAMPP provides a voice for program directors and their counterparts with other professional organizations."
"Due to a membership roster of hundreds rather than thousands, I found it easy to meet education luminaries in our field through SDAMPP and to become a leader in the Society."

Table 1. Quotes from past and present Board members in response to "What stands out to you about SDAMPP as an organization?"

All individuals who are involved in medical physics education are eligible to become a member of the Society. Our members include program directors, associate program directors, aspiring future education leaders, faculty, and support staff. The Society recognizes the vital roles played by all these professionals and encourages them to join the Society as one of four types of member (Table 2).

Membership Category	**Description**
Regular	Currently engaged in senior leadership positions within academic medical physics programs
Emeritus	Formerly held positions of senior leadership within academic medical physics programs
Honorary	Rendered outstanding service in the field of medical physics education, but who would not otherwise qualify for membership
Associate	Interested in medical physics education and in the purposes of the Society, but ineligible for other categories of membership

Table 2. SDAMPP membership categories.

The Society plays a major role in ensuring that future education leaders are developed to achieve the long-term success of the medical physics education enterprise. The Society encourages junior members, including those just beginning their careers in medical physics education, to join and to learn from our more experienced members. International participants do not necessarily need to become members to participate.

IV. Committees

The ***Board of Directors*** comprises leaders in medical physics education who represent graduate, residency, and certificate programs. The Board helps to set the vision and approves activities in accordance with the by-laws, rules, and policies and procedures, which are openly available on the website.

The ***Annual Meeting Committee*** organizes and runs the Society's annual meeting, business meeting, and associated events.

The ***Awards and Honors Committee*** plays a key role in recognizing outstanding members of the community of medical physics educators, solicits nominations from the membership, reviews submissions, and prepares recommendations to recognize outstanding educators who have distinguished themselves through exemplary service to medical physics education.

The ***Education Practices Committee*** considers and makes recommendations on education practice to the Board, including investigating and bringing forward to the Board issues of concern identified by members.

The ***Executive Committee*** supervises the business of the Society in the interval between Board meetings.

The ***Finance Committee*** prepares the annual budget for presentation to the Board, negotiates contracts for services by external organizations, recommends changes in revenue and expenditures, and maintains overall financial viability so that the goals of the Society may be achieved.

The ***Membership Committee*** is responsible for developing and maintaining a vibrant and effective membership of medical physics educators from around the world.

The ***Nominating Committee*** is responsible for identifying and recruiting effective future leadership for the Society by annually submitting names of eligible candidates for officers and directors.

The ***Outreach Committee*** promotes application of the latest education methods and curricula necessary for the successful training of medical physicists worldwide for employment in education, research, and clinical specialties.

The ***Professional Issues Committee*** promotes policies that support program directors and provides recommendations on professional policies.

The ***Publications Committee*** manages online publication of materials necessary to foster the aims of the Society.

V. Conclusion

SDAMPP is a society of medical physics educators whose members have historically been located in North America. As technological advances enable more networking across the globe, we anticipate that international collaborations will increase in order to facilitate the exchange of best practices regarding medical physics education. Thus, we strongly encourage medical physics educators located beyond North America to consider participating in the Society's activities. Because the Society is member governed, opportunities exist to form new committees to address new areas of interest that may be region specific.

VI. References

1. WD Newhauser: The medical physics workforce. Health Physics 112(2):139-148, 2017. https://doi.org/10.1097/HP.0000000000000614

2. Education and Training Report, SDAMPP, 2017. https://www.sdampp.org/documents/SDAMPPMPEducationAndTrainingReportFinal.pdf

3. B Loughery, G Starkschall, K Hendrickson, J Prisciandaro, B Clark, G Fullerton, G Ibbott, E Jackson, J Burmeister: Navigating the medical physics education and training landscape. Journal of Applied Clinical Medical Physics 18(6):275-287, 2017. https://doi.org/10.1002/acm2.12202

4. A Fielding, JI Prisciandaro, CG Orton: Changes and demands in the higher education sector are increasingly making advanced degree medical physics programs nonviable and the profession will have to develop a new model for delivering such education. Medical Physics 45(1):1-4, 2017.

Author: Hania A. Al-Hallaq, PhD, FAAPM, President-Elect SDAMPP, Institution: The University of Chicago, USA, halhalla@uchicago.edu
Author: Samuel G. Armato III, PhD, FAAPM, FSPIE, Secretary SDAMPP, Institution: The University of Chicago, USA, s-armato@uchicago.edu
Author: E. Ishmael Parsai, PhD, FAAPM, FIOMP, FACRO, Past Chair of the Board SDAMPP, Institution: University of Toledo Health Sciences Campus, USA, e.parsai@utoledo.edu
Author: Wayne D. Newhauser, PhD, FAAPM, FAAAS, President SDAMPP, Institution: Louisiana State University, Mary Bird Perkins Cancer Center, USA, newhauser@lsu.edu
Author: Beth A. Schueler, PhD, FAAPM, FACR, Chair of the Board SDAMPP, Institution: The Mayo Clinic, USA, schueler.beth@mayo.edu
Author: Richard E. Wendt III, PhD, FAAPM, Treasurer SDAMPP, Institution: The University of Texas MD Anderson Cancer Center, USA, rwendt@mdanderson.org
Acknowledgments: We would like to thank the founders of SDAMPP for their foresight in forming this Society and to AAPM for their support in its creation. The Society acknowledges with gratitude the collegial and tireless collaborations with AAPM, CAMPEP, and ABR. We would like to acknowledge the members of our committees and our membership-at-large, who contribute much to medical physics education and training.

ENHANCING MEDICAL PHYSICS TEACHING WITH IMAGE REPOSITORIES AND SHARED RESOURCES

Sprawls, P.

Department of Radiology and Imaging Sciences, Emory University, Atlanta, USA
Sprawls Educational Foundation, www.sprawls.org

Abstract— **The effective and safe clinical application of modern diagnostic imaging and therapeutic procedures requires a comprehensive conceptual knowledge and understanding of the physics principles and relationships. It requires learning activities (classes and conferences) with extensive visual representations of the physical interactions and relationships of the procedures with a strong focus on clinical images. A continuing limitation to effective classroom teaching by medical physicists is the availability of adequate visuals and images that can be presented and discussed. This limitation can be overcome and the teaching of medical physics around the world can become much more effective with experienced medical physicists creating and sharing high-quality visuals that can be used by classroom teachers. This is the process of *collaborative teaching* in which both are contributing to the learning process, one as a resource creator and the other as a classroom learning guide…both are teachers. It follows the model of clinical image "Teaching Files" that are the foundation of radiology education.**

The connection between the collaborating teachers can be through teaching image "Repositories" provided by medical physics organizations or institutions. These dedicated Repositories provide opportunities both to the resource creators and the classroom learning guides. Of special significance is that a medical physicist anywhere in the world can use their experience and creativity to contribute to international medical physics education--one visual and image at a time. Guidance is provided for the resource creators, classroom learning guides, and organizations on the development of teaching image Repositories as a major contribution to international medical physics education.

Keywords— **Teaching, Creativity, Collaboration, Visuals, Learning.**

I. INTRODUCTION AND OVERVIEW

Teaching is one of the most valuable and rewarding activities performed by medical physicists around the world. It is the process of helping someone learn or build knowledge structures within the brain. Teaching occurs in many form-- traditional classroom lectures and discussions, mentoring individuals, and providing guidance for laboratory and practical activities. These are direct interactions between the teacher and specific students, or better described as learners. In this role a significant function of the teacher is to guide the learning process which is happening within the brain of the learner. Another highly valuable form of teaching is the process of creating and developing items that can be used to help someone learn, including textbooks and a variety of educational materials. In this context we will identify these two types of teachers as *classroom learning guides* and *resource creators*. There is the opportunity for medical physicists to use their knowledge, experience, vision, and creativity to teach through both of these functions. The contribution of the resource creator/teacher is by creating resources, especially visuals and images that will help learners develop knowledge structures that support the effective application of physics to clinical procedures, both diagnostic and therapeutic.

Images are visuals and we will be using both terms somewhat interchangeably. However, "image" will be used specifically in reference to clinical images (CT, MRI, mammograms, etc.) which are the major physical objects being studied in many medical physics classes. While visuals are also images it will generally be used for composite illustrations developed to show physical functions and relationships, often containing clinical images. The objective of the initiative described here is to develop visuals (images) that will often contain clinical images illustrating various image characteristics and related factors. Fig. 1 is an example.

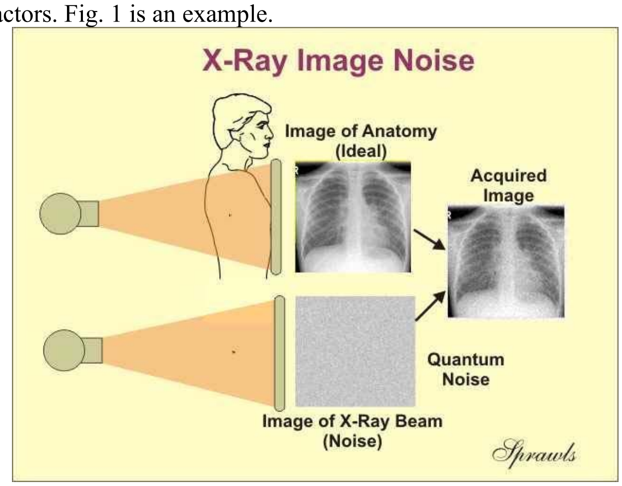


Fig.1. A visual with an imbedded clinical image illustrating the effect of quantum noise.

This is a highly effective visual introducing the concept of x-ray quantum noise that is easy to understand by radiologists and radiology residents. For medical physics students it provides a conceptual understanding to go along with their mathematical knowledge.

When these visuals are made available and shared with classroom learning guides there is the highly valuable process of *collaborative teaching.* Teachers, the resource creators and the classroom learning guides, are applying their knowledge and experience to produce highly effective learning experiences. For this to enhance medical physics education, especially on an international scale, there must be an effective process for connecting the teachers. This can be achieved through the creation of medical physics teaching image Repositories as illustrated in Fig. 2.

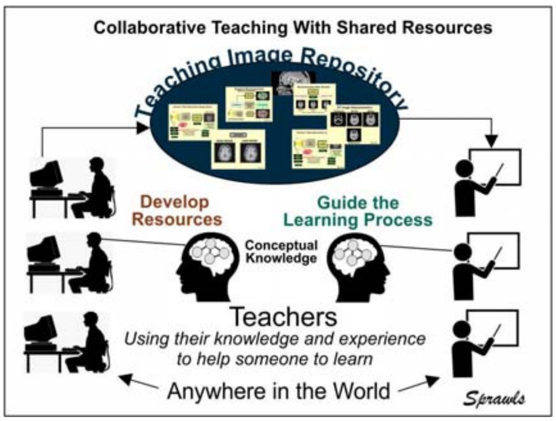


Fig.2. The role of teaching image Repositories in the process of collaborative teaching.

The World Wide Web provides the connection or link between the resource creators and the classroom learning guides. It provides a place where the resource creators can place or post their creations and where the classroom guides can find them. At this time there are many useful visuals and images on the web that can be used for teaching coming from many sources and somewhat randomly posted on a variety of websites. Here we describe a systematic process leading to a much more extensive activity for sharing resources and enhancing medical physics teaching around the world.

The foundation for this is the establishment of teaching image Repositories by medical physics organizations or institutions around the world. The Repositories provide web space for all resource creators to post their visuals in a form that is optimized for finding by classroom learning guides.

After reviewing the concepts of the learning and teaching process, especially for clinical medical physics, and the significant role of images and visuals, the process of developing effective teaching image Repositories will be described.

II. RADIOLOGY CLINICAL IMAGE TEACHING FILES

A major resource for radiology education, especially for residents, are the "teaching files" developed by organizations, institutions, and individual faculty containing clinical images showing various pathologies and normal variants. These are often contributed by individual radiologists as they encounter "interesting cases" during clinical activities. They can be used for self-study by residents and presentations in classroom and conference discussions. A great value is it gives those conducting classes and conferences access to a much greater range of clinical images and cases than they can develop from their own activities. It is an example of *shared resources.*

Clinical radiology teaching files can be considered as a model for the medical physics image teaching Repositories discussed here. There shared characteristics are the use of images to enhance learning, providing access to an extensive range of images and visuals for teaching, an opportunities for individuals to use their experience and contribute to the educational process for many.

III. EFFECTIVE TEACHING

Effective teaching of medical physics, especially clinically applied physics for both physics students and radiology residents, requires images that enable the learners to visualize the physical elements and interactions of the imaging process including the characteristics of images and their relationship to visibility of anatomical structures and pathological conditions as illustrated in Fig. 3.

Fig.3. Using visual resources in the classroom to enhance effective learning and teaching.

Both learning and teaching are human mental activities. The effectiveness of each activity, both learning and teaching, can be enhanced or enriched with an appropriate learning and teaching environment, typically the classroom, physically together or online. A continuing challenge is the availability of appropriate visual resources for classroom and conference learning activities. The development of effective visuals requires medical physics experience, capabilities, resources, and efforts beyond what each individual classroom leader can provide. A solution is the availability of shared resources prepared by many resource creators from around the world.

IV. BUILDING EFFECTIVE KNOWLEDGE STRUCTURES

Teaching should be the processes of helping learners build effective knowledge structures that can be used to perform specific medical physics activities. Effective knowledge structures and their significance in the learning and teaching process have been described in previous publications contained in the Bibliography at the end of this article. A brief review is provided here. The relationship of mental knowledge structures to the physical environment is illustrated in Fig. 4.

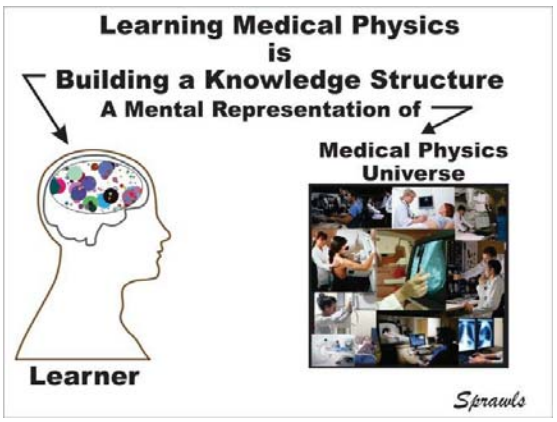


Fig.4. A knowledge structure is a mental representation of segments of the physical universe like medical procedures.

Here we are considering the characteristics of medical physics knowledge structures that determine the types of resources that can be used to enhance the teaching process of *helping the learner develop appropriate knowledge structures.*

Let's "look" into our own minds at our knowledge structures of medical physics and also how we developed them. Typically we can visualize many mathematical equations, memorized verbal descriptions, definitions, and facts. That is good and necessary but is not the knowledge that enables us to perform many medical physics functions, especially in clinical applications.

Sensory Concepts

Learning is an ongoing natural human process throughout life and does not always require classrooms and teachers! The natural learning process, both outside and within formal education school classrooms occurs as we interact with the environment around us with our senses, especially vision, hearing, and touch. These interactions produce knowledge structures consisting of *sensory concepts*. These are generally complex networks of experiences that are mental representations of specific areas of the physical universe. For example, all of us medical physicists have mental concepts of x-ray tubes that perhaps began when we were students and have been expanded and enhanced by our continuing experience and interactions with x-ray tubes.

It is our sensory, especially visual, conceptual knowledge structures, which are required for many applications of physics in clinical medicine. This is especially significant in relation to the physics of images.

V. TEACHING

One method of teaching is just the transfer of information from the mind of the teacher to the mind of the learner. This can be very appropriate and adequate for many situations, but not for many medical physics activities. The application of medical physics in clinical procedures both therapeutic and diagnostic imaging requires a comprehensive conceptual knowledge structure that cannot be developed with verbal lectures and conversations. It requires an intellectual interaction between the learner and the physical reality or sensory representations, especially visual, of the physics within the clinical procedures. That is what can be provided by *resources.*

.

Effective Teaching

Effective teaching is the process of helping someone develop knowledge structures that enable them to perform specific functions, often referred to as tasks. These can be very different ranging from making high scores on a written examination to optimizing an imaging procedure with respect to image quality and radiation exposure. Both are important but require different approaches to teaching.

VI. VISUALS FOR EFFECTIVE LEARNING AND TEACHING

The desired characteristic of visuals for teaching is to enable the learner to form sensory concepts of the physical process being studied. Especially for radiologists and radiology residents *images* are the *physical objects* that are the focus of their required physics knowledge for clinical application. The several functions that require knowledge of the physical characteristics of images and the imaging process are illustrated in Fig.5.

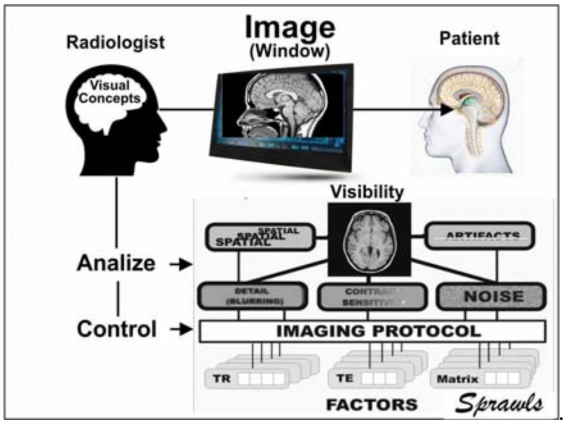


Fig.5. Functions performed by radiologists that require a conceptual knowledge of image characteristics and the formation process.

An effective knowledge of the physics of medical imaging can only be developed by viewing images and visual illustrations of image characteristics and related factors. The following are two illustrations.

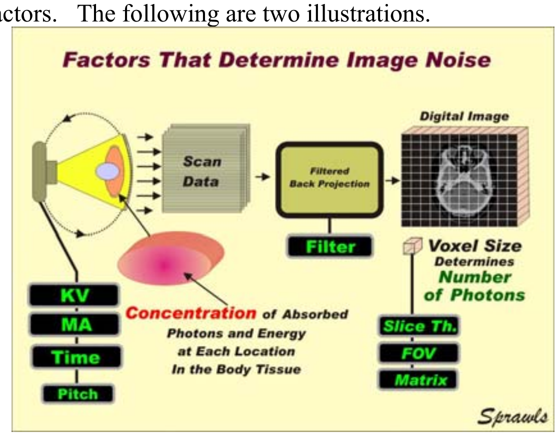


Fig.6. The combination of factors that have an effect on CT image noise.

.

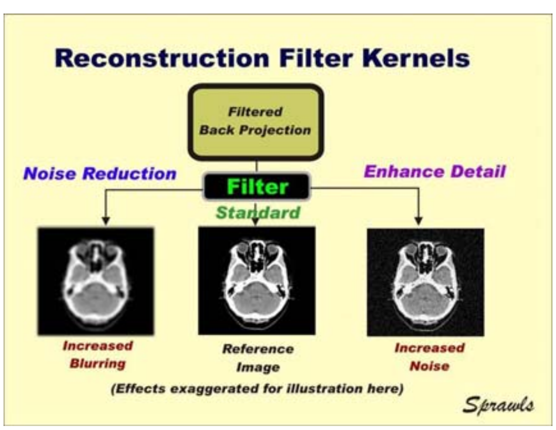


Fig.7. Illustration of the general effect of CT reconstruction filters selections on image quality.

One of the more complex factors in CT imaging is the function of the reconstruction filters as applied in clinical imaging. This visual provides an introduction and illustrates the conflicting effect on image quality that must be considered in clinical imaging.

VII. PRODUCING IMAGES FOR TEACHING

Computer graphics software for producing visuals and images for teaching, like those shown in Figs.6 and 7, use two different mathematical methods, generally referred to as *draw* and *paint*. Each has functions that are needed to produce visuals that illustrate the characteristics of medical images and related factors. The display for the software used by the author that provides both methods is shown in Fig. 8.

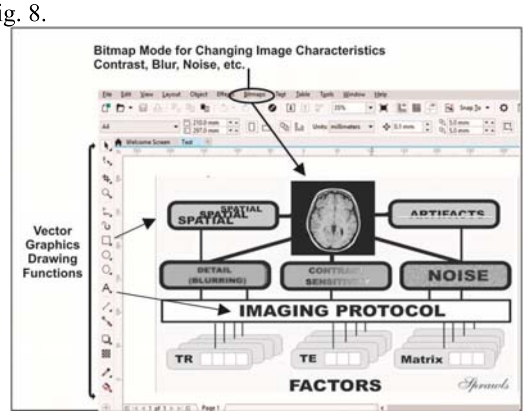


Fig.8. Computer graphics software used to produce visuals for teaching medical physics.

The combination of the two functions, draw and paint, enables the development of comprehensive visuals with embedded images with a range of characteristics.

Programs for Vector Based Images (Draw)

Each object in an image is represented by a series of numerical values (a vector) representing each characteristic, size, shape, position, color, location, etc. The advantage is these are adjustable through the various drawing functions shown on the left side of Fig. 8. This is used to develop illustrations composed of various objects and text. Images of objects from other sources can be imported. An example would be anatomical drawings.

When a visual is completed in vector format it can then be exported into a bitmap for posting on the web or other applications.

Programs for Processing Bitmap Images (Paint)

Virtually all medical images, digital photographs, and images on the web are bitmaps consisting of a matrix of pixels each having a numerical value. Unlike a vector based image the objects in a bitmap cannot be changed with respect to size, shape, location, etc. Those characteristics are fixed. However, the numerical values within each pixel can be changed. These are the factors that represent the image characteristics including contrast, blurring, and noise. The significance is that the bitmap based paint software has many functions for changing these image characteristics, One application is to use the noise function to modify a clinical image with different levels of noise to produce images for teaching.

The Human Factor, Visualization, and Creativity

A computer with the graphics software described here is a tool that can be used by medical physicists to create images that illustrate and convey to learners much of our conceptual knowledge and understanding of applied medical physics. It provides an opportunity for us medical physicists to transfer knowledge from our brains to the brains of others in a visual form that can be applied especially in clinical applications.

Producing visuals like Figs. 6 and 7 requires extensive effort, time, and experience. It is neither possible nor practical for each classroom teacher to produce the visuals they need. The initiative described here is a solution and contribution to more effective medical physics teaching on a global scale.. It is for many medical physicists to produce some visuals and share them with all other teachers anywhere else in the world. It is an opportunity for individual medical physicists to use their unique knowledge and experience to "teach" others…one image at a time. The value of the creations of individuals is magnified many times when they are shared with others to use in classrooms and conferences around the world.

Before discussing the development of image Repositories for teaching it is helpful to confirm the several values of collaborative teaching and its contribution to more effective and efficient medical physics education. There are four major parties that can benefit from the development and sharing of visual resources as described.

Learners: Radiologists and Medical Physics Students

It is the learners who benefit from the greater availability of visual image- based teaching resources that enhance their conceptual knowledge of physics especially applied to medical procedures.

Classroom and Conference Learning Guides

The increased availability of visuals for classroom and conference presentations and discussions can contribute to a higher level of professional performance by medical physics teachers, both in terms of *efficiency* and *effectiveness*.

Their *efficiency* in terms of time and effort is increased by not having to develop all of the visuals for their classes and thus devote more effort in interactions with the learners and guiding the learning process.

Their *effectiveness* as teachers is greatly enhanced by the availability of classroom visuals that can be used to connect learners to the physical objects, systems, interactions, and functions they are studying. The teachers can then contribute their knowledge and experience to the learning process.

Medical Physics Organizations and Institutions

The specific opportunity to medical physics organizations and institutions around the world is to host Teaching Image Repositories on their websites. The details of creating and hosting Repositories are described below. The value to an organization is through the opportunities it provides to members by providing a Repository and encouraging members to use it both as classroom teachers and resource creators. Organizations can promote this through presentations at conferences, periodic publications, and on websites.

Medical Physics Visual Resource Creators

There are generally two categories of medical physicists who are potential contributors to medical physics teaching image Repositories.

Current Classroom Teachers

Many classroom teachers conducting courses for both medical physics students and radiology residents have developed for their use high-quality visuals that would be of value to teachers in other institutions and programs. These teachers can contribute to the global educational process by creating open source teaching image Repositories on their institutional websites and posting selected visuals that they would like to share.

Practicing Clinical Physicists

There is the opportunity for medical physicists with experience in clinical applications to become teachers "to the world". This is done without writing textbooks or providing complete courses and classes--just by creating individual visuals for teaching. The values to the individual physicist are many. It provides an opportunity to use their experience, especially clinically applied medical physics, to create visual "windows" into the physics of medical procedures. For all of us medical physicists this can be an interesting learning experience—first by giving thought to how to best visualize the physics so others can learn from it and then by the process of producing the visuals using computer graphics software.

Of special significance is the fact that medical physicists can acquire international visibility and recognition for their creative work, especially with high-quality visuals that contribute to the learning and teaching process.

When there is an opportunity it is helpful to collaborate with radiologists and residents on developing visuals they see as helpful for learning applied physics.

VIII. REPOSITORY DEVELOPMENT

A Repository provides the connection between two collaborating teachers, the *resource creator* and the *classroom learning guide*. It provides specific opportunities for each. The first is the ability to develop and post images in the Repository with information or "labels" that identify and describe the image subject in sufficient detail. The second is the ability to search a Repository from anywhere in the world to find images illustrating specific concepts and topics. This requires an understanding of the process and how it can be used effectively.

Images on the Web

There are many medical physics related images on the web. These are from many sources including various publications, institutions, organizations, equipment manufacturers, commercial enterprises that sell images, and many more. Even when images are within the context of documents, publications, and various websites they often appear as individual image files with some distinguishing identification characteristics such as file name, content within a specific website, and associated personal names.

There are several web-based programs that can be used to search for specific images, Google Images (https://images.google.com/) is the example used here. These programs, often called "search engines" organize the images on the web into *categories* identified by a combination of words that teachers can use to guide a search.

Here we illustrate by entering " CT Image Artifacts" into Google Images. The result is an extensive collection of images-- many of which can be used for teaching.

Web Crawlers/Spiders

A first function performed by search engines like Google is to detect the images that have been posted on the web and assign them to various categories where they can be found when someone searches like we just did for the category "CT Image Artifacts". The individual images in that category had many different identifying factors or labels that were considered for assigning to categories.

That function is performed by automated computer ro**bots** or bots that are generally known as web crawlers or spiders. This is somewhat descriptive of how they function. They move around the web going into the various web sites analyzing the content, both text and images. Our interest here is the images which can be more difficult to analyze that written text. As described later there are actions we can take when posting images for teaching that will help to get them into appropriate categories.

Many of the images on the web from the many sources are valuable for teaching medical physics and can be found by searching various categories as we just did for "CT Image Artifacts" even though they were not developed for teaching purposes.

The purpose described here with the creation of medical physics teaching image Repositories is to encourage and provide an opportunity for individual medical physicists to create and share images specific for teaching that will enhance international medical physics education.

Search Engine Optimization (SEO)

The ability of web crawlers to find and place images into appropriate categories depends on the information associated with each image that is posted along with the image. Preparing items to maximize their being placed into appropriate categories by web crawlers is the process of search engine optimization (SEO). This is a somewhat complex process when applied to all aspects of a website and tutorials can be found on the web at sites including Search Engine Optimization (SEO) Starter Guide provided by Google.

Our interest here is specifically on optimizing images to enhance the search process. This is by "labels" added to images by the resource creator and repository website manager. The two significant labels are *file names* and *alternate text*.

The file name assigned by the resource creator should be as descriptive and specific to the image as possible using a combination of several words. An example could be CT image noise 01.jpg. There should to be a balance between names that are broad and specific. Generally somewhat broad names, like three words, will enable web crawlers to list the images into categories where they can be found by teachers. When there are several images in the same category, numbers included in the file name (01, 02, 03, etc.), provide specific identity for an image and maintain a category description.

Image *alternate text* is the description of image content added to images when they are posted on the web. This is the text that will be displayed if the actual image cannot be viewed for some technical reasons. Also the alternate text is used by web crawlers to determine the content of images and place them into appropriate categories. Effective alternate text is a series of words describing image content with specific terms (MRI, noise, voxel, etc.) and limited use of general terms (illustration, image, relationship, etc.).

IX. HOSTING A REPOSITORY

A medical physics teaching image Repository is designated space, generally on an organizational or institutional website with an URL of the form www.sprawls.org/repository. This is a model repository provided by the author to illustrate some of the characteristics and functions of Repositories. Organizations and institutions might use variations of this design to best serve their members. A suggestion is a folder or directory with the name "repository" on the website and the index or default webpage within with the name “medical physics teaching images”.

Some Repository hosts might include a Table of Contents or Directory on the website so searchers can go directly to the Repository and see what visuals are available. However, the greatest visibility from around the world will come from searches on specific categories like our example “CT image artifacts”.

Hosting Organization

A hosting organization, or institution, can establish the Repository project within the appropriate committee or administrative unit. Those would provide the specific design, organization, and operation of the Repository that provides support and teaching opportunities for the members. This will include creating a Repository manager or designated individual to manage the content.

Repository Manager

The Repository manager performs several functions as image files are received from the resource creators. First is to check submitted images for both content and format to determine if they are appropriate for the Repository. Then as images are posted on the website providing *file names* and *alternate text* to enhance the function of the web crawlers and search engines.

X. INTERLECTUAL PROPERTY AND PERMISSIONS

One of the purposed of having designated teaching image Repositories on organization or institutional websites is to provide content with specific conditions for us in educational activities including classroom teaching.

Intellectual Property Recognition

The visuals contributed to a Repository are generally the intellectual property of the resource creator that are being providing as an open and free resource to be used for educational purposes. The visuals should not contain any copyrighted material, by the creator or others, that would limit the ethical or legal use in educational activities. The established procedure is for each visual to have an identification of the creator, typically at the bottom.

This identification should not be removed or altered by classroom teachers.

Copyrighting

Unlike much material posted on websites the content of the teaching image Repositories should not be copyrighted that would limit its use or require permission for educational purposes. Copyright protection against unauthorized commercial use is appropriate.

XI. THE SPRAWLS RESOURCES

The concepts of collaborative teaching and shared resources described here are based on the extensive work of the author and provided on the website: www.sprawls.org/resources.

That site is actually a “Repository” of many images and visuals that are used in classrooms around the world to support classroom teachers/learning guides in helping learners develop highly effective and useful conceptual knowledge of medical physics.

XII. THE ENCYLOPAEDIA OF MEDICAL PHYSICS

The Encyclopedia online at: http://www.emitel2.eu/emitwwwsql/project.aspx is a major resource of visuals that can be used for teaching along with discussions and references for virtually every topic in medical physics. It can be searched for specific topics and is a valuable aide in preparing teaching materials, especially on recent developments in medical physics and clinical applications. The content is developed and contributed by many medical physicists from around the world who have knowledge and experience with the various topics. It is an example of the value of shared resources in medical physics education.

XIII. CONCLUSIONS

Physics is the fundamental science of many highly valuable diagnostic and therapeutic methods and procedures. With the increased capabilities and complexities of these procedures a more comprehensive conceptual knowledge of physics is required for the effective and optimized clinical applications. Teaching to help learners develop this knowledge requires extensive visual representations and images that can be used in classroom and conference discussions and learning activities. The creation of teaching image Repositories by medical physics organizations or institutions provides an opportunity for medical physicists from around the world to create and share educational resources in the form of visuals and images that can make a significant contribution to medical physics education.

The teaching of medical physics with visuals and images, especially for radiology residents and other clinical professionals provides several values. The physics class or conference is similar to and connects to those for clinical radiology with a visual focus on images. Most significantly it provides a highly effect conceptual knowledge that is required to apply physics in the practice of clinical radiology.

BIBLOGRAPHY

The publications provided here are devoted to two specific but related issues in medical physics education. One is the factors that determine the effectiveness of educational activities to support clinical applications. The other is the application of specific learning and teaching principles in the optimization of medical imaging procedures.

Effective Learning and Teaching

- Sprawls P. Duong P-A T. Effective Physics Education For Optimizing Ct Image Quality And Dose Management With Open Access Resources. . Medical Physics International Journal, vol.1, No.1, 2013 http://www.mpijournal.org/pdf/2013-01/MPI-2013-01-p046.pdf
- Sprawls P. Education Models for The Expanding Role Of Clinical Medical Physics. Medical Physics International Journal, vol.5, No.2, 2017 http://www.mpijournal.org/pdf/2017-02/MPI-2017-02-p167.pdf
- Sprawls P. Developing Effective Mental Knowledge Structures For Medical Physics Applications. Medical Physics International Journal, vol.6, No.1, 2018 http://www.mpijournal.org/pdf/2018-01/MPI-2018-01-p128.pdf
- Sprawls P. Effective Physics Knowledge For Diagnostic Radiologists. P. Sprawls. Medical Physics International Journal, Vol.7, No.3, 2019 http://www.mpijournal.org/pdf/2019-03/MPI-2019-03-p257.pdf

Optimizing Medical Imaging Procedures

- Sprawls P. Physics Education For The Optimization Of MRI Clinical Procedures: Visualizing The Invisible And Collaborative Teaching. Medical Physics International Journal, Vol.1, No.2, 2013 http://www.mpijournal.org/pdf/2013-02/MPI-2013-02-p134.pdf
- Sprawls P. Optimizing Medical Image Contrast, Detail And Noise In The Digital Era. Medical Physics International Journal, vol.2, No.1, 2014 http://www.mpijournal.org/pdf/2014-01/MPI-2014-01-p041.pdf
- Sprawls P. Digital Elements, Image Quality, Radiation Exposure, and Procedure Optimization. Medical Physics International Journal, vol.6, No.2, 2018 http://www.mpijournal.org/pdf/2018-02/MPI-2018-02-p255.pdf

About the Author:

Perry Sprawls is a clinical medical physicist specializing in diagnostic radiology and an education. He is Distinguished Emeritus Professor at Emory University School of Medicine in Atlanta and now contributes to medical physics education around the world through the Sprawls Educational Foundation, www.sprawls.org. It is the combination of his experience as a clinical physicist and educator that is the foundation for developing and sharing resources to support the teaching of medical physics. His continuing research and development activities are resulting in models for increasing the effectiveness of both the learning and teaching process, especially for clinically applied medical physics. This can be reviewed in the Bibliography.

The current effort described in this article is to encourage the collaboration of medical physicists in the creation, sharing, and use of visuals and images to enhance medical physics teaching and learning.

Contact Information: sprawls@emory.edu

HOW TO

MULTI-CENTRE INTENSITY MODULATED RADIOTHERAPY AUDIT IN MALAYSIA

Nur Diyana Afrina Hizam[1], Ngie Min Ung[1], Wei Loong Jong[1,2], Hafiz Mohd Zin [3], Kwan Hoong Ng[4]

[1] Clinical Oncology Unit, Faculty of Medicine, University of Malaya, Kuala Lumpur, Malaysia
[2] Department of Radiation Oncology, Auckland City Hospital, Auckland 1023, New Zealand
[3] Advanced Medical and Dental Institute, Universiti Sains Malaysia, Penang, Malaysia
[4] Department of Biomedical Imaging, University of Malaya, Kuala Lumpur, Malaysia

Abstract— **It is widely known that there is a need to assess the accuracy levels of the current practices in radiotherapy centres, and identify issues which may exist for future improvement and development. There is yet a national audit programme in Malaysia that assess the accuracy of the IMRT delivery. This paper describes the first trial of audit activities that had been carried out between 2018 and 2019 in Malaysia. The IMRT technique in Malaysia, in general, is well implemented following the recommendations from international guidelines. This study provides an invaluable measure of the treatment quality that any necessary improvement can be planned and implemented.**

Keywords— **Dosimetry audit, IMRT, national survey, planning, QA.**

I. INTRODUCTION

Dosimetry audit is one of the main components when it comes to managing the quality of the radiotherapy treatment [1]. It plays an important role to ensure the safe implementation of new technologies or techniques [2]. Besides, the external dosimetry audit can provide an independent check of the local approaches and allow the comparison among the participating centres. The sharing of experience among the participating centres allow benchmarking of centres with similar equipment and thus increases the knowledge of what is achievable with a particular combination of equipment. This activity will help the new or less-experienced centres in the implementation of new technologies or techniques.

Dosimetry audit may cover various levels from basic reference dosimetry to the treatment outcome [3]. In 2018, the University of Malaya in collaboration with Universiti Sains Malaysia has conducted the first external dosimetry audit activities in Malaysia. These activities focus on the Intensity Modulated Radiotherapy Technique (IMRT) where the majority of the centres had implemented the techniques after the year of 2010s. This activity is supported by Malaysia Oncological Society (MOS) and aims to assess the current practice and quality of IMRT delivery among radiotherapy centres in Malaysia. This article summarises the overall activity that had been conducted.

II. ACTIVITIES AND STATUS

There are in total 33 radiotherapy centres/department compromises of 9 public or university hospitals and 24 private centres from the list provided by Ministry of Health (MOH) Malaysia at the time of this audit was conducted. The first part of the audit programme conducted in Malaysia was carrying out a facility questionnaire followed by the IMRT planning activities and the on-site visit of verifying the deliverability of the IMRT plans. These activities were conducted in sequence as shown in Figure 1.

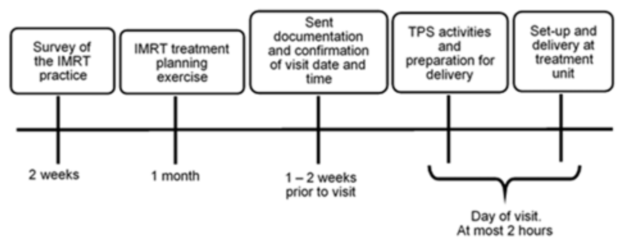


Fig. 1 The timeline of the audit activities

Facility questionnaire

The questionnaire was developed, and it contained several sections that covered the medical physics staffing information, treatment planning system, treatment units, IMRT QA tools and IMRT process. The questionnaire was then distributed to all radiotherapy centres/departments in Malaysia between December 2018 and September 2019.

There were 26 centres participated in this survey representing 79% of the response rate. From this survey, it was observed that the IMRT practice in Malaysia is homogenous with some variation in certain practice. All centres performed IMRT QA before starting the treatment [4]. About the IMRT process, the physicist in Malaysia spent a long time to produce a clinically acceptable head and neck treatment plan compared to those in the UK [4]. The survey provides a picture of medical physics of IMRT practice in Malaysia where the data can be used by radiotherapy centres to benchmark their local practice. The full results had been reported and can be found here (https://doi.org/10.1016/j.ejmp.2019.10.023).

IMRT treatment plan

In this second part of the audit activities, looking into the quality of the treatment plan produced by the physicist among participating centres. The controlled dataset was given and the participating centres produced their treatment plan within the given time frame. The documentation was prepared and sent to the centres as guidance for the physicist to complete this part of the audit activity.

All plans were analysed against the planning goals provided using a commercialised software where the dose distribution can also be viewed as shown in Figure 2. Looking into details of the dose distribution, some variations were observed from the plan produced by the participating centres. Besides, some metrics were calculated to quantify the quality and complexity of the plans between participating centres. The full report of the results is set to be published soon.

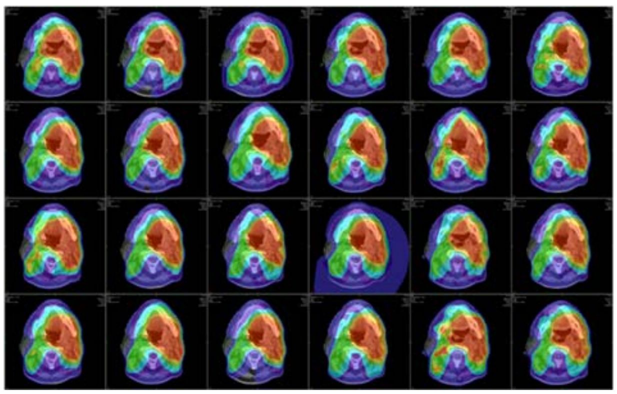


Fig. 2 Screenshot of the transverse view of the dose distribution from the plan produced by the participating centres

On-site visit

The last part of the audit activity was an on-site visit to the participating centres to assess the accuracy of the IMRT delivery. This part of the audit activity required more preparations as it involved visiting the centres where the flow of the activities was important due to the known busy clinics in radiotherapy centres/departments. Several documents were prepared and sent to the participating centres before visiting them. The measurements were done by using independent tools where the point dose and the planar dose were compared with the calculated dose distribution of the plan produced from the treatment planning system of the centres.

Due to the limited resources, 11 centres were visited in Klang valley area and Penang between April to September 2019. Figure 3 shows the photo taken during the visit from one of the participating centres. The dose difference of the point doses and the gamma analysis of the planar dose were analysed by using a recommended tolerance. The full results of the analysis will be available soon.

III. Conclusions and suggestions for future

A first multi-centre audit had been successfully conducted in Malaysia. This dosimetry audit should be continuously upgraded and conducted within radiotherapy centres. These activities will contribute towards advancement and harmonization of IMRT/VMAT treatment delivery in this country. Besides, the audit can be extended to more advanced techniques that have been introduced in radiotherapy.

Acknowledgement

This work was supported by the Malaysian Oncological Society (MOS) and the University of Malaya. The authors therefore gratefully acknowledge the MOS and the University of Malaya for financial support. We would like to thank the medical physicists in the following centres for taking the time to participate in this audit activity: AMDI USM, Gleneagles Kuala Lumpur, Gleneagles Penang, Hospital Fatimah Ipoh, Hospital Sultan Ismail, Hospital Wanita & Kanak-Kanak Sabah, HUSM, KPJ Damansara, KPJ Sabah, Loh Guan Lye Specialist Centre, Mahkota Medical Centre, Mount Miriam Cancer Hospital, National Cancer Institute, Nilai Medical Centre, Pantai Hospital Kuala Lumpur, Pantai Hospital Malacca, Pantai Hospital Penang, Penang Adventist Hospital, Prince Court Medical Centre, Sarawak General Hospital, Subang Jaya Medical Centre, Sunway Medical Centre, Tung Shin Hospital, UKMMC, UMMC.

References

1. Clark, C. H., et al. (2015). Radiotherapy dosimetry audit: three decades of improving standards and accuracy in UK clinical practice and trials. The British journal of radiology, 88(1055), 20150251.
2. Clark, C. H., Jornet, N., & Muren, L. P. (2018). The role of dosimetry audit in achieving high-quality radiotherapy. In: Elsevier.
3. Bolt, M. A. (2018). Evidence-based assessment of the clinical impact of dose variations arising in the clinical radiotherapy dosimetry chain. University of Surrey (United Kingdom),
4. Hizam, N. D. A., Ung, N. M., Jong, W. L., Zin, H. M., Rahman, A. T. A., Loh, J. P. Y., & Ng, K. H. (2019). Medical physics aspects of Intensity-Modulated Radiotherapy practice in Malaysia. Physica Medica, 67, 34-39.

Contacts of the corresponding author:

Author: Ngie Min Ung
Institute: Clinical Oncology Unit, University of Malaya
City: Kuala Lumpur
Country: Malaysia
Email: nmung@ummc.edu.my

TECHNOLOGY INNOVATION

THE MATHEMATICAL, PROBABILISTIC AND COMPUTATIONAL GENERATORS OF DISCRETE PROBABILISTIC DISTRIBUTIONS APPLIED TO MEDICAL PHYSICS

Terman Frometa-Castillo[1], Anil Prasad Pyakuryal[2], Asghar Mesbahi[3], Amadeo Wals-Zurita[4]

[1]Statistical models project, LLC, USA
[2]University of District of Columbia, Division of Science and Mathematics USA.
[3]Tabriz University of Medical Sciences, Iran.
[4]Hospital Universitario Virgen Macarena, Spain.

Abstract— **Despite the binomial distribution (BD) and its limiting case, the Poisson distribution (PD) are probabilistic functions (PFs), they are mathematical derivations, where little probabilistic foundations were used in their formulations. These PFs have been overestimated and irrationally used in many scientific/technical fields.**

This work discussed three practical examples. One of them shows the expected values for "*k*" trails of a stochastic process characterized with a success probability *"p"*. Another examples are related with use of the BD as an excellent-mathematical generator of NTCP(xi) discrete probabilistic distributions; and with use of BD/Poisson distribution (PD) in the nuclear medicine for evaluating probabilities of measurements of a long-lived radioactive sample as a random variable N, as well as use of cumulative distribution functions for evaluating probabilities of some interval of N, and for determining with iterative calculations confidence intervals. The BD(x;2,p) terms are probabilistically obtained; as well as a MatLab application was developed, which generates random discrete probabilistic distributions based on probabilistic foundations. The irrational use of the PD in the derivation of the Poisson-based TCP model has been described.

This work will help medical physics community to understand: 1) How the BD and PD were derived; 2)What really the BD and PD are; 3) How one should use the BD; 4) The PD is not a new PF, but the own BD with simplifications valid for some values of BD parameters, and changes of variable and parameters; and 5) Given the essential condition for a PF is not satisfied in the PD for some values of its parameter, also we can say that: The PD is not a PF. For these reasons, the PD(x;µ) could be replaced with the BD(x;Xmax,p), where *Xmax* is the possible outcomes of a stochastic process, *Xmax=n* and *p= µ/Xmax*.

Keywords—**Binomial distribution, Poisson distribution, Computational simulation, TCP, Probability**

I. INTRODUCTION

The SMp(x) of [1] is a probabilistic function (PF) that lets us generating probability density functions and discrete probabilistic distributions (DPDs). Although SMp(x) has six parameters, up to five of them are independent given its condition of PF.

.

The BD and PD are analytical functions that generate DPDs. These functions have mathematical origins, and have been over-estimated in their applications. Besides, they have been irrationally used in the ionizing radiation field for deriving the Poisson-based tumor control probability (TCP) model and describing the interactions of ionizing radiation with living tissues.

Despite the associated elaboration of a computational application is one of our objectives; in this study there are others more important purposes, such as

1- To show the probabilistic way of obtaining the BD(x;2,p) terms.

2- To show the irrational use of the PD in the derivation of the Poisson-based TCP model.

3- To show the PD is not a new probabilistic function, nor its parameter is a new one. PD is the own BD(k;n,p) with some mathematical simplifications valid only for some values of parameters *n* and *p*, and change of the BD variable *k* by *x*, as well its parameters *n* and *p* by λ or µ as the product of them; i.e. $\lambda=\mu=n*p$. For these reasons, the PD(x;µ) should be replaced with the BD in the form BD(x;Xmax,p), where *Xmax* is the possible outcomes of a stochastic process, *Xmax=n* and *p= µ/Xmax*.

4- To establish the BD(x;Xmax,p), SMp(x;Xmax,p) and SMp(x;Xmax) simulator as ways of obtaining DPDs.

We hope the student/teacher/researcher communities will understand that BD is only an excellent- mathematical generator of DPDs, and PD is not a new probabilistic function, but the own BD, as well as λ and μ are not new parameters, but the product of BD ones; i.e. λ=μ=n*p. This understanding could avoid the overestimated, confused and irrational use of BD and PD in different fields.

It is very essential to understand that if a stochastic process has a success probability p, *p=K/N* (*K*: Success events, and *N*: Total of events) and for *n* trials, the ratio k/n (*k*: Expected success events) is equal to or approximately equal to *p*. This understanding will let you realizing of the little probabilistic and no practical importance of the BD(k;n,p).

I.1 The binomial distribution

The binomial expression of the Eq. (2) mathematically provides a sum of $\binom{n}{k}$ of $p^k(1-p)^{n-k}$ as result of replacing *a=p* and *b=1-p* in the Eq. (1), the binomial theorem, with which one can determine the series of sums for the power *n* of a sum of two number *a* and *b*. Here *p* is a parameter < 1 and *k=0,1,2,……n*

$$(a+b)^n = \binom{n}{0}a^0b^{n-0} + \binom{n}{1}a^1b^{n-1} + \cdots + \binom{n}{n}a^nb^{n-n} \tag{1}$$

$$(p+(1-p))^n = 1 = \binom{n}{0}p^0(1-p)^{n-0} + \binom{n}{1}p^1(1-p)^{n-1} + \ldots\ldots + \binom{n}{n}p^n(1-p)^{n-n} \tag{2}$$

$$\binom{n}{k} = \frac{n!}{k!(n-k)!} \tag{3}$$

The BD generates DPDs in the interval [0;n] varying its parameter *p*, where *n* is the other mathematical parameter.

The computational simulations of the BD generates a DPD of stochastic processes with three or more possible outcomes from many (>10000) simulations of a stochastic process with success probability *p* and *n* trials. This was computationally demonstrated with the simulator of [2].

I.2 The Poisson distribution.

Siméon Denis Poisson, the creator of the PD had two important merits: 1) Mathematically simplifying the BD expression; and 2) Replacing the BD variable *k* by *x* in his simplified expression; where they left to mention *k* as success trails and *p* as success probability, but variable *x* and parameter *μ* as the value of *x* with the maximum probability. *μ* is not a new parameter, but the product of the two BD parameters; i.e. *λ=μ=n*p*.

The PD was determined as follows

$$\lim_{n\to\infty} BD(k;n,p) = PD(k;\lambda) = \frac{e^{-\lambda}\lambda^k}{k!} \tag{4}$$

and employed for calculating probabilities of a random discrete variable X as

$$PD(x;\mu) = \frac{e^{-\mu}\mu^x}{x!} \tag{5}$$

I.3 The irrational use of the BD and PD in the ionizing radiation field

In the ionizing radiation field, the BD and PD are irrationally used for deriving some probabilistic models and concepts.

The use of Poisson statistics (PS) in TCP models has led to a negative-exponential expression in [3] and [4]. Also, the cell survival (S) has been described with the PS in these same references. The ways of describing S with the PS is probabilistically very complicated. Really, S is a probabilistic complement of the cell kill (K); i.e. K=1-S, and K can be modelled with the SMp(x) function of [1] as a stochastic effect type SMp P1.

For the formulation of TCP model of [3], the Eq. (5) was used and transformed as

$$PD = e^{-\mu} \tag{6}$$

that is result of considering the Poisson independent variable x as number of tumor clonogens, and equal to zero.

As expressed in [3]: "The Poisson probability of there being no surviving cells in a population of like tumors after a fractionated treatment is given by"

$$TCP = e^{-N_S} \tag{7}$$

$$N_S = N_0 S \quad (8)$$

where N_0: number initial of tumor clonogens.

S: The cell survival probability, which is modeled with the well-known linear-quadratic cell survival model for a fractionated radiation treatment.

II. RESULTS

II.1 Probabilistic determination of the BD(x;2,p) terms.

The BD(2;2,p) term associated to the probability $P_{k=2}$ is defined as

$$P_{k=2} = EV2/rtrials \quad (9)$$

where $EV2$ is equal or approximately equal to the number of trials with two successes in two trials; *rtrials*: number of times is repeated the two trials.

$$K_1 = p * rtrials \quad (10)$$

$$K_2 = p * rtrials \quad (11)$$

where K_1: Equal or approximately equal to amount of successes in the first trials; and K_2: The same to K_1 in the second trials.

For many *rtrials* (>10000) $K_1 \cong K_2$, and $p*K_2$ is equal or approximately equal to the number of times that two trials will produce two successes; i.e. $p*K_2=EV2$, substituting $EV2$ in the Eq. (9), and K_2 from the Eq. (11), we obtain that

$$P_{k=2} = {p * p * rtrials}/{rtrials} \quad (12)$$

$$P_{k=2} = p * p \quad (13)$$

$$P_{k=2} = p^2 \quad (14)$$

The BD(0;2,p) associated to probability $P_{k=0}$ is determined with a similar procedure employed in the term BD(2;2,p), but in this analysis the failures should be considered, instead of successes. For these reasons,

$$P_{k=0} = (1-p)^2 \quad (15)$$

The BD(1;2,p) associated to probability $P_{k=1}$ is defined as

$$P_{k=1} = EV1/rtrials \quad (16)$$

where $EV1$ is equal or approximately equal to the number of trials with one success in two trials; *rtrials*: number of times is repeated the two trials.

$$K_1 = p * rtrials \quad (17)$$

$$K_2 = p * rtrials \quad (18)$$

where K_1 is equal or approximately equal to amount of successes in the first trials; and K_2: The same to K_1 in the second trials.

For many *rtrials* (>10000) $K_1 \cong K_2$, and $(1-p)*K_2=K''$ is equal or approximately equal to the number of successes in the second trial that have a failure in first trial, $(1-p)*K1=K'$ is equal or approximately equal to the number of successes in first trials that have a failure in second trials, and $EV1=K'+K''$, and substituting K_1 in K', and K_2 in K'' of the Eq. (17) and Eq. (18) respectively, then

$$K' = (1-p) * p * rtrials \quad (19)$$

$$K'' = (1-p) * p * rtrials \quad (20)$$

Substituting $EV1$ in the Eq. (16),

$$P_{k=1} = \frac{K'+K''}{rtrials} \quad (21)$$

Using the Eq. (19) and Eq. (20),

$$P_{k=1} = \frac{(1-p)*p*rtrials+(1-p)*p*rtrials}{rtrials} \quad (22)$$

$$P_{k=1} = 2*(1-p)*p \quad (23)$$

II.2 Random generation of discrete probabilistic distributions

II.2.1 Description of the codes

This work has developed a MatLab computational tool, which generates random discrete probabilistic SMp(x;Xmax) distributions, where *Xmax* is number of possible cases. This application is available in the “GenDPD” project of https://gitlab.com/tfrometa. The generation of these distributions probabilistically satisfies that $\sum SMp(x_i;Xmax) = 100\%$ always.

II.2.2 Reproducibility

At the application, the input value (IV) *Xmax* appears in yellow color, while outcome of the sum of simulated probabilities appears in green. One should press the "Enter" key placed at Xmax field for introducing its value into the application. The Figure 1 shows a generated discrete probabilistic SMp (x;5) distribution.

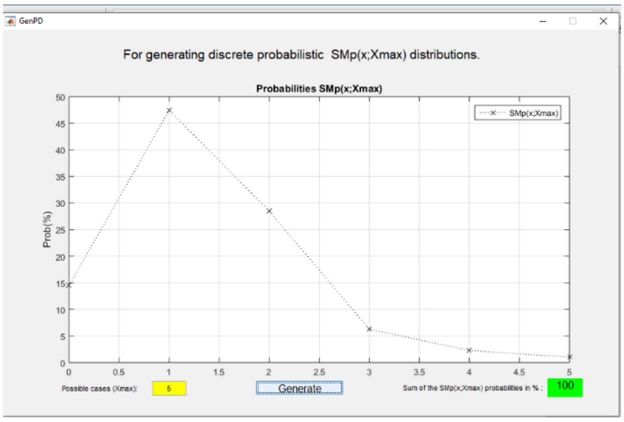


Figure 1. It is shown that a random-generated discrete probabilistic distribution and its sum as $\sum_{i=0}^{5} \mathrm{SMp}(x_i; 5) = 100\%$.

The steps for the execution of this module are: a) Introduce parameters *Xmax*; and b) Press the "Generate" button

III. Discussion

III.1 The binomial and Poisson distributions

Really, PD is a mathematical simplification of the BD. While PD has simplified the BD expression, the methodologies employed in the "Binomial" and "Poisson" modules of [2], are very similar. For these reasons, in the new computational simulator of the "SimPD1" project of https://gitlab.com/tfrometa, the "Poisson" module has been eliminated, and the "Binomial" module has been renamed as "Binomial-Poisson", which generates probabilistic SMp(x;Xmax,p) distributions, where *p=μ/Xmax* and *Xmax=n*. The Figure 2 and Figure 3 are results obtained by the computational simulator developed in [2] and one of the two applications developed in this study; and show the whole coincidence of the simulated SMp(x;Xmax,p) distributions with the BD.

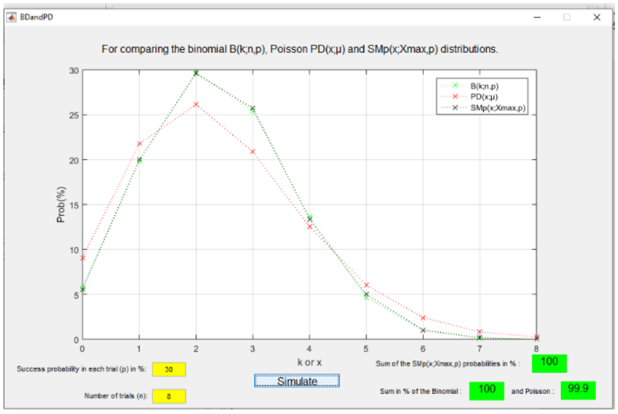


Figure 2. It is shown that Poisson generates a proper for describing this discrete distribution, since $\sum_{i=0}^{8} PD(x_i) \approx 100\%$.

While the BD results are obtained with mathematical procedures, the simulated SMp distributions are obtained by means many simulations (>10000) of a stochastic process with a success probability *p* and repeated *rtrials* its *n* trials.

The BD and SMp distributions are always DPDs in the interval [0;Xmax], however for some values of parameters *n* and *p*, as the Figure 2 shows, the PD is good approximation of the BD and generates DPDs, but for others, as the Figure 3 illustrates, PD is not good approximation of the BD and does not generate DPDs because of this PD does not satisfy the essential condition for the probabilistic functions, where *sum(PD(x_i))* must be equal to 100%.

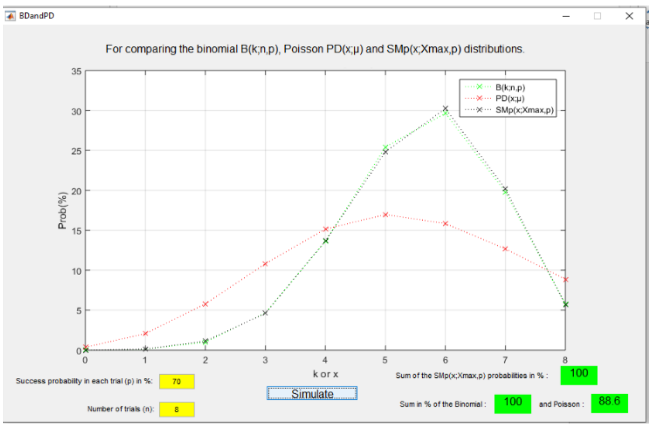


Figure 3. It is shown that this PD does not generate a DPD in this interval, and is not good approximation of the BD. There a difference of 11.4% in the sum of the P(x*i*); i.e. $\sum_{i=0}^{8} \mathrm{PD}(x_i) \neq 100\%$.

Although the BD expression coincidently is a DPD of *k* successes of many repeated (>10000) *n* trials of a stochastic process (SP) with success probability *p*, really when a SP is characterized with a success probability *p*, it implies that:

a) *p* was obtained as *p=K/N*, where *K* is the number of success results and *N* is the total of events.

b) Each trial has a success probability *p*.

c) In *n* trials, the ratio of *k* successes and *n* trials should be equal or approximately equal to *p*; i.e. $\frac{k}{n} \cong p = K/N$. For example: When a homogeneous population of 100 patients are treated with a same radiation oncology treatment, and 60 of them were cured; we say this treatment has a tumor control probability (TCP) equal to 60%; and if *n* new patients are treated later, the relationship between *n* and expected patients cured (*k*) will be

New patients (n)	5	10	25	40	70	80	100
Expected patients cured (k)	3	6	13	24	42	48	60

d) There is no need of creating a second and new probability P(k;n,p) dependent of *p*, like the BD(k;n,p).

III.2 The Poisson distribution in ionizing radiation field

The Poisson-based TCP model is wide employed in the field of the radiation treatments, how is shown in [5] and [6].

The criteria of "no surviving cells" or "100% killed cells" are proper for determining TCP. In fact, this condition was used in the first radiobiological simulator of [7].

Although the "no surviving cells" is a good criterion associated to TCP, it is not correct to associate the Poisson independent variable x with the number of tumor clonogens, and the Eq. (5) with TCP.

The BD can be used for describing or assuming $NTCP_i$ *i=0:n* (n: number of complications) that involves NTCPs (Normal tissue complication probabilities) and NTCP0 (Normal tissue non-complication probability). NTCP0 is a new probabilistic metric associated to evaluations of safety in whatever risky activity, like radiation oncology therapy. NTCP0=$NTCP_0$ and is probabilistic complement of the total NTCP (TNTCP); NTCP0=100%-TNTCP, and $TNTCP = \sum_{i=1}^{n} NTCP_i$. TNTCP is a new probabilistic metric too. NTCP0 is associated to the safety, and TNTCP is associated to toxicity, how is described in [8].

III.3 Teaching/learning importance of this work.

This work provides the following teaching lessons:

a)- The BD and PD have been overestimated and irrationally used in different fields, like the ionizing radiation one.

b)- The BD is an excellent-mathematical generator of DPDs, and coincidentally is associated to the probabilities P(k;n,p) only for many repeated *n* trials (> 10000).

c)- The PD(x;μ) is not a new probabilistic function, but the own BD with a change of variables and simplifications valid for determined values of the BD parameters (*n* and *p*); and its parameters (λ and μ) are only the product of *n* and *p*. A simple change of variable *k* by *x* does not generate a new function. For these reasons, the PD(x; μ) should be replaced with the BD(x;Xmax,p). Even, given the essential condition for a PF is not satisfied in the PD for some values of its parameter (See Figure 3), also we can say that: The PD is not a PF.

d)- The probabilistic generation of the BD(x;2,p) terms.

e)- The irrational use of the PD in the derivation of the Poisson-based TCP model.

f)- Additional to mathematical way of generating DPDs, there are other methods, such as the probabilistic and computational.

g)- Unnecessary use of the P(k;n,p) probabilities, like the BD, for stochastic processes are characterized with a success probability *p*. In the Section III.1, with a practical example, we show what means whether a stochastic process is characterized with a success probability *p*. For this reason, the BD should be used as BD(x;Xmax,p), where *p* is simply a mathematical parameter. For choosing the binomial parameter *p*, one should take into account that: 1) if *p << 0.5*, the *BD(0;Xmax,p)* is the event with maximum probability (EwMP) ; 2) if *p < 0.5*, one of the *BD(x≠0;Xmax;p)* is the EwMP, and *BD(0;Xmax,p)>>0%*; if p≈0.5, one of the *BD(x≠0;Xmax,p)* is the EwMP, and BD(0;Xmax,p) >0%; and 3) if *p>0.5*, one of the *BD(x≠0;Xmax,p)* is the EwMP, and *BD(0;Xmax,p)*≈0%.

h)- While mathematically BD does not show, our applications show that BD is associated to *k* success events of *n* trials of a many times (>10000) simulated stochastic process with a success probability *p*.

All new knowledges have been validated with theoretical demonstrations or with computational tools.

These new knowledges could avoid the overestimated, confused and irrational use of the BD and PD by the student/teacher/researcher communities in different fields. Take into account that the BD and PD are elemental topics in many teaching materials of the statistics, and are probabilistic functions that have been well-established for more than 200 years.

Our work shows that there are three ways of obtaining DPDs: mathematical, probabilistic and computational, used respectively in the BD(x;Xmax,p), SMp(x) function, and SMp simulators. Although these ways are different, they generate similar DPDs, which can be used for describing or assuming discrete stochastic variables with three or more possible outcomes.

When a process is deterministic, this will occur always or will not occur never. While if a process is stochastic, the expected ratio *k/n* of the number of success events (*k*) and total of them (*n*) will be equal or approximately equal to the success probability *p*, which is generally determined as *p=K/N*; where *K*: success observations, and *N*: Total of them. For these reasons, the BD(k;n,p) has little probabilistic and does not have practical importance. The BD is a mathematical exercise that is result of evaluating respectively the variables *a* and *b* of the binomial theorem by *p* and *1-p*; and its expression is a sum of the "*n+1"* elements of a DPD.

The Figure 4 illustrates a hypothetical example of a NTCP(x_i) DPD= BD(x;4,0.3) for describing or assuming the probabilities of late complications discussed in [9]-[10], and associated to a chest radiation treatment involving complications of two OARs: heart and lung. The NTCP0=NTCP(0)=24%. This value increases if prescribed dose (*D=nd*; *n*: Number of fractions, and *d*: Dose per fraction) decreases, and vice versa, as result of variations of *d* for a treatment with a constant *n*; or variations of n for a constant d. The NTCP0 value increases if D decreases, and vice versa, how is shown by the four arrows on the right-side of the y-axis of the Figure 4.

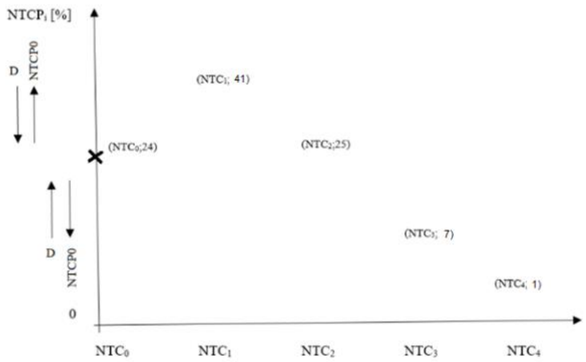


Figure 4. Hypothetical example of a NTCP$_i$ or NTCP(x) DPD equal to BD(x;4,0.3) for describing or assuming the probabilities of late complications associated to a chest radiation treatment. Abbreviations: **D:** Prescribed dose; **NTC$_0$** No complication; **NTC$_1$** Congestion heart failure; **NTC$_2$** Ischemia; **NTC$_3$** Coronary artery disease; **NTC$_4$** Pneumonitis. The NTCP0=NTCP$_0$=24% is represented by a **x.**

Whatever radiation therapy or radiation activity with similar circumstances has its own NTCP(xi) DPD caused by the affected OARs and others have physiological relationships with these.

Probabilistically one can say for a stochastic process (SP) with only one outcome; for example, if a radiation treatment has a TCP=60%, that there is not tumor control 100%-60%=40%; while one can say for a SP with more than one outcome, like late normal tissue complications (NTC), that this SP have a NTCP(xi) DPD, where NTCP0, i.e. the probability for non-complications is NTCP(0).

It is very important to know how the BD and PD were derived for understating how the BD should be used. These functions are not only mathematical, but they were created as probabilistic functions, which must satisfy the essential condition of a DPD: $\sum$ BD(x_i)=100% and $\sum$ PD(x_i)=100%. The PD is a discrete function, how is shown by its denominator called factorial that is defined only for nonnegative integer values.

Another example taken from [11] that shows the use of BD and PD is the following: "Suppose that a long-lived radioactive sample is counted repeatedly under supposedly identical conditions with a properly operating counting system. Because the disintegration rate of the radioactive sample undergoes random variations from one moment to the next, the numbers of counts recorded in successive measurements (*N*1, *N*2, *N*3, etc.) are not the same. Given that different results are obtained from one measurement to the next, one might question if a "true value" for the measurement actually exists. One possible solution is to make a large number of measurements and use the average as an estimate for the "true value."".

The Figure 5 is the graphical representation of [11] for showing the use of the PD; but its DPD can be described with BD(N;20,0.5) or PD(N;10). These DPDs let us evaluating probabilities of each value of N; and their cumulative distribution functions allow to determine probabilities of intervals, like m±ΔN as

$$P(N > m - \Delta N \;\&N < m + \Delta N) = \sum_{m-\Delta N}^{m+\Delta N} BD(N; 20{,}0.5) \quad (24)$$

or

$$P(N > m - \Delta N \;\&N < m + \Delta N) = \sum_{m-\Delta N}^{m+\Delta N} PD(N; 10) \quad (25)$$

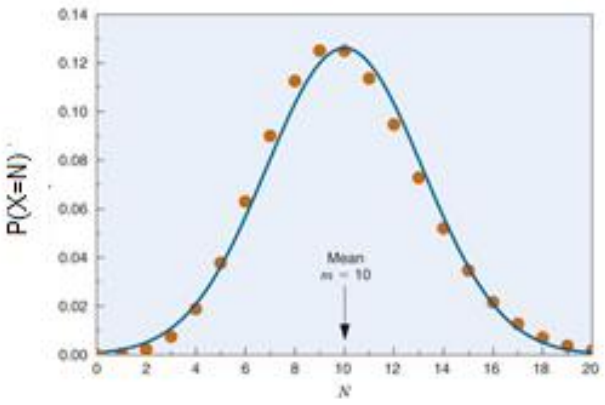


Figure 5. Graphical representation of [11] for showing the use of the Poisson distribution with expression PD(N;10).

The probability of N equal to the mean (m=10) is equal to BD(10;20,0.5)=12.51%; and P(N>6 & N<14); i.e. ΔN=4, is equal to 85%. Another important value of a DPD is the most likelihood (ML). In our case, as a symmetric function m=ML.

Using interactive calculations one can determine a confidence interval (CI). For example, CI=95%, ΔN≈5.

IV. Conclusion

This study has let probabilistically obtaining the BD(x;2,p) terms; developing a computational generator of random DPDs based on probabilistic foundations, and showing the irrational use of PD in the derivation of the Poisson-based TCP model.

The BD and generated SMp distributions could be used for describing or assuming DPDs, like NTCPi (i=0:nc, nc: number of complications) in the radiation oncology therapies, which includes NTCP0 and NTCPs. NTCP0: Normal tissue non-complication probability; and NTCPs: Normal tissue complication probabilities.

In the way that BD was formulated, one cannot say that its DPD is associated to probabilities of *k* successes *n* trails of a stochastic process with a success probability p. Only with methods, like computational simulations this association is demonstrated. Also, based on the BD formulation, one should not treat to *p* as a probabilistic parameter, but as mathematical one, where *p<1*. In the computational tools, *p* is considered as a success probability.

We have probabilistically derived the BD(x;2,p) terms, and computationally demonstrated that BD is DPD of *k* success events of *n* trails (>10000) of a stochastic process with success probability *p.*

Given that: a) The current high computational and technological degree is a situation that lets going without of a simplification of the BD expression; b) Contrary to the BD, PD is not always an acceptable DPD for an interval [0;Xmax] nor a good approximation of the BD; c) Very simple relationships among the parameters *n, p* and *μ*; and d) the BD(x;Xmax,p) can play a better role than PD(x;μ), where is easily determined *p* from μ as *p=μ/Xmax*; we propose the following:

1- Using as generators of DPDs to:

- As a mathematical method, the BD as BD(x;Xmax,p); i.e. the BD with change of variable *k* by *x,* and parameter *n* by *Xmax.*
- As a probabilistic method, the SMp(x) function
- As a computational methods, the SMp simulator that generates the SMp(x;Xmax,p) distributions for many repeated *n* trials (> 10000), and the SMp simulator that generates random SMp(x;Xmax) distributions

2- Analyzing the possibility of replacing the PD(x;μ) with the BD(x;Xmax,p), where *Xmax=n* and *p=μ/Xmax*. Due to all previously said, the use of PD will become unnecessary.

The dissemination of the new and elemental knowledges provided by our study will lead change of statistics courses involving the BD and PD topics, and will let the students a better understanding of BD and PD, as well as they will be provided of other tools for generating DPDs, such as probabilistic and computational, different to the mathematical employed in the BD.

V. References

1.Frometa-Castillo T. (2018) The SMp(x or y;PXmin,Xmax,ML,p1,p2,Max) a probabilistic distribution, or a probability density function of a random variable X, Chapter 48 of 16th International Conference on Information Technology-New Generations (ITNG 2019), Springer Nature Switzerland AG.

2. Frometa-Castillo T, Pyakuryal A, Wals-Zurita A, Mesbahi A (2020) Computational Simulations of Similar Probabilistic Distributions to the Binomial and Poisson Distributions. *Preprints*, 2020010065. doi: 10.20944/preprints202001.0065.v1).

3. Chapman JD, Nahum AE (2015) Radiotherapy treatment planning Linear-Quadratic Radiobiology. Taylor & Francis Group, LLC.

4. Dawson A, Hillen T (2006) Derivation of the tumour control probability (TCP) from a cell cycle model, Computational and Mathematical Methods in Medicine, 7:2-3, 121-141. DOI: 10.1080/10273660600968937.

5. Fiorino C, Broggi S, Fossati N. et al. (2015) Predicting Clinical Outcome Following Post Prostatectomy Radiation Therapy: A Poisson-Based Tumor Control Probability (TCP) Model Based on a Large Multi-institutional Series, International Journal of Radiation Oncology Biology Physics, Volume 93, Issue 3.

6. Schinkel, C, Stavreva N, Stavrev P, et al. (2007) Functional form comparison between the population and the individual Poisson based TCP models, Radiol Oncology,41(2); 90-98.

7. Frometa-Castillo T, Pyakuryal A, Piseaux-Aillon R (2019) Simulator of radiation biological effects in tumor in order to determinate the tumor control probability; Informatics in Medicine Unlocked; 16. https://doi.org/10.1016/j.imu.2019.100217.

8. Frometa-Castillo T, Pyakuryal A, Wals-Zurita A, Mesbahi A. (2020) Proposals of models for new formulations of the current complication-free cure (P+) and uncomplicated tumor control probability (UTCP) concepts, and total normal tissue complication probability of late complications, Int J Radiat Biol; 96(7):847-850. DOI: 10.1080/09553002.2020.1741722.

9. Marks LB, Bentzen SM, Deasy JO, et al. (2010) Radiation dose-volume effects in the lung, International Journal of Radiation Oncology • Biology • Physics, Volume 76, Issue 3, S70 – S76. DOI: https://doi.org/10.1016/j.ijrobp.2009.06.091.

10. Gagliardi G., Constine L.S., Moiseeko V., et al. (2010) Radiation dose-volume effects in the heart, Int J. Radiation Oncology Biol. Phys. Vol. 76 No. 3, Supplement, pp. S77-S85.

11. Nuclear Counting Statistics, Radiology Key at https://radiologykey.com/nuclear-counting-statistics/

Contacts of the corresponding author: Terman Frometa-Castillo, Institute: Statistical models project, LLC, 123 Akin Ave, Joliet, 60433, IL, USA, terman.frometa@gmail.com

THE MODERN TECHNOLOGY OF RADIATION ONCOLOGY: A Compendium for Medical Physicists and Radiation Oncologists. Volume 4

Jacob Van Dyk

Departments of Oncology and Medical Biophysics, Western University, London, Ontario, Canada

***Abstract*— The technology of radiation oncology is evolving at an unprecedented rate. The challenge for medical physicists and radiation oncologists is to stay "au courant" with these rapidly changing advances that provide a better quality of life for cancer patients. The goal of *The Modern Technology of Radiation Oncology* is to provide state-of-the-art updated information on making these technologies available in the clinic. These volumes have not only been valued by medical and physics practitioners, but have also been appreciated by medical physicists and radiation oncologists who are in their residency training or in early years of practice, in addition to being a useful, single source compendium in preparation for certification exams. At the invitation of the co-editor of Medical Physics International, this paper provides a summary of the latest technological advances in radiation oncology as contained in *Volume 4* of *The Modern Technology of Radiation Oncology.* In addition to a brief historical review of the previous volumes, the following topics are summarized:**

- **Surface-guided radiation therapy (SGRT),**
- **Hybrid PET/MRI in radiation oncology,**
- **Real-time image guidance with magnetic resonance imaging,**
- **Stereotactic body radiotherapy**
- **Robust optimization and evaluation of radiation treatment uncertainties,**
- **Automated treatment planning,**
- **Artificial intelligence in radiation oncology,**
- **Adaptive radiation therapy,**
- **Machine learning in radiation oncology,**
- **Applications of big data in radiation oncology,**
- **Quantitative radiomics in radiation oncology,**
- **Radiobiological updates in particle therapy,**
- **High atomic number nanoparticle applications in radiation oncology,**
- **Financial and economic considerations in radiation oncology,**
- **Global considerations in the practice of medical physics,**
- **Emerging technologies for improving access to radiation therapy, and**
- **FLASH radiation therapy**

The intent of this book is that it will continue to provide guidance on the cost-effective and safe implementation of these new technologies into clinical practice with the ultimate aim of improving the quality of life of cancer patients.

Keywords— **Technology, radiation oncology, acceptance, commissioning, quality assurance.**

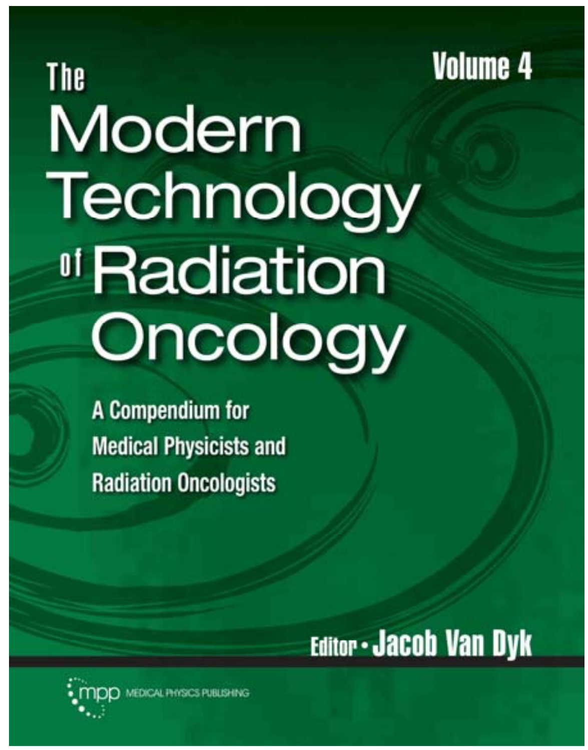


Figure 1. The front cover of *The Modern Technology of Radiation Oncology* published by Medical Physics Publishing in September 2020 [52].

I. Introduction

This paper is in response to an invitation by Perry Sprawls, the co-editor of Medical Physics International, in which he asked if I would consider writing an article presenting the new edition of T*he Modern Technology of Radiation Oncology*. *Volume 4* (Figure 1) [52] to the international medical physics community "with the purpose being to introduce this edition and emphasize the advances that are the major reason for this new publication." As he indicated, this is not a traditional book review but rather an article "briefly describing some of the advances and the new edition as the source of complete information and its value to the international medical physics community." I am delighted to provide this review in response to his invitation.

By way of background, it is helpful to understand a bit of the history of the previous volumes of the *Modern Technology of Radiation Oncology.*

Medical Physics Publishing (MPP) is a not-for-profit publisher, originally founded in 1985 by the renowned medical physicist, John Cameron, of the University of Wisconsin [25], In 1997, MPP approached me with an invitation to consider producing a book addressing issues related to the implementation of radiation therapy technologies into clinical practice. This invitation was instigated by Dr. Tomas Kron from Australia who upon request for ideas for new books had suggested this topic and me as a possible editor. The result was the first volume of *The Modern Technology of Radiation Oncology: A Compendium for Medical Physicists and Radiation Oncologists*, which was published in 1999 [49]. To quote from the preface,

> "**The purpose of this book is to describe the details of the technology associated with radiation oncology.** A special emphasis is placed on the **design** of all the equipment allied with radiation treatment. In addition, this book describes the procedures that are required to implement this equipment into clinical service (**needs assessment, purchase, acceptance, and commissioning**) and, once it is in use, the **quality assurance** that is required to keep the equipment operational at acceptable levels. In addition to describing all the tools that are used in "standard" radiation treatment centers, **this book addresses the less common or evolving technologies** and, thus, provides a comprehensive overview. Anyone embarking on any of these new procedures will be able to gain some basic insight as to what is required to make that procedure clinically viable."

The book consisted of 25 chapters and 1072 pages produced by 56 authors and co-authors, representing five countries, mostly the United States and Canada.

A few years after the publication of this book, the publisher asked me to consider a second edition. My reaction was that the contents in the original book and their applications had not changed substantially; however, in the previous five years, there were significant advances in ***new*** technologies associated with radiation oncology both in terms of hardware and software. These advances were attributed to innovations associated with oncological imaging, automated optimization of 3-D dose distributions, computer-controlled treatment delivery, and image-guided treatment. Thus, instead of producing a second edition, Volume 2 was developed "**to describe the significant incremental advances that have occurred with the technology associated with radiation oncology over the past 5 years.**" [50] Volume 2 was published in 2005 and consisted of 10 chapters and 466 pages produced by 22 authors and co-authors, representing three countries, again primarily from the United States and Canada.

Due to the advancements of new technologies in radiation oncology, primarily related to intensity-modulated radiation therapy, image-guided radiation therapy, adaptive radiation therapy, radiation therapy with light ions, and robotic radiation therapy, Volume 3 was published in 2013 [51]. In addition to the technological advances, other areas of increasing interest were also considered including quality assurance in the modern era, accuracy considerations in radiation oncology, growing concerns over patient safety and medical errors, staffing and resource issues, ethics, and medical physics considerations in clinical trials. The last chapter entitled *Radiation Oncology Medical Physics Resources for Working, Teaching, and Learning* provides a summary of useful resources for medical physicists working in the clinic, for medical physicists involved in teaching, and for medical physicists in training either at the graduate student or resident level. This chapter is a "live" chapter in that it is available on the Medical Physics Publishing website [48] and updated on a semi-regular basis approximately once per year.

Volume 3 consisted of 16 chapters and 574 pages produced by 34 authors and co-authors, representing five countries.

Figure 2 shows a graph of the number of books of the first three volumes sold per year over the 21 years that these books have been produced. The total books delivered by September 2020 was about 3500 books. eBooks of all three volumes were first made available in 2014, although eBooks sales are still in a minority with major preference still being given to hard copies. Records of purchases from specific countries did not start until 2018. While sales have always gone throughout the world, recent records include countries or regions such as China, Taiwan, Italy, Spain, United Kingdom and Oceania.

II. VOLUME 4

In late 2018 and early 2019, I was invited to give a couple of talks at joint international radiation oncology and medical physics conferences on the topic of future trends in the technology of radiation oncology. The preparation for these talks instigated some reflection on what had progressed in the technological evolution of radiation therapy in the last 5 to 10 years. In performing this review, it was clear that there were so many new advances in progress that it seemed important to produce another volume of *The Modern Technology of Radiation Oncology*. While not everything new started in the last 5

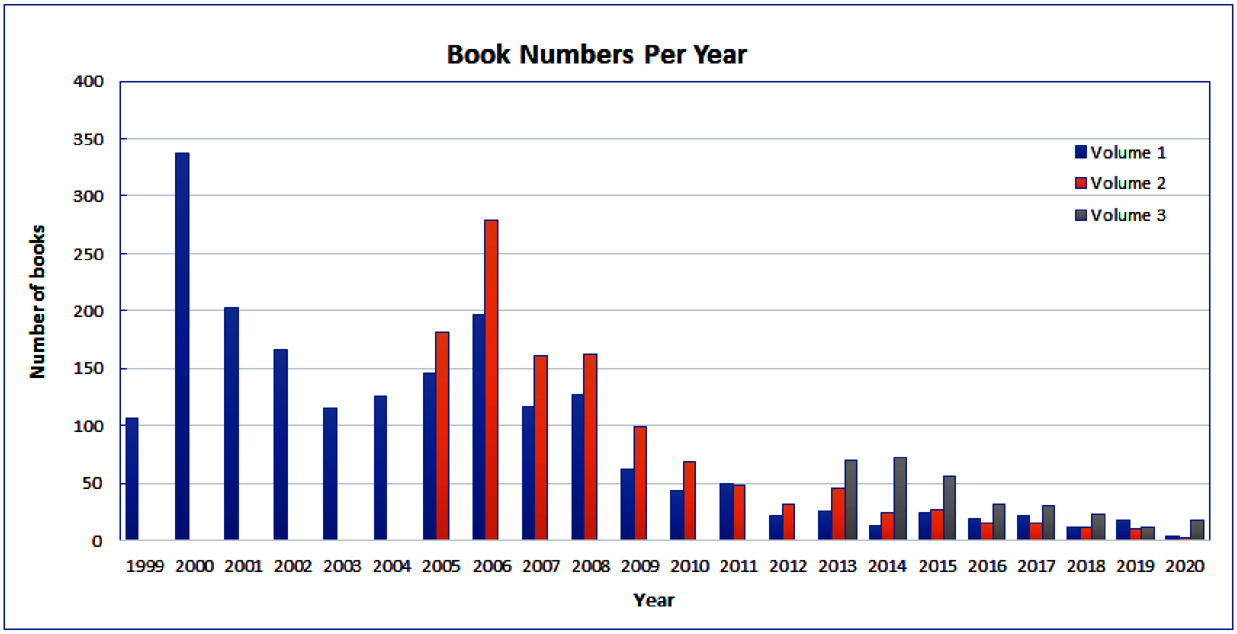


Figure 2. Number of books sold per year for the three volumes of *The Modern Technology of Radiation Oncology* since the publication of the first volume in 1999.

to 10 years, significant developments are presently in the process of being implemented in the clinical environment. Topics contained within Volume 4 include:

- Surface-guided radiation therapy (SGRT),
- Hybrid PET/MRI in radiation oncology,
- Real-time image guidance with magnetic resonance imaging,
- Stereotactic body radiotherapy
- Robust optimization and evaluation of radiation treatment uncertainties,
- Automated treatment planning,
- Artificial intelligence in radiation oncology,
- Adaptive radiation therapy,
- Machine learning in radiation oncology,
- Applications of big data in radiation oncology,
- Quantitative radiomics in radiation oncology,
- Radiobiological updates in particle therapy,
- High atomic number nanoparticle applications in radiation oncology,
- Financial and economic considerations in radiation oncology,
- Global considerations in the practice of medical physics,
- Emerging technologies for improving access to radiation therapy, and
- FLASH radiation therapy

Volume 4 was published in September 2020 and consists of 18 chapters and 524 pages printed in full color produced by 78 authors and co-authors, representing 11 countries [52]. This is the greatest international representation of all four volumes with nearly 40% of the authors being from countries other than Canada or the United States.

The following provides a very brief overview of the topics in each of the chapters in Volume 4. Some of these summaries are partially extracted from Chapter 1, which is available on-line [46].

Chapter 1. ***Technology Evolution in Radiation Oncology: The Rapid Pace Continues*** by J. Van Dyk

This chapter begins with a review of the technological evolution of radiation therapy since the discovery of x-rays in 1895 and addresses the question as to whether new technologies make a difference. While clinical benefits as a result of the introduction of new technologies are difficult to quantify in view of the multiple variables that are changing at the same, data from the 1970s and the 2010s demonstrate significant quantitative improvements in clinical outcomes, which can, at least in part, be attributed to the improvements in treatment technologies. The chapter goes on to provide a high-level summary of the subsequent chapters in the book. For several of the new technologies, annual journal publication rates are shown demonstrating that many of the topics are very recent areas of research and development.

One of the significant contributors to the improvements in radiation treatment technologies is the evolution of computer technology. Nearly all the steps in the radiation treatment process involve computer applications from diagnostic imaging, to surface or other guidance for patient set-up, to imaging for treatment planning, to the generation of an optimal treatment plan, to data transfer and automated treatment delivery along with image-guidance of the treatment set-up. All these computer-related procedures aim for the reduction of treatment margins to minimize normal tissue complications and allow for the escalation of tumor doses.

The chapter closes out with some predicted trends in radiation oncology including:

- More hybrid technologies,
- More automation,
- Turnkey installations,
- Reduced use of planning target volumes,
- Increased emphasis on cost considerations,
- Increased regulatory oversight,
- Increased use of particle therapy,
- Increased use of radiobiological models in treatment planning,
- Further development of radiomics applications, and
- Clinical implementation of FLASH therapy.

The chapter summary indicates that perhaps the title should have been *Technology Evolution in Radiation Oncology: The Rapid Pace Escalates* since the rate of change is significantly more rapid now than at the time of the previous volumes.

Chapter 2. ***Surface Guidance in Radiation Therapy*** *by* Hania A. Al-Hallaq, Alonso N. Gutierrez, and Laura I. Cerviño

While surface guidance technologies have been under development already since the 1970s, it is only during the last decade that these have become more routinely and commercially available. Surface-guided radiation therapy (SGRT) involves the use of real-time patient position data before and during simulation with imaging modalities such as CT, MR and PET, and for radiation treatment delivery on the treatment machine. This also includes positioning for respiratory-correlated procedures. SGRT uses sophisticated 3-D camera technologies to track the patient's skin surface; hence, its ability not only to position the patient accurately and reproducibly but also allow for motion management. It provides a positioning accuracy of better than 1 mm and can detect rotational offsets of less than 1 degree. Developments under consideration include collision detection and biometric measurements. In view of the non-ionizing nature of this 3-D imaging modality, it enables the collection of vast amounts of real-time data about patient treatments that is expected to benefit the field in novel ways in the future. It is only in the last 2 years (2018-2019) that publications on the use of SBRT have started to appear more frequently, with 53% appearing in those years compared to the total number of publications since 1975.

Chapter 3. ***PET/MRI as a Tool in Radiation Oncology*** by Jonathan D. Thiessen, Stewart Gaede, and Glenn Bauman

PET/MRI is a hybrid imaging technology that incorporates MRI soft tissue morphological imaging and PET functional imaging providing information on metabolic activity. While this hybrid technology has been in a developmental stage already since 1997 [26], it was first introduced commercially in 2011. One recent study compared PET/MRI to PET/CT in whole body oncological imaging for lesion detection and classification using 1003 examinations [23]. Their conclusions were that PET/MRI improves lesion detection and potentially reduces additional examinations in tumor staging, and especially younger patients may benefit from the clinically relevant dose reduction of PET/MRI compared to PET/CT. However, the significant cost of whole-body PET/MRI (approximately double that of a standalone 3T MRI or PET/CT systems with similar specifications) has limited its implementation in the clinic. With further advancements in technology, future PET/MRI systems may target a more affordable price point.

Chapter 4. ***Real-Time Image Guidance with Magnetic Resonance*** by Jan J. W. Lagendijk, Bas W. Raaymakers, Rob H. N. Tijssen, and Bram van Asselen

Image-guided radiation therapy using 3-D CT imaging has been in the clinic since the early 2000s. Helical tomotherapy was already described in detail in Volume 1 in 1999 [29]. Since then cone-beam CT (CBCT) has been implemented for IGRT on conventional linacs [18]. The CT imaging on both technologies is usually done prior to treatment. Upon review of the images, the patient is repositioned and treated. The total process of imaging and review may take several minutes. These systems cannot provide any *real-time* feedback during the actual treatment to see if there is any change in position while the beam is on. More recently, the combination of a linear accelerator (linac) with an MR scanner has become available clinically and provides real-time imaging while the treatment beam is on. Thus, the radiation oncologist can see if there is a change in tumor volume and surrounding structures daily and determine if the treatment plan needs to be adapted to the modified anatomical shape. Also, the real-time images will allow tracking of the tumor position during treatment with the possibility of the beam position being adjusted to follow the motion of the tumor, especially for cases such as lung tumors, where there is significant breathing motion during the treatment.

To quote from the conclusions, “The “blue sky” will be real-time adaptive radiotherapy where the dose delivery is continuously being optimized during the actual delivery using the continuous stream of imaging data, making radiotherapy a robotic interventional procedure [22]. The extreme targeting accuracy will facilitate the use of dose painting, but consequently will require knowledge on tumor characterization and delineation. A close collaboration between the radiation oncologist, radiologist, pathologist, and medical physicist is needed. Online MRI also provides capabilities of tumor characterization and tumor response assessment in the actual treatment optimization.

Online MRI guidance may start a paradigm shift in radiotherapy: the central position becomes MRI-guided targeting and its related tumor delineation and characterization.”

Chapter 5. ***Stereotactic Body Radiotherapy*** by Mischa S. Hoogeman, Patrick V. Granton, Maaike T. W. Milder, Ben J. M. Heijmen, and Hanbo Chen

Stereotactic body radiotherapy (SBRT) has become a clinical standard of practice in nearly every modern radiation therapy department. SBRT delivers a precise, high doses of radiation to the tumor especially for tumors in the lung, prostate, pancreas, liver, spine, and kidney while minimizing damage to the surrounding normal, healthy tissues. It allows for high doses per fraction and relatively fewer fractions. For non-small cell lung cancer (NSCLC), the preponderance of evidence suggests that SBRT is associated with excellent local control (~90% at 3 years) and a favorable toxicity profile [6]. In patients with higher operative risks, such as the elderly and patients with severe chronic obstructive pulmonary disease, SBRT may provide a less-toxic treatment than surgery with similar oncologic outcomes. Ongoing studies are evaluating the use of SBRT for locally advanced or oligometastatic NSCLC.

Chapter 6. ***Radiation Treatment Uncertainties: Robust Evaluation and Optimization*** by Roel G. J. Kierkels, Albin Fredriksson, and Jan Unkelbach

Giving the highest dose possible to the tumor while constraining normal tissue doses to acceptable levels are two of the main considerations in developing an optimized treatment plan. However, it is now well recognized that treatment uncertainties can vary dramatically dependent on the nature of the treatment plan in terms treatment technique and the technology used. The concept of *robust optimization* has been under consideration for a number of years. In 1997, our group began addressing issues related to uncertainties and their impact on developing optimized treatment plans [56]. The field has advanced to robust optimization whereby plans are calculated and optimized in such a way that they are minimally affected by uncertainties. Robust optimization is now available on commercial treatment planning systems. In reviewing the number of publications per year on robust planning in radiotherapy, nearly 50% occurred in the last 5 years. Robust planning has become especially relevant for particle therapy where range uncertainties can have dramatic effects on dose delivery both to the target and the normal tissues. This has led to probabilistic estimations of dose distributions. These distributions can now be calculated and could possibly replace the planning target volume (PTV) concept since the generation of the clinical target volume (CTV) to the PTV margin is performed based on the uncertainty distributions [44]. Our group already proposed the direct calculation of treatment plans without using the PTV concept in 2001 [7].

Chapter 7. ***Automated Treatment Planning*** by Laurence Court, Carlos Cardenas, and Lifei Zhang

The entire radiation treatment process has multiple steps. With the recent rapid advancements in computer technology and the development of improved and faster optimization algorithms, the calculation component of generating a treatment plan has improved significantly. In addition, auto-segmentation for tumor and normal tissue delineation allows the time taken by the radiation oncologist and the treatment planner to be reduced significantly. Many treatment planning systems now provide scripting capabilities where it is possible to record a sequence of messages or keystrokes while the user is operating the system. Scripts can be used within the radiation treatment planning system to reduce human error, to increase treatment planning efficiency, to reduce confusion, and to promote consistency within an institution or even among different institutions [16]. Scripting has been used for automated IMRT planning both for simple cases such as localized prostate and whole breast cancers [33] as well as more complex cases such as head and neck, anal canal and prostate with pelvic nodes [57]. Xhaferllari et al [57] make a comparison between the time to generate a manual plan versus the time to generate an automated plan. Their results demonstrate a huge time savings by automation (up to factors of 30). In addition, because of the self-consistency of the scripting process, the scripts can reduce variations of plan quality due to the differences in experience of the planners.

Software for auto-contouring of images and automatic generation of treatment plans is becoming more readily available on commercial treatment planning systems. Furthermore, their speed is increasing such that they allow for on-line adaptation of the treatment during every treatment fraction. A critical step is the validation and clinical approval of the auto-segmentation and automatically generated treatment plans by radiation oncologists and medical physicists. To reach the goal of on-line biological image-guided adaptive radiation therapy, this validation and approval needs to be streamlined so that it can be done in a few minutes rather than in hours [12]. As pointed out in this chapter, the type of software that supports automation of the contouring and treatment planning process is especially useful in lower income contexts since it provides the potential for scaling up radiation therapy capacity to meet global needs.

*Chapter 8. **Artificial Intelligence in Radiation Oncology*** by Tomi Nano, Matthieu Lafrenière, Benjamin Ziemer, Alon Witztum, Jorge Barrios, Taman Upadhaya, Martin Vallières, Yannet Interian, Gilmer Valdes, and Olivier Morin

Artificial intelligence (AI) is the simulation of human intelligence processes by machines, especially computer systems [39]. Specific applications of AI include expert systems, natural language processing (NLP), speech recognition and machine vision. AI programming focuses on three cognitive skills: learning, reasoning and self-correction. The **learning process** aspect of AI programming focuses on acquiring data and creating rules for how to turn the data into actionable information. The rules (algorithms) provide computing devices with step-by-step instructions for how to complete a specific task. The **reasoning process** focuses on choosing the right algorithm to reach a desired outcome. The **self-correction process** is designed to continually fine-tune algorithms and ensure they provide the best results possible.

The annual publication rate for "artificial intelligence in radiation oncology" demonstrates a clear dramatic growth in the last few years with 50% of all publications occurring between 2016 and 2019.

The applications in the context of radiation oncology are numerous including, for example, automated treatment planning, auto-segmentation, image processing and QA activities [8;54]. Applications of AI to improve the quality and safety in radiation therapy are also in progress [32].

By way of their conclusion, a long-term hypothesis is that AI development in radiation oncology will provide solutions that are able to create real-time, patient-specific knowledge which will save lives and reduce side effects.

*Chapter 9. **Adaptive Radiation Therapy (ART)*** by Emily A. Hewson, Doan T. Nguyen, Geoffrey D. Hugo, Jeremy T. Booth, and Paul J. Keall

While ART was first described in 1997 by Di Yan [58], the onset of multiple publications per year started in about 2005. This chapter addresses ART directly although aspects of ART are also discussed several other chapters.

.

Biologically adapted radiotherapy can be considered as the most advanced form of ART, since it involves functional imaging to extract biological tumor surrogates or features, and thus needs a multidisciplinary approach. Thorwarth illustrates the complexity by discussing the whole development chain of biologically ART from radiobiologically relevant processes, to functional imaging techniques which visualize tumor biology non-invasively, to the implementation of biologically adapted radiation therapy in clinical practice [41]. It is clear that ART will be a main contributor to the radiation oncology process with geometric and anatomical adaption being available and biological adaption evolving such that it becomes a true contributor to personalized medicine.

*Chapter 10. **Machine learning in Radiation Oncology: What Have We Learned So Far?*** by Issam El Naqa, Jean M. Moran, and Randall K. Ten Haken

As a significant component of AI, machine learning is the development of data-driven algorithms that learn to mimic human behavior based on prior example or experience [19]. The recent rapid increase on machine learning publications shows that 70% of them occurred in 2018 and 2019.

Applications of machine learning [19] include improvements in low-dose imaging for therapy planning, the use of MRI for the generation of CT-like electron densities for treatment planning [10;11;24], multimodal image fusion for radiation therapy planning [5;21], image segmentation for tumor and normal tissue delineation [36], treatment planning, plan approval and QA [37;42], and, finally, dose delivery and treatment adaptation [43]. Significant components of the treatment process have had considerable research in the context of machine learning and the corresponding challenges. One of the main challenges is knowing the ground truth. Learning-based models are only as good as their training data. Machine learning is evolving rapidly and is an excellent means of providing consistency and efficiency facilitating both transfer of best practice between physicians and clinics and greater process automation.

*Chapter 11. **Applications of "Big Data" in Radiation Oncology*** by Biche Osong, Andre Dekker, and Johan van Soest

The radiation therapy process is complex consisting of multiple steps. The new advances in technology allow enormous amounts of data to be generated for each patient during their total treatment process. The comparison is like a snowball rolling down a hill. It is the accumulation of these data for each step in the process for which the radiation oncologists need help for translation into knowledge that supports decision-making in their clinical practice.

The research analysis of these large amounts of data relies on analytical methods from the emerging science of “big data” informatics. This “big data” refers to extremely complex datasets characterized by the four Vs: *volume*, which refers to the sheer number of data elements within these extremely large datasets; *variety*, which describes the aggregation of data from multiple sources; *velocity*, which refers to the high speed at which data is generated; and *veracity*, which describes the inherent uncertainty in some data elements [20].

In summary, the promise of big data in radiation oncology is to provide improved access to the collective experience of treating patients to improve care for new and future patients. This improvement can take the form of actions such as reducing geographic disparities in care; ensuring continual quality improvement for individual practices; and ideally, personalizing treatments based on the outcomes of prior, similar patients. Each of these objectives requires different levels and resolution of clinical data that may be contained in registries, electronic medical records, tissue banks, and treatment planning and imaging systems [3].

Chapter 12. ***Quantitative Radiomics in Radiation Oncology*** by Mattea L. Welch, Alberto Traverso, Caroline Chung, and David A. Jaffray

A very recent, new field of study in radiation oncology and diagnostic imaging is known as *radiomics*. The first publications on “radiomics occurred in 2012 and since then over 70% of the publications occurred in 2018 and 2019 indicating an extremely rapidly increasing area of research. Radiomics is based on the extraction of a large variety of features from medical images using data-driven algorithms to characterize tumors [35]. The image data are further processed with a variety of reconstruction algorithms to obtain images that generate tumor-characteristic features. Automatic image segmentation is used to generate appropriate volumes of interest.

Radiomics has the potential for providing guidance on a number of applications in radiation oncology including [55]: (1) prediction of clinical outcomes [27;28]; (2) prognostication [17]; (3) prediction of the risk of distant metastases [45]; (4) assessment of cancer genetics [13;14]; (5) tumor dynamics changes through data generated by IGRT [59]; (6) distinguishing tumor progression from radionecrosis [31]; (7) prediction of physiological events with, e.g., the use of functional MRI [15]; and (8) the use of multiparametric radiomics for detection, characterization and diagnosis of various diseases including breast cancer [30].

The use of radiomics overlaps with applications of AI, machine learning and big data. Machine learning algorithms of AI boost the powers of radiomics for the prediction of prognoses or factors associated with treatment strategies, such as survival time, recurrence, adverse events, and subtypes. Radiomic approaches, in combination with AI, may potentially enable practical use of precision medicine in radiation therapy by predicting outcomes and toxicity for individual patients [1].

Chapter 13. ***Radiobiological Updates in Particle Therapy*** by Harald Paganetti and Michael Scholz

In the early years (1950-1970s), proton therapy was only available in very few institutions that had access to high energy particle facilities that were primarily used for physics research purposes. More recently, accelerator technology has been designed very specifically for clinical radiation therapy applications for both protons and heavier particles and the number of hospital-based clinical facilities is escalating rapidly. Furthermore, new advanced capabilities, such as beam scanning, IMRT, IGRT, along with robust treatment planning are providing further advances beyond the tight dose distributions provided by particle treatment. While the majority are proton centers, there are also some dedicated carbon ion facilities, as well as several facilities with the capability to treat with either [9]. Of the number of publications per year on protons and heavier particle radiation therapy since 1954, about 50% were published between 2014 and 2019.

Generally, it has been assumed that the relative biological effectiveness (RBE) for protons is a constant 1.1 over the entire irradiated volume. However, as pointed out in this chapter, RBE values are probably higher at the end of the proton range, potentially affecting normal tissue toxicities, although the RBE variations are likely smaller than the variability in patient radiosensitivity. For heavier particles, however, the change in RBE values are significantly larger and need to be considered as a function of particle species, particle energy, depth of penetration and type of tissue. It appears that current models, while not mechanistic, seem to be sufficiently accurate for clinical treatment planning purposes.

Chapter 14. ***Radiation Oncology using Nanoparticles with High Atomic Numbers*** by Romy Mueller, Jana Wood, Mohammed Jermoumi, Ysaac Zegeye, Sayeda Yasmin-Karim, Kaylie DeCosmo, Michele Moreau, Francis Boateng, Juergen Hesser, and Wilfred Ngwa

Nanotechnology relates to the manipulation of matter on atomic or molecular scales, generally less than 100 nanometers. The use of nanotechnology in medicine has led to what is now known as *theranostics*, where theranostics involves using nanoscience to unite diagnostic and therapeutic applications to form a single agent, allowing for diagnosis, drug or dose delivery and treatment response monitoring. Nanomaterials have several characteristics that are relevant for oncology applications, including preferential accumulation in tumors, low distribution in normal tissues, and biodistribution, pharmacokinetics, and clearance, that differ from those of small molecules. Because these properties are also well suited for applications in radiation oncology, nanomaterials have been used in many different areas of radiation oncology for imaging and treatment planning, as well as for radiosensitization to improve the therapeutic ratio [34;53]. Nanoparticles have been engineered from a wide range of materials that can be divided into inorganic and organic nanoparticles. One unique strategy is to increase the effect of the external beam radiation dose within tumor tissue by using materials with high atomic numbers (Z). This is because the dose absorbed by any tissue is related to some power of Z of the material depending on the energy. If an agent can increase the overall effective Z of the tumor without affecting the Z of nearby normal tissue, it can lead to increased radiotherapy dose to tumors and higher therapeutic efficacy.

This review summarizes the current status of research and development toward the use of high-Z nanoparticles to enhance radiation therapy. Considerations addressed nanoparticle design, delivery, as well as radiotherapy beam and treatment planning factors. Various innovative developments were addressed as a part of the outlook.

Chapter 15. ***Financial and Economic Considerations in Radiation Oncology*** by Yolande Lievens, Danielle Rodin, and Ajay Aggarwal

While the increasing complexity of the modern technology of radiation oncology has demonstrated improvements in patient outcomes, this comes at a considerable cost. Much emphasis has been placed in recent years on the financial and economic considerations in radiation oncology. Furthermore, there has been significant discussion in the recent literature on the global needs of radiation oncology along with the estimated overall costs according to national income levels [2;47;60]. This chapter provides detailed guidance on economic considerations. One of the issues that arises out of these discussions goes beyond the dollar cost analysis and has been described as assessing *value* per dollar spent. The discussion on *value* is complex. The definition of value will vary depending on several factors, including the social identity and the social context of the person purchasing the product or service [40]. The desirable product or service as well as the fair price is in the eye of the beholder. Teckie et al go on to describe their interpretation of *value* in healthcare [40]. Where value has been described as outcomes/cost, they suggest it should be expanded to include structure and process; thus, transforming the value equation to value equals quality/cost. The key components of value include structure, process, outcomes and costs. This type of value-based approach requires more involvement of the patient and adds another component to what has become known as personalized medicine.

The chapter summary indicates that in an era of restricted healthcare budgets, the need for knowledge on the cost and economic aspects of existing and novel interventions has increased.

Chapter 16. ***Global Considerations for the Practice of Medical Physics in Radiation Oncology*** by Jacob Van Dyk, David Jaffray, and Robert Jeraj

This chapter on global considerations in radiation oncology medical physics provides a worldwide perspective of medical physics, addressing questions such as: what is the status of medical physics around the world, how are medical physicists trained, what are the issues, what are the solutions, etc. For example, as pointed out by the Global Task Force on Radiotherapy for Cancer Control (GTFRCC) [2], it is clear that there is a huge disparity of the availability of medical physicists by country, dependent on the country's income level as described by the gross national product.

Many scientific and professional organizations, also those related to Medical Physics, provide various levels of support to international outreach activities for individuals from LMICs via reduced membership fees, special travel grants, other specific awards, as well as in the realm of providing education and training. Indeed, many of these organizations are increasing their outreach efforts. It is clear that future demand for medical physics research and clinical support around the world requires multipronged approaches with the global community working together.

In summary, this chapter has addressed a number of issues related to global considerations in radiation oncology medical physics, ranging from variations in education and training (along with the corresponding credentialing) to addressing global disparities that are not only manifested in LMIC contexts, but also exist in HIC contexts. Models for addressing global physics education are reviewed, along with a discussion on issues to contemplate in addressing global disparities and the corresponding considerations in international outreach. These issues and their solutions are not simple; however, this chapter has attempted to provide some food for thought on factors to consider in this context.

Chapter 17. ***Emerging Technologies for Improving Access to Radiation Therapy*** by Holger Wirtz, Ralf Müller-Polyzou, Anke Engbert, Rebecca Bücker, Godfrey Azangwe, Tomas Kron, Marian Petrovic, Mahmudul Hasan, and Ernest Okonkwo

The report by the GTFRCC [2] as well as others make it very clear that there is a need for additional radiation therapy equipment as the burden of cancer escalates, especially in LMICs. Filling the gap in cancer care in underserved regions worldwide requires global collaboration and concerted effort to share creative ideas, pool talents and develop sustainable support from governments, industry, academia and non-governmental organizations. To build capacity with high quality capability and with the credibility to conduct research to understand specific diseases and treatment outcomes requires a complex systems approach toward both expertise and technology. This chapter addresses some of these issues in detail.

Chapter 18. ***"FLASH" Radiation Therapy: A New Treatment Paradigm*** by Peter G. Maxim, Billy W. Loo, Jr., Claude Bailat, Pierre Montay-Gruel, Charles L. Limoli, and Marie-Catherine Vozenin

Recent research delivering radiation doses at ultrahigh dose rates, roughly 50 Gy/s and above, could vastly reduce normal tissue toxicity while preserving anti-tumor activity [38]. So far, the evidence is growing in laboratory experiments. If the evidence is maintained in human clinical trials, this has the potential of being one of the very significant breakthroughs in radiation therapy of recent times [4]. Details of FLASH radiation therapy are discussed in this chapter. Based on their summary, FLASH promises to be a paradigm shift in curative radiation therapy with preclinical evidence of fundamentally improved therapeutic index. While much remains to be learned about the mechanisms underlying the phenomenon, technological developments are in place for both short-term clinical implementation of FLASH radiation therapy for limited clinical scenarios and longer-term application for more general cancer indications. Selective early clinical testing of FLASH will provide unique opportunities for elucidating its biological mechanisms in human patients through the collection and analysis of biosamples, the understanding of which will ultimately be needed for optimal clinical application of FLASH radiation therapy.

III. Summary

The Modern Technology of Radiation Oncology of Radiation Oncology: A Compendium for Medical Physicists and Radiation Oncologists. Volume 4 consists of a compilation of recent technological advances in addition to related considerations. It is clear that the technological changes have increased at unprecedented rates. The challenge for medical physicists and radiation oncologists is to stay "au courant" with these rapidly changing advances that provide a better quality of life for patients. These volumes have not only been valued by clinical and physics practitioners, but also have been appreciated by medical physicists and radiation oncologists who are in their residency training or in early years of practice, in addition to being a useful resource compendium in preparation for certification exams. My hope remains that this series of books will continue to provide guidance on the cost-effective and safe implementation of these technologies into clinical practice with the ultimate aim of improving the quality of life of cancer patients.

Acknowledgment

A sincere thank you:

- To the *authors and co-authors of the chapters* of this series of books. They have given much of their time and knowledge to make these the quality books they are. Without their contributions, these books would not exist.
- To *Todd Hanson and the staff at Medical Physics Publishing* for detailed editing support of Volume 4 and for bringing this work to a timely completion.

References

1. Arimura H, Soufi M, Kamezawa H, Ninomiya K, Yamada M (2019) Radiomics with artificial intelligence for precision medicine in radiation therapy. J Radiat Res 60:150-157
2. Atun R, Jaffray DA, Barton MB, Bray F, Baumann M, Vikram B, Hanna TP, Knaul FM, Lievens Y, Lui TY, Milosevic M, O'Sullivan B, Rodin DL, Rosenblatt E, Van Dyk J, Yap ML, Zubizarreta E, Gospodarowicz M (2015) Expanding global access to radiotherapy. Lancet Oncol 16:1153-1186
3. Benedict SH, Hoffman K, Martel MK, Abernethy AP, Asher AL, Capala J, Chen RC, Chera B, Couch J, Deye J, Efstathiou JA, Ford E, Fraass BA, Gabriel PE, Huser V, Kavanagh BD, Khuntia D, Marks LB, Mayo C, McNutt T, Miller RS, Moore KL, Prior F, Roelofs E, Rosenstein BS, Sloan J, Theriault A, Vikram B (2016) Overview of the American Society for Radiation Oncology-National Institutes of Health-American Association of Physicists in Medicine Workshop 2015: Exploring Opportunities for Radiation Oncology in the Era of Big Data. Int J Radiat Oncol Biol Phys 95:873-879
4. Bourhis J, Montay-Gruel P, Goncalves JP, Bailat C, Petit B, Ollivier J, Jeanneret-Sozzi W, Ozsahin M, Bochud F, Moeckli R, Germond JF, Vozenin MC (2019) Clinical translation of FLASH radiotherapy: Why and how? Radiother Oncol 139:11-17
5. Cao X, Gao Y, Yang J, Wu G, Shen D (2016) Learning-Based Multimodal Image Registration for Prostate Cancer Radiation Therapy. Med Image Comput Comput Assist Interv 9902:1-9
6. Chehade S, Palma DA (2015) Stereotactic radiotherapy for early lung cancer: Evidence-based approach and future directions. Rep Pract Oncol Radiother 20:403-410

7. Craig T, Battista J, Moiseenko V, Van Dyk J (2001) Considerations for the implementation of target volume protocols in radiation therapy. Int J Radiat Oncol Biol Phys 49:241-250
8. Deig CR, Kanwar A, Thompson RF (2019) Artificial Intelligence in Radiation Oncology. Hematol Oncol Clin North Am 33:1095-1104
9. DeLaney TF (2018) Charged Issues: Particle Radiation Therapy. Semin Radiat Oncol 28:75-78
10. Dinkla AM, Florkow MC, Maspero M, Savenije MHF, Zijlstra F, Doornaert PAH, van SM, Philippens MEP, van den Berg CAT, Seevinck PR (2019) Dosimetric evaluation of synthetic CT for head and neck radiotherapy generated by a patch-based three-dimensional convolutional neural network. Med Phys 46:4095-4104
11. Dinkla AM, Wolterink JM, Maspero M, Savenije MHF, Verhoeff JJC, Seravalli E, Isgum I, Seevinck PR, van den Berg CAT (2018) MR-Only Brain Radiation Therapy: Dosimetric Evaluation of Synthetic CTs Generated by a Dilated Convolutional Neural Network. Int J Radiat Oncol Biol Phys 102:801-812
12. Fiorino C, Guckemberger M, Schwarz M, van der Heide UA, Heijmen B (2020) Technology-driven research for radiotherapy innovation. Mol Oncol doi: 10.1002/1878-0261.12659:
13. Grossmann P, Gutman DA, Dunn WD, Jr., Holder CA, Aerts HJ (2016) Imaging-genomics reveals driving pathways of MRI derived volumetric tumor phenotype features in Glioblastoma. BMC Cancer 16:611
14. Gutman DA, Dunn WD, Jr., Grossmann P, Cooper LA, Holder CA, Ligon KL, Alexander BM, Aerts HJ (2015) Somatic mutations associated with MRI-derived volumetric features in glioblastoma. Neuroradiology 57:1227-1237
15. Hassan I, Kotrotsou A, Bakhtiari AS, Thomas GA, Weinberg JS, Kumar AJ, Sawaya R, Luedi MM, Zinn PO, Colen RR (2016) Radiomic Texture Analysis Mapping Predicts Areas of True Functional MRI Activity. Sci Rep 6:25295
16. Holdsworth C, Hummel-Kramer SM, Phillips M (2011) Scripting in radiation therapy: an automatic 3D beam-naming system. Med Dosim 36:272-275
17. Huang P, Park S, Yan R, Lee J, Chu LC, Lin CT, Hussien A, Rathmell J, Thomas B, Chen C, Hales R, Ettinger DS, Brock M, Hu P, Fishman EK, Gabrielson E, Lam S (2018) Added Value of Computer-aided CT Image Features for Early Lung Cancer Diagnosis with Small Pulmonary Nodules: A Matched Case-Control Study. Radiology 286:286-295
18. Jaffray DA, Bissonnette J-P, Craig T (2005) X-ray Imaging for Verification and Localization in Radiation Therapy. In: Van Dyk J (ed) The Modern Technology of Radiation Oncology: A Compendium for Medical Physicists and Radiation Oncologists, Volume 2. Medical Physics Publishing, Madison, WI, pp 260-284
19. Jarrett D, Stride E, Vallis K, Gooding MJ (2019) Applications and limitations of machine learning in radiation oncology. Br J Radiol 92:20190001
20. Kansagra AP, Yu JP, Chatterjee AR, Lenchik L, Chow DS, Prater AB, Yeh J, Doshi AM, Hawkins CM, Heilbrun ME, Smith SE, Oselkin M, Gupta P, Ali S (2016) Big Data and the Future of Radiology Informatics. Acad Radiol 23:30-42
21. Kearney V, Haaf S, Sudhyadhom A, Valdes G, Solberg TD (2018) An unsupervised convolutional neural network-based algorithm for deformable image registration. Phys Med Biol 63:185017
22. Lagendijk JJ, van Vulpen M, Raaymakers BW (2016) The development of the MRI linac system for online MRI-guided radiotherapy: a clinical update. J Intern Med 280:203-208
23. Martin O, Schaarschmidt BM, Kirchner J, Suntharalingam S, Grueneisen J, Demircioglu A, Heusch P, Quick HH, Forsting M, Antoch G, Herrmann K, Umutlu L (2020) PET/MRI versus PET/CT in whole-body staging: results from a unicenter observational study in 1003 subsequent examinations. J Nucl Med 61:1131-1136
24. Maspero M, Savenije MHF, Dinkla AM, Seevinck PR, Intven MPW, Jurgenliemk-Schulz IM, Kerkmeijer LGW, van den Berg CAT (2018) Dose evaluation of fast synthetic-CT generation using a generative adversarial network for general pelvis MR-only radiotherapy. Phys Med Biol 63:185001
25. Medical Physics Publishing. About Us. MPP, https://www.medicalphysics.org/SimpleCMS.php?content=aboutus.html, Madison, WI . 2020.
26. Meyer CR, Boes JL, Kim B, Bland PH, Zasadny KR, Kison PV, Koral K, Frey KA, Wahl RL (1997) Demonstration of accuracy and clinical versatility of mutual information for automatic multimodality image fusion using affine and thin-plate spline warped geometric deformations. Med Image Anal 1:195-206
27. Nasief H, Hall W, Zheng C, Tsai S, Wang L, Erickson B, Li XA (2019) Improving Treatment Response Prediction for Chemoradiation Therapy of Pancreatic Cancer Using a Combination of Delta-Radiomics and the Clinical Biomarker CA19-9. Front Oncol 9:1464
28. Nasief H, Zheng C, Schott D, Hall W, Tsai S, Erickson B, Allen L, X (2019) A machine learning based delta-radiomics process for early prediction of treatment response of pancreatic cancer. NPJ Precis Oncol 3:25
29. Olivera GH, Shepard DM, Ruchala K, Aldridge JS, Kapatoes J, Fitchard EE, Reckwerdt PJ, Fang G, Balog J, Zachman J, Mackie TR (1999) Tomotherapy. In: Van Dyk J (ed) The Modern Technology of Radiation Oncology: A Compendium for Medical Physicists and Radiation Oncologists. Medical Physics Publishing, Madison, WI, pp 522-587
30. Parekh VS, Jacobs MA (2020) Multiparametric radiomics methods for breast cancer tissue characterization using radiological imaging. Breast Cancer Res Treat 180:407-421
31. Peng L, Parekh V, Huang P, Lin DD, Sheikh K, Baker B, Kirschbaum T, Silvestri F, Son J, Robinson A, Huang E, Ames H, Grimm J, Chen L, Shen C, Soike M, McTyre E, Redmond K, Lim M, Lee J, Jacobs MA, Kleinberg L (2018) Distinguishing True Progression From Radionecrosis After Stereotactic Radiation Therapy for Brain Metastases With Machine Learning and Radiomics. Int J Radiat Oncol Biol Phys 102:1236-1243
32. Pillai M, Adapa K, Das SK, Mazur L, Dooley J, Marks LB, Thompson RF, Chera BS (2019) Using Artificial Intelligence to Improve the Quality and Safety of Radiation Therapy. J Am Coll Radiol 16:1267-1272
33. Purdie TG, Dinniwell RE, Letourneau D, Hill C, Sharpe MB (2011) Automated planning of tangential breast intensity-modulated radiotherapy using heuristic optimization. Int J Radiat Oncol Biol Phys 81:575-583
34. Rancoule C, Magne N, Vallard A, Guy JB, Rodriguez-Lafrasse C, Deutsch E, Chargari C (2016) Nanoparticles in radiation oncology: From bench-side to bedside. Cancer Lett 375:256-262
35. Reuze S, Schernberg A, Orlhac F, Sun R, Chargari C, Dercle L, Deutsch E, Buvat I, Robert C (2018) Radiomics in Nuclear Medicine Applied to Radiation Therapy: Methods, Pitfalls, and Challenges. Int J Radiat Oncol Biol Phys 102:1117-1142
36. Rigaud B, Simon A, Castelli J, Lafond C, Acosta O, Haigron P, Cazoulat G, de CR (2019) Deformable image registration for radiation therapy: principle, methods, applications and evaluation. Acta Oncol 58:1225-1237
37. Stanhope C, Wu QJ, Yuan L, Liu J, Hood R, Yin FF, Adamson J (2015) Utilizing knowledge from prior plans in the evaluation of quality assurance. Phys Med Biol 60:4873-4891
38. Symonds P, Jones GDD (2019) FLASH Radiotherapy: The Next Technological Advance in Radiation Therapy? Clin Oncol (R Coll Radiol) 31:405-406
39. TechTarget. Artificial intelligence (Accessed 2020-03-23). TechTarget . 2020.
40. Teckie S, McCloskey SA, Steinberg ML (2014) Value: a framework for radiation oncology. J Clin Oncol 32:2864-2870
41. Thorwarth D (2018) Biologically adapted radiation therapy. Z Med Phys 28:177-183
42. Tol JP, Dahele M, Delaney AR, Slotman BJ, Verbakel WF (2015) Can knowledge-based DVH predictions be used for automated, individualized quality assurance of radiotherapy treatment plans? Radiat Oncol 10:234
43. Tseng HH, Luo Y, Ten Haken RK, El N, I (2018) The Role of Machine Learning in Knowledge-Based Response-Adapted Radiotherapy. Front Oncol 8:266

44. Unkelbach J, Alber M, Bangert M, Bokrantz R, Chan TCY, Deasy JO, Fredriksson A, Gorissen BL, van HM, Liu W, Mahmoudzadeh H, Nohadani O, Siebers JV, Witte M, Xu H (2018) Robust radiotherapy planning. Phys Med Biol 63:22TR02
45. Vallieres M, Freeman CR, Skamene SR, El N, I (2015) A radiomics model from joint FDG-PET and MRI texture features for the prediction of lung metastases in soft-tissue sarcomas of the extremities. Phys Med Biol 60:5471-5496
46. Van Dyk J (2020) Technology Evolution in Radiation Oncology: the Rapid Pace Continues (https://www.medicalphysics.org/documents/vandyk4_ch1.pdf). In: Van Dyk J (ed) The Modern Technology of Radiation Oncology: A Compendium for Medical Physicists and Radiation Oncologists. Volume 3. Medical Physics Publishing, Madison, WI, pp 1-23
47. Van Dyk J, Zubizarreta E, Lievens Y (2017) Cost evaluation to optimise radiation therapy implementation in different income settings: A time-driven activity-based analysis. Radiother Oncol 125:178-185
48. Van Dyk J (2013) Radiation Oncology Medical Physics Resources for Working, Teaching, and Learning (https://medicalphysics.org/documents/vandykch16.pdf). In: Van Dyk J (ed) The Modern Technology of Radiation Oncology: A Compendium for Medical Physicists and Radiation Oncologists. Volume 3. Medical Physics Publishing, Madison, WI, pp 511-554
49. Van Dyk J, (Ed) (1999) The Modern Technology of Radiation Oncology: A Compendium for Medical Physicists and Radiation Oncologists. Medical Physics Publishing, Madison, WI
50. Van Dyk J, (Ed) (2005) The Modern Technology of Radiation Oncology: A Compendium for Medical Physicists and Radiation Oncologists. Volume 2. Medical Physics Publishing, Madison, WI
51. Van Dyk J, (Ed) (2013) The Modern Technology of Radiation Oncology: A Compendium for Medical Physicists and Radiation Oncologists. Volume 3. Medical Physics Publishing, Madison, WI
52. Van Dyk J, (Ed) (2020) The Modern Technology of Radiation Oncology: A Compendium for Medical Physicists and Radiation Oncologists. Volume 4. Medical Physics Publishing, Madison, WI
53. Wang AZ, Tepper JE (2014) Nanotechnology in radiation oncology. J Clin Oncol 32:2879-2885
54. Wang C, Zhu X, Hong JC, Zheng D (2019) Artificial Intelligence in Radiotherapy Treatment Planning: Present and Future. Technol Cancer Res Treat 18:1533033819873922
55. Wikipedia. Radiomics (Accessed 2020-03-29). Wikipedia . 2020.
56. Wong E, Van Dyk J, Battista JJ, Barnett RB, Munro PN (1997) Uncertainty Analysis: A Guide to Optimization in Radiation Treatment Planning. In: Leavitt DD, Starkschall G (eds) Proceedings of the XIIth International Conference on the Use of Computers in Radiotherapy. Medical Physics Publishing, Madison, WI, pp 259-261
57. Xhaferllari I, Wong E, Bzdusek K, Lock M, Chen J (2013) Automated IMRT planning with regional optimization using planning scripts. J Appl Clin Med Phys 14:4052
58. Yan D, Vicini F, Wong J, Martinez A (1997) Adaptive radiation therapy. Phys Med Biol 42:123-132
59. Yip SS, Coroller TP, Sanford NN, Huynh E, Mamon H, Aerts HJ, Berbeco RI (2016) Use of registration-based contour propagation in texture analysis for esophageal cancer pathologic response prediction. Phys Med Biol 61:906-922
60. Zubizarreta E, Van Dyk J, Lievens Y (2017) Analysis of Global Radiotherapy Needs and Costs by Geographic Region and Income Level. Clin Oncol (R Coll Radiol) 29:84-92

Contacts of the corresponding author:

Jacob (Jake) Van Dyk, MSc, FCCPM, FAAPM, FCOMP, DSc(hon)
Professor Emeritus
Departments of Oncology and Medical Biophysics
Western University
London, Ontario, Canada
Founder and Past-President,
Medical Physics for World Benefit (www.mpwb.org)
Email: vandyk@uwo.ca

BOOKS

COLLABORATING TOPICS AND BOOK REVIEWS

SHIELDING TECHNIQUES FOR RADIATION ONCOLOGY FACILITIES (3RD EDITION) (PATTON H. MCGINLEY, MELISSA MARTIN, AUTHORS)

Peter J. Biggs[1]

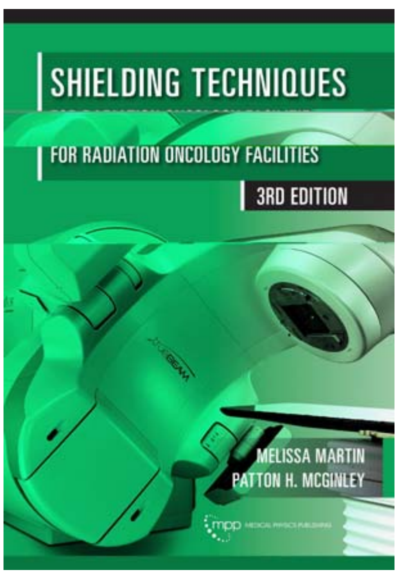
[1]Department of Radiation Oncology,
Massachusetts General Hospital, Harvard Medical School, Longboat Key, FL, US

I. Book details

Shielding Techniques for Radiation Oncology Facilities, 170 pp, Medical Physics Publishing Corporation, 2020

Author: Melissa Martin and Patton H. McGinley

ISBN: 9781951134013 (e-book)
ISBN: 9781951134006 (hard cover)



II. Review

Since the second edition of this book by Patton McGinley was published in 2002, NCRP Report No. 151 appeared in 2005 to supersede Report No. 49. That report was an up-to-date review of the field of radiation shielding, including data from Report Nos. 49, 51 and 79. Importantly, more data relevant to calculations was included, as well as, for the first time, a section on explicit calculations for typical primary and secondary barriers. A new edition of McGinley's book, now co-authored by Melissa Martin, has recently been published. This edition is a significant update to the last version as well as to NCRP Report No. 151 and the authors are to be commended for the advances this tome makes to the field.

A major, and welcome, addition to this edition is the enlargement of the special topics section to include radiation therapy modalities that are new to the market since the previous publication, including Cyberknife® and Tomotherapy® (even NCRP Report No. 151 barely covers these topics) and other ring-mounted gantry systems. This is important since, for these machines, the target to isocenter distance is no longer 1m so the workloads at isocenter have to be adjusted accordingly; the calculations provided are a great help in this regard. In particular, the section on the Elekta Unity® is very detailed and a great help to a designer to avoid calculational pitfalls. Finally, skyshine and side scatter is also covered in considerably more detail than in the previous edition.

One major improvement appears in this version, namely doors, both with and without mazes. The section on doors at the end of a maze for low energy beams has been expanded to consider alternative maze designs. The section on mazes and doors for high energy rooms (now the norm) includes more detail on direct shielded doors and, importantly, calculations detail the case for three energy machines that are now becoming more common in the field (this is important because the 'extra HVL' recommendation for handling combined leakage and scatter, which was, in any case, difficult to apply for dual energy machines, is virtually impossible for three energy machines). Experienced room designers recognize that primary and secondary barrier calculations are easily handled by spreadsheets, but direct shielded doors for high energy rooms and also HVAC ducts require ray tracing and hand calculations, which are both time-consuming and tedious. What makes this section so useful, in light of this, is the detailed practical considerations that usually only come with experience and should be welcomed by the novice.

The treatment of x-ray simulators has been deleted, appropriately, since most departments routinely use CTs for simulation. A brief section on CT simulators would have been useful, however, since, although NCRP Report No. 147 describes CT dosimetry in detail, CT workloads in radiation therapy can be quite different from diagnostic radiology, e.g., 4D CT. While the leakage TVL for forward radiation is correctly noted to be 5.7, the leakage radiation at 90° for the barriers not in the gantry plane is not identified as 4.5 cm as given in the 2nd edition.

Placement of all the tables in an appendix is a sensible move to allow a designer to look up a parameter more readily. The notations in the previous edition of "nSv/s" and "cSv/wk" for dose equivalent and "6.67 cGy/s" for dose rate have been changed to conventional units. There are a few errata to be noted: Figs. 4-3 and 5-13 are missing and equation 5-9 is lacking a divisor. Interestingly, new vocabulary has entered the field: gantries and collimators are no longer 'rotated' but 'clocked.' An unresolved issue remains as to how to determine TVLs for high density concrete, given that the NCRP reports the first and additional TVLs separately for primary and leakage radiation, while vendors use only one TVL for primary beams and one TVL for both leakage and scatter.

This book adds extra value to the previous addition and NCRP Report No. 151 in areas that, as noted above, were described, but lacked sufficient detail to aid the shielding designer in their calculations; this edition corrects that deficiency. This book is destined to be a standard reference book for all medical physics undergraduate, graduate and residency programs. In summary, this book is a welcome addition to radiation therapy bibliography and should be on the bookshelf of every medical physicist.

Contacts of the corresponding author:

Peter J. Biggs Ph.D.,
Formerly Associate Professor,
Department of Radiation Oncology,
Massachusetts General Hospital,
Harvard Medical School,
Longboat Key, FL

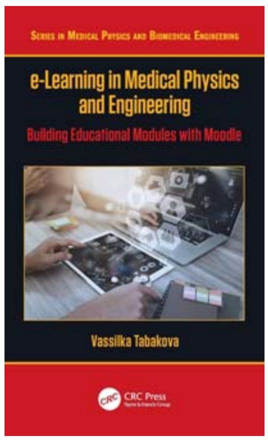
E-LEARNING IN MEDICAL PHYSICS AND ENGINEERING. BUILDING EDUCATIONAL MODULES WITH MOODLE by V Tabakova

Padovani, Renato[1]

[1] Director MMP, ICTP Trieste, Italy

Abstract: **This article is a brief review of the textbook "e-Learning in Medical Physics and Engineering. Building Educational Modules with Moodle" by Vassilika Tabakova, 2020, CRC Press, 152 p., ISBN9781138347328 (hard cover)**

Kindle edition (all images in colour): ASIN : B087QRV8T9



I. Description

'e-Learning in Medical Physics and Engineering' covers in 5 Chapters the history of e-learning in medical physics and engineering, introduces the e-learning methodologies, describes the Virtual Learning Environment (VLE) Moodle open-source and provides step-by-step instructions of how to design and build a course/module for higher education in medical physics and engineering.

II. Purpose

The need for qualified specialists to work with and apply sophisticated technology in contemporary medicine is rapidly growing. Professional bodies predict that meeting the needs of healthcare globally will require almost tripling the present number of medical physicists by 2035, with a higher factor for the low and medium income (LMI) countries. This challenging target, the author says, can be reached if efficient and effective e-learning tools and free and open-source software packages are used. The book aims to provide the essential knowledge to develop e-learning course/modules to higher education medical physics' teachers.

III. Contents/features

Chapter 1 gives an overview of pioneering e-learning projects in medical physics and engineering started in the late 90', the well-known EMERALD image database and training courses in Medical Radiation Physics, the Sprawls Resources database and the EMITEL e-Encyclopaedia. The Chapter 2 introduces the terminology used by the VLE Moodle and in other popular VLE environments. The author discusses the prerequisites for introducing a VLE, focusing on the steps the educator needs to undertake. In Chapter 3, the major Moodle Teacher's functions and a step-by-step procedures to edit and create contents in the form of lectures, coursework and quizzes, and, forums and chats to communicate with students are detailed. Text is supported by example, graphs and screenshots. The role of the VLE Manager in designing and organising the whole programme is described in Chapter 4. The Student and the Teacher functions on the assessment of student's performances (grades and activity) and how this information is maintained and shared are discussed. The Chapter 5 displays the results of surveys on e-learning in medical physics to be developed in LMI countries conducted by the author in international course/workshops organised by IOMP, AOCMP and ICTP. From the surveys, the major limiting factors preventing the implementation of e-learning are the lack of experience, suitable teaching material, finance and IT staff. After a short introduction on methodologies and instruments, the author conducted a second survey and reported a 75% increase of the participants willing and confident of engaging with e-learning platforms. To support the development of e-learning in LMI countries, the author finally illustrates how to build an educational programme with limited resources, comparing and discussing various VLE options and costs.

IV. Assessment

This textbook is a useful source of information and a useful guide how to design and develop a whole e-learning educational programme. Introducing and detailing the most important functions of the VLE Moodle open-source package, the book serves as a guide for the Manager and the Teacher to develop modules and courses, assess student's performances and activity and interact with students via forums and chats. The author highlight that both the Manager, the designer of the programme, and the Teachers, the builders of the modules/course, do not need to be IT experts as all Moodle functions and screenshots are intuitive and supported by online helps. Only the server maintenance requires IT competences that, if not present in the institution/university, should be delegated to Moodle or to external providers. In conclusion, this is a very well-written, comprehensive book on e-learning in higher education in medical physics and engineering, an indispensable resource for medical physics teachers aiming to develop e-learning in their institutions/associations/hospitals.

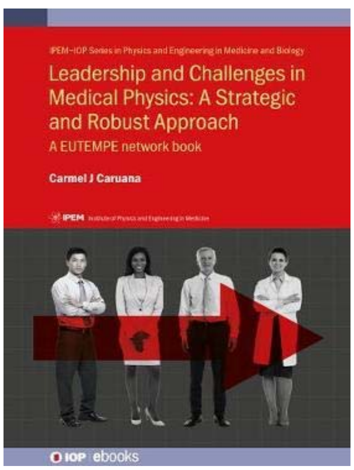
LEADERSHIP AND CHALLENGES IN MEDICAL PHYSICS: A STRATEGIC AND ROBUST APPROACH by C Caruana

Kwan-Hoong Ng[1]

[1] University of Malaya, Kuala Lumpur, Malaysia

Carmel J Caruana

Online ISBN: 978-0-7503-1395-7 • Print ISBN: 978-0-7503-1396-4, Part of IPEM–IOP Series in Physics and Engineering in Medicine and Biology.



Medical physicists as clinical scientists are facing tremendous challenges in their professional clinical practice and administration in the real world. Confronted with strategic planning, project planning, team building, negotiation skill, manpower development, …they are more confused and frustrated. Furthermore, our education and training programmes do not equip them in dealing with the complex issues in healthcare settings.

Professor Caruana, a very experienced academic as well as clinical medical physicist, is the originator and leader of the EFOMP-EUTEMPE module MPE01 on 'Leadership in Medical Physics', advocates a contemporary practical approach for aspiring leaders. He says candidly, 'We are a highly intelligent group, we have excelled as clinical scientists - I am very confident that we can excel in leadership too provided we give it the attention it deserves'.

In this very readable 104-page 10-chapter book, the author aims to present aspiring future medical physics leaders with effective, strategic and robust leadership skills in a very competitive and uncertain world. He has in mind to impart healthy leadership and leadership styles, organizational politics, organizational psychology and negotiating skills.

The author provides a compendium of SWOT (Strengths, Weaknesses, Opportunities and Threats) themes for leaders with a resource of several ideas to trigger initial SWOT brainstorming sessions when developing strategic plans with the team. It also has a compendium describing various leadership styles.

This book is filled with reflection/discussion points or case studies to facilitate a systematic approach for strategic planning. It is also sprinkled with many words of wisdom. One that I particularly like is this; 'Please keep in mind that no book will turn you into a leader – Ultimately ***you have to make yourself one***.

The book can certainly benefit from the inclusion of diagrams like mindmaps showing the relationships between the abstract ideas to help our early career practitioners remember better when it comes to putting them into practice. It would be nice to see future case studies showing how these ideas are put into real practice by real people.

If you are curious to find out how you could survive and win the political game, then this primer is highly recommended for you.

Reviewed by:
Kwan-Hoong Ng, PhD, DABMP, FInstP
University of Malaya, Kuala Lumpur, Malaysia

HISTORY

Obituary: John Robert (Jack) Cunningham, O.C., B.Eng., M.Sc., Ph.D., FCCPM, FAAPM, FCOMP 1927–2020

FIG. 1. John Robert "Jack" Cunningham upon winning the Order of Canada in 2005. [Color figure can be viewed at wileyonlinelibrary.com]

The medical physics community has lost one of its great pioneers with the passing of John R. Cunningham O.C., B.Eng., M.Sc., Ph.D., FCCPM, FAAPM, FCOMP in Calgary, Alberta, Canada, where he lived most recently with his wife, Sheila Cunningham. He was known universally, simply as "Jack." He passed away on 04 January 2020, one day before his 93rd birthday, as a result of progression of prostate cancer.

Jack was born in Regina, Saskatchewan in 1927. He was immediately adopted by Elizabeth and Alexander Cunningham. Jack lived his younger years in Assiniboia, in the province of Saskatchewan in Canada.

Jack's first introduction to Medical Physics occurred during his undergraduate years when he was involved in the operation of a Radon Plant for the Saskatchewan Cancer Commission, Saskatoon, Saskatchewan, Canada between 1948 and 1950. In 1951, Jack received an M.Sc. degree under the supervision of Dr. Harold E. Johns working on electron range-energy relationships measured on an early version of a clinical betatron.[1] After a sojourn from Medical Physics for 7 years at the Grain Research Laboratory in Winnipeg, Manitoba, Jack obtained his Ph.D. in Physics at the University of Toronto in 1955 on polymer research using ultrasound techniques. He then worked for the Canadian Defense Research Board in Ottawa on issues related to "The Effects of Nuclear Weapons."

In 1958, Harold Johns enticed Jack to return to Medical Physics at the Ontario Cancer Institute (OCI)/Princess Margaret Hospital (PMH) in Toronto. Except for a leave of absence between 1964 and 1965, when he worked under the auspices of the International Atomic Energy Agency (IAEA) as an Advisor in Medical Physics and Radiation Protection to the government of Ceylon (now known as Sri Lanka), he continued to work at the OCI/PMH until 1989. From 1965 to 1989, he was the Chief of Clinical Physics. He also moved through the ranks of academic appointments in the Department of Medical Biophysics of the University of Toronto where he became a Full Professor.

Jack contributed significantly to the *genesis* of Canadian Medical Physics. In his early years at the OCI/PMH, Jack, in collaboration with Harold Johns, was heavily involved in the design of radiation therapy apparatus.[2–6] One of the first rotational cobalt-60 machines was designed and built in 1958.[4] In fact, this machine contained a diagnostic x-ray tube in its head for therapy verification — a concept that has been rejuvenated in recent years as "image-guided radiation therapy." In those days, conventional simulators were not yet commercially available so that this concept also provided pre-treatment simulation capabilities. Jack also developed a scanning beam technique for total body irradiation.[2] In 1962, Jack and Harold designed and built the world's first double-headed cobalt-60 machine[3] capable of delivering parallel-opposed fields, an innovative machine that could take partially decayed sources from any two of the other 8 or so cobalt machines at PMH and use them for another 5 years.

After 1989, Jack left OCI/PMH and became a consultant for a Canadian, Ottawa-based company (Theratronics, MDS Nordion) that was marketing software for radiation treatment planning, software that Jack originally developed throughout his career in Toronto. From the early 1960s, his major contribution was in radiation dose distribution calculations for cancer patients requiring radiation treatments.[7–10] His methods used differential scatter quantities, known as *scatter-air ratios*[9,11–13], and became widespread on commercial treatment planning workstations throughout the world. This was a breakthrough advance in dose accuracy that recognized the pivotal importance of splitting the total dose of an external beam of radiation into primary and secondary components, especially for irregular beam shapes and in the presence of tissue inhomogeneities as well as beam modifiers.[9,14–20] This methodology was also used to develop and evaluate various clinical treatment procedures.[13,21–25] This activity is also the reason why Jack has had a very significant involvement in many International Conferences on the Use of Computers in Radiotherapy (ICCR), especially the 1984 meeting held in Toronto, for which he served as the chairman.[26] The development and application of his treatment planning programs has had a major impact on the dosimetric accuracy of radiation treatment for millions of cancer patients worldwide.

Jack Cunningham's global impact on the practice of Medical Physics can probably best be summarized by his publications which includes approximately 90 papers as well as the famous textbook he co-authored with Dr. H.E. Johns entitled *The Physics of Radiology*[27]— generally known as the "bible" of Medical Physics, last published in 1983. This book remains a classic text in our field. Jack was never one to publish too quickly, often considering his research and developmental work to just be part of the normal responsibility of a Medical Physicist.

Jack was a supervisor and mentor to a number of graduate students. Examples include: Louis Beaudoin, who performed tissue inhomogeneity corrections with differential scattering volumes for photon beams — a method that was very computer intensive and well-ahead of its time — likely the first voxel-based method;[28,29] Alan Rawlinson, who evaluated synchronous shielding for cobalt-60 teletherapy[30,31] — a concept that was a forerunner of intensity modulated radiation therapy; Jacques Niederer, who developed a sophisticated cell response model to fractionated doses of radiation, a model capable of describing most of the radiobiological functions that are commonly studied;[32] Marc Sontag, who developed the equivalent tissue-air ratio method for tissue inhomogeneity corrections in photon beams at a time when maps of patient-specific tissue density became available with the advent of x-ray computed tomography[17,33–35] — a method that accounted for the third dimension in dose calculations and was the most sophisticated clinical method available for a number of years as the field progressed from 2-D radiation therapy to 3-D conformal radiotherapy; Milton Woo, who then added the consideration of electronic disequilibrium in photon beam dose calculations[16,36] — providing yet another level of physics complexity to patient-related dose computations. Furthermore, Jack guided and mentored a number of visiting medical physicists from around the world resulting in precise measurements of tissue-air ratios,[12,37] new procedures for radiation treatment,[2,5,6] and dosimetry for beta sources.[38]

Jack has been very active in the national Medical Physics scene in Canada. He served twice as the Chair of the Division of Medical and Biological Physics of the Canadian Association of Physicists (the forerunner of the Canadian Organization of Medical Physicists, COMP). Internationally, Jack Cunningham served as the Canadian representative to the International Organization for Medical Physics (IOMP) and in the late 1980s served as its president.

Jack also had a significant influence on promoting the importance of Canadian science. In 1984, as a cost-saving measure, Prime Minister Mulroney's government decided to disband the radiation standards group at the National Research Council in Ottawa. Jack was interviewed on a national radio program called *Quirks and Quarks* and was asked about the impact of closing the Canadian radiation standards lab. As a result of this interview and the subsequent news media coverage and public reaction, the dosimetry group was promptly reinstated.

FIG. 2. Jack and Sheila Cunningham lunching at the AAPM Annual Meeting in San Diego in 2003. [Color figure can be viewed at wileyonlinelibrary.com]

Although Jack retired from the OCI/PMH in 1989, he remained active in the field, continuing to participate in scientific meetings and lecturing in the radiation physics course at the University of Alberta until very recent years. Jack continued to serve on multiple journal editorial boards and contributed to several major reports under the auspices of the International Commission on Radiation Units and Measurements (ICRU).[39,40] In the 1980s and 1990s, he participated in basic data generation for dose determination[41–47] as well as the development of dosimetry protocols including ICRU 24,[39] of which he was the chairman, and AAPM Task Group 21.[48]

The Canadian Organization of Medical Physicists established the *J.R. Cunningham Young Investigator Awards* to recognize his significant contributions to medical physics. The awards are presented to the top three speakers in the Young Investigators' Symposium held during the COMP's annual scientific meeting. The Symposium is widely recognised as one of the highlights of the annual meeting, with a quality of presentations that is of international calibre. Jack often served as honoree and co-chair of this symposium — an inspiration to newcomers in the field.

Jack's contributions to the scientific world have resulted in many visiting lectureships and honours from scientific organizations. One of the most prestigious is the Coolidge Award given by the American Association of Physicists in Medicine in 1988 recognizing his distinguished career in Medical Physics. In 2005, Jack received the Order of Canada, the top award given by the Canadian government for those "who exemplify citizenship and whose contribu- tions enrich the lives of their contemporaries." In 2006, Jack received the inaugural COMP Gold Medal, COMP's highest honour, recognizing his outstanding contributions to the field of medical physics in Canada. Other awards include the Kirkby Award, a joint award of COMP and the Canadian Association of Physicists, recognizing his outstanding service to general Canadian physics, and the International Union for Physical and Engineering Sciences in Medicine (IUPESM) Award.

Even in his retirement years, Jack continued to serve unofficially as the friendly international diplomat of Canadian medical physics.

The above gives a brief glimpse of this outstanding individual in the context of his scientific and academic achievements. In addition to these achievements, however, Jack possessed a very outgoing, congenial and personable character, for which he is well-renowned by all those who have had personal contact with him. I (JVD), as one who has worked with him on a daily basis for over 18 years and have known him for over 48 years, can attest to this fact, a char- acteristic which is rare for an individual of his expertise and international stature. I (JJB) can state that Jack was an approachable and influential mentor and role model, illuminating my career path into radiation oncology physics. A further demonstration of his generosity is that his home was often offered as a temporary residence for new graduate students, international visitors and visiting professors. A further description of his personality and humour is well exemplified by the entertaining 300-page memoir that Jack wrote, entitled *And I Thought I Came From a Cabbage Patch!*[49]

Jack is survived by his wife of 68 years, Sheila, three daughters, Susan, Joan, and Karen and their partners and two sons, Ian and Clifton and their partners along with 9 grandchildren and 3 great-grandchildren. We in the Medical Physics community of Canada and beyond extend our sincere condolences to them.

Jack will be greatly missed, but his influence will live on.

Jacob (Jake) Van Dyk
Jerry J. Battista

REFERENCES

1. Cunningham JR. *Extraction of the Electron Beam from the Betatron.* MSc Thesis. University of Saskatchewan; 1951.
2. Cunningham JR, Wright DJ. A simple facility for wholebody irradiation. *Radiology*. 1962;78:941−949.
3. Cunningham JR, Ash CL, Johns HE. A double headed cobalt 60 teletherapy unit. *Am J Roentgenol Radium Ther Nucl Med*. 1964;92:202−206.
4. Johns HE, Cunningham JR. A Precision cobalt-60 unit for fixed field and rotation therapy. *Am J Roentgenol Radium Ther Nucl Med*. 1959;81:4−12.
5. Cunningham JR, Wright DJ, Webb HP, Rawlinson JA, Leung PM. A semi-automatic cutter for compensating filters. *Int J Radiat Oncol Biol Phys*. 1976;1:355−360.
6. Cunningham JR, Wright DJ, Bellinger D. A new method for making air-gap compensating filters and wedges. *Radiology*. 1964;82:130−131.
7. International Atomic Energy Agency (IAEA). *Atlas of radiation dose distributions. Vol. 3: Moving field isodose charts* (compiled by Tsien, K. C.; Cunningham, J. R.; Wright, D. J.; Jones, D. E. A.; Pfalzner, P. M.). Vienna: IAEA, 1967.
8. International Atomic Energy Agency (IAEA). Computer Calculation of Dose Distributions in Radiotherapy, Technical Report Series No. 57. Vienna, Austria: International Atomic Energy Agency (IAEA). 1966.
9. Cunningham JR. Calculation of dose in a single beam using scatter-air ratios. *Rev Paul Med*. 1969;75:211.
10. Tsien KC, Cunningham JR, Wright DJ. Effects of different parameters on dose distributions in cobalt 60 planar rotation. *Acta Radiol Ther Phys Biol*. 1966;4:129−154.
11. Cunningham JR. Scatter-air ratios. *Phys Med Biol*. 1972;17:42−51.
12. Gupta SK, Cunningham JR. Measurement of tissue-air ratios and scatter functions for large field sizes, for cobalt 60 gamma radiation. *Br J Radiol*. 1966;39:7−11.
13. Van Dyk J, Leung PM, Cunningham JR. Dosimetric considerations of very large cobalt-60 fields. *Int J Radiat Oncol Biol Phys*. 1980;6:753−759.
14. Cunningham JR, Shrivastava PN, Wilkinson JM. Program IRREG: calculation of dose from irregularly shaped radiation beams. *Comput Programs Biomed*. 1972;2:192−199.
15. Bjarngard BE, Cunningham JR. Comments on "Validity of the concept of separating primary and scatter dose". *Med Phys*. 1986;13:760−762.
16. Woo MK, Cunningham JR. The validity of the density scaling method in primary electron transport for electron and photon beams. *Med Phys*. 1990;17:187−194.
17. Sontag MR, Cunningham JR. The equivalent tissue-air ratio method for making absorbed dose calculations in a heterogeneous medium. *Radiology*. 1978;129:787−794.
18. Cunningham JR. Development of computer algorithms for radiation treatment planning. *Int J Radiat Oncol Biol Phys*. 1989;16:1367−1376.
19. Cunningham JR. Dose calculations for high energy electron and photon beams. *Comput Med Imaging Graph*. 1989;13:241−250.
20. Cunningham JR. The Gordon Richards memorial lecture: the stampede to compute: computers in radiotherapy. *J Can Assoc Radiol*. 1971;22:242−251.
21. Van Dyk J, Battista JJ, Cunningham JR, Rider WD, Sontag MR. On the impact of CT scanning on radiotherapy planning. *Comput Tomogr*. 1980;4:55−65.
22. Cunningham JR, Van Dyk JV. Laryngeal cancer: practical problems in effective dose delivery. *Laryngoscope*. 1975;85:1029−1038.
23. Cundiff JH, Cunningham JR, Golden R, et al. A method for the calculation of dose in the radiation treatment of Hodgkin's disease. *Am J Roentgenol Radium Ther Nucl Med*. 1973;117:30−44.
24. Van Dyk J, Jenkin RD, Leung PM, Cunningham JR. Medulloblastoma: treatment technique and radiation dosimetry. *Int J Radiat Oncol Biol Phys*. 1977;2:993−1005.
25. Mackie TR, el Khatib E, Battista J, Scrimger J, Van Dyk J, Cunningham JR. Lung dose corrections for 6- and 15-MV x rays. *Med Phys*. 1985;12:327−332.
26. Cunningham JR, Ragan D, Van Dyk J eds. *Proceedings of the Eighth International Conference on the Use of Computers in Radiation Therapy, Toronto, 1984*. Silver Springs, MD: IEEE Computer Society Press; 1984.
27. Johns HE, Cunningham JR. *The Physics of Radiology (fourth edition)*. Springfield, IL: Charles C Thomas; 1983.
28. Beaudoin L. *Analytic Approach to the Solution of the Dosimetry in Heterogeneous Media. M.Sc. Thesis*. University of Toronto; 1968.
29. Cunningham JR, Beaudoin L. Calculations of tissue inhomogeneities with experimental verification. In: Gomez Lopez J, Bonmati J eds. *Radiology: Proceedings of the XIII International Congress of Radiology, Madrid, 15−20 October, 1973* (Vol 2). Amsterdam: Excerpta Medica; 1974;653−657.
30. Rawlinson JA, Cunningham JR. An examination of synchronous shielding in 60 Co rotational therapy. *Radiology*. 1972;102:667−671.
31. Rawlinson JA, Cunningham JR. A direct experimental evaluation of computed cobalt-60 rotation dose distributions. *Phys Med Biol*. 1971;16:511−519.
32. Niederer J, Cunningham JR. The response of cells in culture to fractionated radiation: a theoretical approach. *Phys Med Biol*. 1976;21:823−839.
33. Sontag MR, Cunningham JR. Clinical application of a CT based treatment planning system. *Comput Tomogr*. 1978;2:117−130.
34. Sontag MR, Cunningham JR. Corrections to absorbed dose calculations for tissue inhomogeneities. *Med Phys*. 1977;4:431−436.

35. Sontag MR, Battista JJ, Bronskill MJ, Cunningham JR. Implications of computed tomography for inhomogeneity corrections in photon beam dose calculations. *Radiology*. 1977;124:143−149.
36. Woo MK, Cunningham JR, Jezioranski JJ. Extending the concept of primary and scatter separation to the condition of electronic disequilibrium. *Med Phys*. 1990;17:588−595.
37. Cunningham JR, Johns HE, Gupta SK. An examination of the definition and magnitude of back-scatter factor for cobalt 60 gamma rays. *Br J Radiol*. 1965;38:637−638.
38. Supe SJ, Cunningham JR. A physical study of a strontium 90 beta-ray applicator. *Am J Roentgenol Radium Ther Nucl Med*. 1963;89:570−574.
39. International Commission on Radiation Units and Measurements. *ICRU Report 24: determination of absorbed dose in a patient irradiated by beams of x or gamma rays in radiotherapy procedures.* Washington, DC: International Commission on Radiation Units and Measurements; 1976.
40. International Commission on Radiation Units and Measurements. *ICRU Report 42: Use of computers in external beam radiotherapy procedures with high-energy photons and electrons.* Bethesda, MD: International Commission On Radiation Units and Measurements; 1987.
41. Cunningham JR, Johns HE. Calculation of the average energy absorbed in photon interactions. *Med Phys*. 1980;7:51−54.
42. Cunningham JR, Johns HE. The calculation of absorbed dose from exposure measurements: practical problems in dosimetry. *Phys Med Biol*. 1970;15:71−77.
43. Cunningham JR, Johns HE. Calculation of dose from exposure measurements. *Phys Med Biol*. 1969;14:329−330.
44. Cunningham JR, Holt JG. Air versus water calibration for 60Co gamma rays. *Med Phys*. 1978;5:63−65.
45. Cunningham JR, Sontag MR. Displacement corrections used in absorbed dose determination. *Med Phys*. 1980;7:672−676.
46. Cunningham JR, Schulz RJ. On the selection of stopping-power and mass energy-absorption coefficient ratios for high-energy x-ray dosimetry. *Med Phys*. 1984;11:618−623.
47. Cunningham JR, Woo M, Rogers DW, Bielajew AF. The dependence of mass energy absorption coefficient ratios on beam size and depth in a phantom. *Med Phys*. 1986;13:496−502.
48. Schulz RJ, Almond PR, Cunningham JR, et al. A protocol for the determination of absorbed dose from high-energy photon and electron beams. *Med Phys*. 1983;10:741−771.
49. Cunningham JR. *And I Thought I Came From a Cabbage Patch (A Memoir)*, (2nd edn). Camrose, AB: Self-Published; 2014.

PhD ABSTRACTS

Dependence of Tissue Inhomogeneity Correction Factors on Photon Beam Energy

M. Akhtaruzzaman[1,2], P. Kukolowicz[1]

[1]*Medical Physics Department, Maria Sklodowska-Curie Memorial Cancer Center and Institute of Oncology, Warsaw, Poland*
[2]*Medical Physics Department, Labaid Cancer Hospital, Dhaka, Bangladesh*

I. INTRODUCTION

When using megavoltage photon beams in the radiotherapy treatment of cancer, commissioning of the treatment planning system includes the accuracy of dose calculation in inhomogeneous media. Several results for measurement of inhomogeneity correction factors (ICFs) have already been published. However, a dependence of ICFs on beam energy may preclude such results from being applied to the general user's beam. The purpose of the study was to assess the dependence of ICFs on the tissue phantom ratio ($TPR_{20,10}$), the so-called photon beam quality index (QI).

II. METARIALS & METHODS

The range of $TPR_{20,10}$ was found to be 4.2% and 2.2% for photon beams with nominal energies of 6 MV and 15 MV, respectively. This range of QI was obtained based on data collected for the 42 accelerators installed in Poland (as part of the database of the local Secondary Standards Dosimetry Laboratory). Therefore, the QI range was considered as $TPR_{10}^{20} = 0.67 \pm k * 0.01$ and $TPR_{10}^{20} = 0.76 \pm k * 0.01$ for 6 and 15 MV respectively, where k = -3, -2, -1, 0, 1, 2, 3.

A preliminary study on the dependence of ICFs on energy was performed with the Batho correction method for several geometries comprising lung 0.25g/cm^3. Three different thicknesses of lung (3, 5 and 8 cm), introduced as broad slabs, oriented normal to the beam axis, within an otherwise homogenous water-equivalent phantom, and with a front surface at a depth of 3 cm. The front surface of the water phantom was at a source-to-surface (SSD) distance of 100 cm. The calculations were performed at four different field sizes of 5x5, 10x10, 15x15 and 20x20 cm^2 defined at the surface. The calculations were undertaken using an in-house developed Microsoft Visual Basic programme.

Water phantoms containing regions of lung (0.26g/cm^3), adipose tissue (0.92g/cm^3) and bone (1.85g/cm^3) were constructed in the Eclipse treatment planning system. Dose calculations were performed with the Anisotropic Analytical Algorithm (AAA) method for several beam sizes and for points lying at several depths inside of and below different thicknesses and densities of the inhomogeneities.

ICFs were also measured in a CIRS (Norfolk, VA) Tissue Simulation Phantom (thorax with lungs) for 10x10 cm^2 field size, for the 6 MV and 6 MV FFF generated in a TrueBeam accelerator. A PTW (Freiburg, Germany) Farmer type ionization chamber and Unidos (PTW, Freiburg, Germany) electrometer were used for measurements.

III. RESULTS

In calculations employing the Batho power law method, a linear dependency of ICF on beam QI was obtained. A maximum variation in ICFs of 3.7% (6 MV) and 4.1% (15 MV) was observed across the considered range of beam QI, when calculated at 5 cm depth below a 5 cm slab of lung.

Calculations with AAA predicted that 6% variations in QI lead to changes of ICFs of 10.0% (6 MV) and 13.8% (15 MV) for points 1 cm below the water-lung interface for a 5x5 cm^2 field size.

For the slab of adipose, less than 1% range in ICF was found across the considered range of QI for both energies. 2% (6 MV) and 2.4% (15 MV) differences were found for points lying 1 cm below the bone slab. These differences of ICFs decreased when calculated inside of inhomogeneities.

ICFs also decreased with increasing field size. Measurements with the CIRS phantom also demonstrated differences of ICFs consistently up to 6% between the 6 MV and 6 MV FFF beams.

IV. CONCLUSIONS

For a range of QIs representative of the range of beam qualities encountered in practice, small changes in correction factors were found in inhomogeneous phantoms in the regions where charged particle equilibrium (CPE) exists.

For regions, where there is no charged particle equilibrium, the dependence of the ICFs on the beam quality is more complicated. In addition, the field size significantly affects the results, especially if there is a lack of lateral CPE.

Results of measurements carried out with the CIRS phantom were consistent with calculations. The dependence of ICFs on beam quality was close to the linear.

Therefore, it is concluded that the ICFs measured for one accelerator beam can be used with some caution on another with the same nominal energy.

V. RFERENCES

1. Batho H F (1964). Lung corrections in cobalt 60 beam therapy. J Can Assoc Radiol, 15, 79-83.

2. Bruce J. Gerbi (1991). A mathematical expression for %DD accurate from Co-60 to 24 MV. Med. Phys., 18(4), 724-726. DOI: 10.1118/1.596666
3. X. Allen Li (1999). Peak scatter factors for high-energy photon beams. Med. Phys., 26(6), 962966. DOI: 10.1118/1.598489
4. Technical Report Series (TRS) No. 430 (2004), Commissioning and Quality Assurance of Computerized Planning Systems for Radiation Treatment of Cancer. International Atomic Energy Agency (IAEA).
5. Nikos Papanikolaou, Jerry J. Battista, Arthur L. Boyer, Constantin Kappas, Eric Klein, T. Rock Mackie, Michael Sharpe & Jake Van Dyk (2004). Report of the AAPM Task Group No. 85: Tissue inhomogeneity corrections for megavoltage photon beams. *Madison WI:* Medical Physics Publishing.
6. Robinson D (2008). Inhomogeneity correction and the analytic anisotropic algorithm. J. Appl. Clin. Med. Phys., 9(2), 112-122. DOI: 10.1120/jacmp. v9i2.2786.
7. Ding W, Johnston P.N., Wong T.P.Y & Bubb I.F. (2004). Investigation of photon beam models in heterogeneous media of modern radiotherapy. Australas Phys Eng Sci., 27, 39–48. DOI: 10.1007/BF03178375.
8. Carrasco P, Jornet N, Duch M, et al. (2004). Comparison of dose calculation algorithms in phantoms with lung equivalent heterogeneities under conditions of lateral electronic disequilibrium. Med Phys., 31, 2899–2911. DOI: 10.1118/1.1788932.
9. M. Akhtaruzzaman, P. Kukolowicz (2018). Dependence of Tissue Inhomogeneity Correction Factors on Nominal Photon Beam Energy. International Journal of Nuclear Research, NUKLEONIKA, 63(1), 3–7, DOI: 10.1515/nuka-2018-0001.
10. E.B. Podgorsak (2005). Radiation Oncology Physics: a *handbook for teachers and students. International Atomic Energy Commission (IAEA), Vienna.*
11. Technical Report Series (TRS) No. 398 (2000), Absorbed Dose Determination in External Beam Radiotherapy. International Code of Practice for Dosimetry Based on Standards of Absorbed dose to Water. International Atomic Energy Agency (IAEA).
12. ICRU. (1987). ICRU Report No. 42: Use of computers in external beam radiotherapy procedures with high-energy photons and electrons. Maryland, USA.

Author: M. Akhtaruzzaman, PhD, Head of Medical Physics, Labaid Cancer Hospital, Dhaka, Bangladesh. akhzam@gmail.com

INFORMATION FOR AUTHORS

PUBLICATION OF DOCTORAL THESIS AND DISSERTATION ABSTRACTS

A special feature of Medical Physics International (on line at www.mpijournal.org) is the publication of thesis and dissertation abstracts for recent graduates, specifically those receiving doctoral degrees in medical physics or closely related fields in 2010 or later. This is an opportunity for recent graduates to inform the global medical physics community about their research and special interests.

Abstracts should be submitted by the author along with a letter/message requesting and giving permission for publication, stating the field of study, the degree that was received, and the date of graduation. The abstracts must be in English and no longer than 2 pages (using the MPI manuscript template) and can include color images and illustrations. The abstract document should contain the thesis title, author's name, and the institution granting the degree.

Complete information on manuscript preparation is available in the INSTRUCTIONS FOR AUTHORS section of the online journal: www.mpijournal.org.

INSTRUCTIONS FOR AUTHORS

The goal of the new IOMP Journal Medical Physics International (http://mpijournal.org) is to publish manuscripts that will enhance medical physics education and professional development on a global basis. There is a special emphasis on general review articles, reports on specific educational methods, programs, and resources. In general, this will be limited to resources that are available at no cost to medical physicists and related professionals in all countries of the world. Information on commercial educational products and services can be published as paid advertisements. Research reports are not published unless the subject is educational methodology or activities relating to professional development. High-quality review articles that are comprehensive and describe significant developments in medical physics and related technology are encouraged. These will become part of a series providing a record of the history and heritage of the medical physics profession.

A special feature of the IOMP MPI Journal will be the publication of thesis and dissertation abstracts for will be the publication of thesis and dissertation abstracts for recent doctoral graduates, specifically those receiving their doctoral degrees in medical physics (or closely related fields) in 2010 or later.

MANUSCRIPT STYLE

Manuscripts shall be in English and submitted in WORD. Either American or British spelling can be used but it must be the same throughout the manuscript. Authors for whom English is not their first language are encouraged to have their manuscripts edited and checked for appropriate grammar and spelling. Manuscripts can be up to 10 journal pages (approximately 8000 words reduced by the space occupied by tables and illustrations) and should include an unstructured abstract of no more than 100 words.

The style should follow the template that can be downloaded from the website at:

http://mpijournal.org/authors_submitapaper.asp x

ILLUSTRATIONS SPECIAL REQUIREMENTS

Illustrations can be inserted into the manuscript for the review process but must be submitted as individual files when a manuscript is accepted for publication.

The use of high-quality color visuals is encouraged. Any published visuals will be available to readers to use in their educational activities without additional approvals.

REFERENCE WEBSITES

Websites that relate to the manuscript topic and are sources for additional supporting information should be included and linked from within the article or as references.

EDITORIAL POLICIES, PERMISSIONS AND APPROVALS

AUTHORSHIP

Only persons who have made substantial contributions to the manuscript or the work described in the manuscript shall be listed as authors. All persons who have contributed to the preparation of the manuscript or the work through technical assistance, writing assistance, financial support shall be listed in an acknowledgements section.

CONFLICT OF INTEREST

When they submit a manuscript, whether an article or a letter, authors are responsible for recognizing and disclosing financial and other conflicts of interest that might bias their work. They should acknowledge in the manuscript all financial support for the work and other financial or personal connections to the work.

All submitted manuscripts must be supported by a document (form provided by MPI) that:

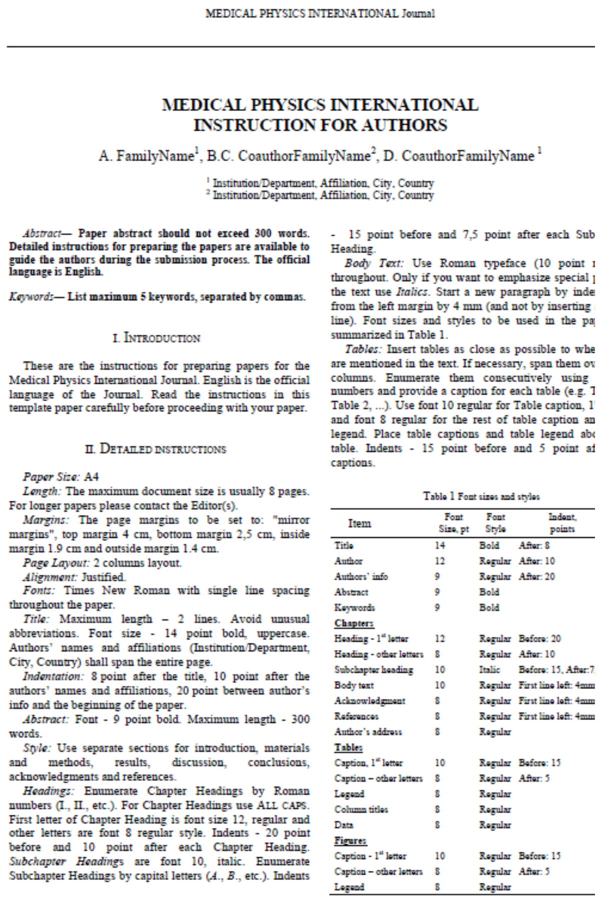
• Is signed by all co-authors verifying that they have participated in the project and approve the manuscript as submitted.

• Stating where the manuscript, or a substantially similar manuscript has been presented, published, or is being submitted for publication. Note: presentation of a paper at a conference or meeting does not prevent it from being published in MPI and where it was presented can be indicated in the published manuscript.

• Permission to publish any copyrighted material, or material created by other than the co-authors, has been obtained.

• Permission is granted to MPI to copyright, or use with permission copyrighted materials, the manuscripts to be published.

• Permission is granted for the free use of any published materials for non-commercial educational purposes.



MEDICAL PHYSICS INTERNATIONAL Journal

MEDICAL PHYSICS INTERNATIONAL
INSTRUCTION FOR AUTHORS

A. FamilyName[1], B.C. CoauthorFamilyName[2], D. CoauthorFamilyName [1]

[1] Institution/Department, Affiliation, City, Country
[2] Institution/Department, Affiliation, City, Country

Abstract— **Paper abstract should not exceed 300 words. Detailed instructions for preparing the papers are available to guide the authors during the submission process. The official language is English.**

Keywords— **List maximum 5 keywords, separated by commas.**

I. INTRODUCTION

These are the instructions for preparing papers for the Medical Physics International Journal. English is the official language of the Journal. Read the instructions in this template paper carefully before proceeding with your paper.

II. DETAILED INSTRUCTIONS

Paper Size: A4
Length: The maximum document size is usually 8 pages. For longer papers please contact the Editor(s).
Margins: The page margins to be set to: "mirror margins", top margin 4 cm, bottom margin 2,5 cm, inside margin 1.9 cm and outside margin 1.4 cm.
Page Layout: 2 columns layout.
Alignment: Justified.
Fonts: Times New Roman with single line spacing throughout the paper.
Title: Maximum length – 2 lines. Avoid unusual abbreviations. Font size - 14 point bold, uppercase. Authors' names and affiliations (Institution/Department, City, Country) shall span the entire page.
Indentation: 8 point after the title, 10 point after the authors' names and affiliations, 20 point between author's info and the beginning of the paper.
Abstract: Font - 9 point bold. Maximum length - 300 words.
Style: Use separate sections for introduction, materials and methods, results, discussion, conclusions, acknowledgments and references.
Headings: Enumerate Chapter Headings by Roman numbers (I., II., etc.). For Chapter Headings use ALL CAPS. First letter of Chapter Heading is font size 12, regular and other letters are font 8 regular style. Indents - 20 point before and 10 point after each Chapter Heading. *Subchapter Headings* are font 10, italic. Enumerate Subchapter Headings by capital letters (*A.*, *B.*, etc.). Indents - 15 point before and 7,5 point after each Sub Heading.

Body Text: Use Roman typeface (10 point r throughout. Only if you want to emphasize special p the text use *Italics*. Start a new paragraph by inde from the left margin by 4 mm (and not by inserting line). Font sizes and styles to be used in the pa summarized in Table 1.

Tables: Insert tables as close as possible to whe are mentioned in the text. If necessary, span them ov columns. Enumerate them consecutively using numbers and provide a caption for each table (e.g. T Table 2, ...). Use font 10 regular for Table caption, 1 and font 8 regular for the rest of table caption an legend. Place table captions and table legend abo table. Indents - 15 point before and 5 point af captions.

Table 1 Font sizes and styles

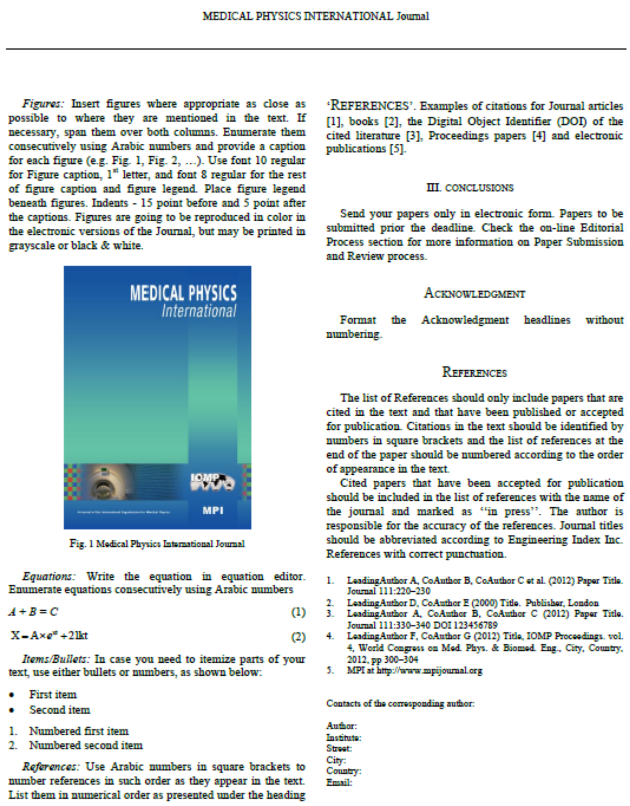
Item	Font Size, pt	Font Style	Indent, points
Title	14	Bold	After: 8
Author	12	Regular	After: 10
Authors' info	9	Regular	After: 20
Abstract	9	Bold	
Keywords	9	Bold	
Chapters			
Heading - 1st letter	12	Regular	Before: 20
Heading - other letters	8	Regular	After: 10
Subchapter heading	10	Italic	Before: 15, After:7
Body text	10	Regular	First line left: 4mm
Acknowledgment	8	Regular	First line left: 4mm
References	8	Regular	First line left: 4mm
Author's address	8	Regular	
Tables			
Caption, 1st letter	10	Regular	Before: 15
Caption – other letters	8	Regular	After: 5
Legend	8	Regular	
Column titles	8	Regular	
Data	8	Regular	
Figures			
Caption - 1st letter	10	Regular	Before: 15
Caption – other letters	8	Regular	After: 5
Legend	8	Regular	

SUBMISSION OF MANUSCRIPTS

Manuscripts to be considered for publication should be submitted as a WORD document to: Slavik Tabakov, Co-editor: slavik.tabakov@emerald2.co.uk

MANUSCRIPT PROPOSALS

Authors considering the development of a manuscript for a Review Article can first submit a brief proposal to the editors. This should include the title, list of authors, an abstract, and other supporting information that is appropriate. After review of the proposal the editors will consider issuing an invitation for a manuscript. When the manuscript is received it will go through the usual peer-review process.



MEDICAL PHYSICS INTERNATIONAL Journal

Figures: Insert figures where appropriate as close as possible to where they are mentioned in the text. If necessary, span them over both columns. Enumerate them consecutively using Arabic numbers and provide a caption for each figure (e.g. Fig. 1, Fig. 2, ...). Use font 10 regular for Figure caption, 1st letter, and font 8 regular for the rest of figure caption and figure legend. Place figure legend beneath figures. Indents - 15 point before and 5 point after the captions. Figures are going to be reproduced in color in the electronic versions of the Journal, but may be printed in grayscale or black & white.

Fig. 1 Medical Physics International Journal

Equations: Write the equation in equation editor. Enumerate equations consecutively using Arabic numbers

$$A + B = C \quad (1)$$

$$X = A \times e^{\pi} + 2\mathrm{lkt} \quad (2)$$

Items/Bullets: In case you need to itemize parts of your text, use either bullets or numbers, as shown below:

- First item
- Second item

1. Numbered first item
2. Numbered second item

References: Use Arabic numbers in square brackets to number references in such order as they appear in the text. List them in numerical order as presented under the heading 'REFERENCES'. Examples of citations for Journal articles [1], books [2], the Digital Object Identifier (DOI) of the cited literature [3], Proceedings papers [4] and electronic publications [5].

III. CONCLUSIONS

Send your papers only in electronic form. Papers to be submitted prior the deadline. Check the on-line Editorial Process section for more information on Paper Submission and Review process.

ACKNOWLEDGMENT

Format the Acknowledgment headlines without numbering.

REFERENCES

The list of References should only include papers that are cited in the text and that have been published or accepted for publication. Citations in the text should be identified by numbers in square brackets and the list of references at the end of the paper should be numbered according to the order of appearance in the text.

Cited papers that have been accepted for publication should be included in the list of references with the name of the journal and marked as "in press". The author is responsible for the accuracy of the references. Journal titles should be abbreviated according to Engineering Index Inc. References with correct punctuation.

1. LeadingAuthor A, CoAuthor B, CoAuthor C et al. (2012) Paper Title. Journal 111:220–230
2. LeadingAuthor D, CoAuthor E (2000) Title. Publisher, London
3. LeadingAuthor A, CoAuthor B, CoAuthor C (2012) Paper Title. Journal 111:330–340 DOI 123456789
4. LeadingAuthor F, CoAuthor G (2012) Title, IOMP Proceedings. vol. 4, World Congress on Med. Phys. & Biomed. Eng., City, Country, 2012, pp 300–304
5. MPI at http://www.mpijournal.org

Contacts of the corresponding author:

Author:
Institute:
Street:
City:
Country:
Email: