



Science diplomacy in medical physics – an international perspective

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Abstract

Purpose Science diplomacy in medical physics is a relatively young research field and translational practice that focuses on establishing international collaborations to address some of the questions biomedical professionals face globally. This paper aims to present an overview of science diplomacy in medical physics, from an international perspective, illustrating the ways collaborations within and across continents can lead to scientific and professional achievements that advance scientific growth and improve patients care.

Methods Science diplomacy actions were sought that promote collaborations in medical physics across the continents, related to professional and scientific aspects alike.

Results Several science diplomacy actions have been identified to promote education and training, to facilitate research and development, to effectively communicate science to the public, to enable equitable access of patients to healthcare and to focus on gender equity within the profession as well as healthcare provision. Scientific and professional organizations in the field of medical physics across all continents have adopted a number of efforts in their aims, many of them with great success, to promote science diplomacy and to foster international collaborations.

Conclusions Professionals in medical physics can advance through international cooperation, by building strong communication across scientific communities, addressing rising demands, exchange scientific information and knowledge.

Keywords Teaching and education · Research and development · Gender equity · Leadership · STEM fields · Scientific collaboration

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1 Medical physics – the profession behind advances in medical technology

Medical physicists are professionals actively involved in science diplomacy mainly due to the multidisciplinary character of their work, whether it be in research, education, or clinical service. They regularly interact with clinicians, technologists, nurses, hospital administrators, other health professionals such as radiation protection experts, radiopharmacists or maintenance technicians. In addition, they consult for government regulators, in relation to new medical technologies or various safety aspects (e.g. radiation or laser safety). They also interact with patients, either in a clinical setting or during stakeholder engagement activities, such as public and or educational talks on various technical aspects of health technologies.

Over the years, medical physicists have been instrumental in the development and implementation of new technologies for diagnosis or treatment of disease, for example new techniques for delivery of radiation therapy for cancer patients or development of new diagnostic equipment (e.g., high Tesla magnetic resonance units or whole-body positron emission tomography equipment). They have also been instrumental in communicating radiation risks to public and developing emergency procedures in radiology departments during the recent COVID pandemic. As such, this paper looks at the broader role of medical physicists as science diplomats within national and international communities.

Being the global leader in the field of medical physics, the International Organization for Medical Physics (IOMP) plays a key role when it comes to science diplomacy. Working in close collaboration with its members and international partner organizations, IOMP sets the global standards for science diplomacy in medical physics and healthcare [1, 2]. IOMP represents over 27,000 medical physicists, 87 adhering national member organisations, 2 affiliates, 6 regional organizations (EFOMP, MEFOMP, SEAFOMP, AFOMP, FAMPO, ALFIM), corporate members and is in official relations with WHO and the IAEA.

The international recognition of the profession is an important aspect in the global development of medical physics where the key role is played by the IOMP. The International Labor Organization (ILO) classified medical physicists as a profession in the International Standard Classification of Occupations-08 (ICSO-08), one of the most important reference documents for governments for recognition and classification of occupations [1, 3]. Medical physicists are classified under physics and astronomy within the category “Science and Engineering Professionals” and as “Health Professionals” when they are part of the health work force. This achievement of international recognition of the profession of medical physics is an important step for

the development of the whole medical physics community, and it has been critical to ensure their employment globally, in particular in the developing countries, with the growing need for building capacities in medical physics [4].

WHO promotes medical physics activities through programs in the areas of medical devices and radiation safety, often working in collaboration with its six Regional Offices. In the America’s Region, the Pan American Health Organization (PAHO), an international organization on its own right, founded in 1902, serves as the Regional Office for the Americas. PAHO has had medical physicists as Regional Advisers in the so-called Radiological Health Program since 1960 [5]; the program carries out activities in medical physics and radiation protection.

The IAEA supports many programs and has several medical physicists in their team covering the areas of diagnostic and interventional radiology, radiation oncology, nuclear medicine, and radiation protection and safety [6].

2 Science diplomacy in medical physics

Science diplomacy (SD) is a novel field of research and translational practice that employs integration of science and technology and international collaborations (whether scientific, professional, or political) to address essential questions that mankind faces globally [7]. It also involves community engagement so that the various national and international policies and actions are made based on the societal needs while, at the same time, these actions are informed by scientific facts and advice, as appropriate. The need for science diplomacy was evident during the COVID pandemic with lots of misinformation circulated in the media, social platforms and/or actions determined by various governments not having the full buy-in from the public. Other global issues where science diplomacy can play a significant role include climate change or the use of radiation for medical purposes and/or energy production.

There are a number of definitions and descriptions of science diplomacy in current literature and as defined by various organizations, with a couple of examples shown below:

- “Science diplomacy seeks to build scientific collaboration that enhances relationships between nations. It can also inform foreign policy objectives by supplying scientific advice and facilitate international cooperation and investment.” [8].
- “Science is a process for pursuing answers, while diplomacy is a process for dialogue and cooperation between countries and citizens. By integrating the two, we can face challenges and take opportunities to advance humanity.” [9].

In short, the main objective is to use science to advance political and diplomatic objectives, with the common aim of increasing equity and prosperity of all mankind [9]. It is a collaborative relationship between scientists and governing bodies where diplomatic and/or political decisions can enable faster translation of scientific knowledge into practice and vice versa, so that the relevant administrative decisions, policies and international advocacy are being informed by the latest scientific knowledge and evidence. The process is multifaceted and can happen on multiple levels and through various engagements, including cooperation agreements, transnational research organization, funding programs, international science exchange, open access publishing, consumer engagement, scientific advisory committees to governing bodies, etc.

According to the Madrid Declaration on Science Diplomacy [10], science diplomacy is a transboundary field sitting across:

- • “National borders, entailing bilateral or multilateral relationships;
- • policy frameworks, combining the policy realms of science, technology, innovation and foreign affairs — each with clear-cut definitions of competencies, actors and levels — and establishing complex and fluid interactions with joint jurisdictions;
- • stakeholders of all natures, involving government actors as well as international organisations, scientific institutions, non-governmental organisations (NGOs), the private sector and so forth; and.
- • professional backgrounds.”

Geographically, science diplomacy occurs at a national level, determining the actions that would address the needs of any particular country. At the next level, SD informs decisions that improve cross-border collaborations and interests. Finally, at a global stage, SD influences actions designed to address world-wide issues [11]. The additional potential benefit of SD is enabling collaboration and providing stabilizing influences between countries of varied cultural backgrounds and political systems [12] – it could serve as a unifying international platform.

To enact science diplomacy into practice, the so-called science diplomats are required. According to Melchor [13], a science diplomat is:

- • “The diplomat scientist.
- • The scientist diplomat.
- • All different actors — civil servants, science/policy managers, innovation delegates, liaison officers,

policy scientists,... mediating between science and diplomacy.”

Similar to leadership and/or management, good scientific professionals do not automatically become good science diplomats, thus relevant training and support is required. It appears that SD has been mostly taught through workshops or is organized by professional groups, and limited education is currently available at a university level as formal training – both a gap and an opportunity for academic programs around the world [14].

Opportunity also presents itself from the point of view of various medical physics organizations, who can play active role in SD nationally and internationally. The missions and visions of these organizations are already aligned with the main objectives of SD by advancing the medical physics worldwide, fostering professional development and education and thus contributing towards safe and high-quality medical services for patients globally. In addition, these organizations already have strong links with other multinational and global organizations such as the IAEA and WHO, as well as other stakeholders such as universities and governments. Therefore, they can build bridges between individual countries, societies, and international institutions to lead and support development of strategies for the advancement of biomedical sciences worldwide. Additionally, they are in a position to provide education in SD as well as to assist publicizing the role of SD to communities and government bodies.

An example of the excellent collaboration between the inter-governmental and the scientific/professional organizations is the inclusion of “medical physicist” in the publication *The Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards (BSS)*, sponsored by all the intergovernmental organizations involved in radiation protection and safety and published by the IAEA in 2014 [15]. The importance of this publication is that it is adapted/adopted by most of the countries as their radiation control regulations. To ensure consensus by the Member States, the IAEA hosted during the drafting process ‘Technical Committee Meetings’. It was during one of these meetings, that, mainly due to the input provided by medical physicists representing the IOMP, EFOMP, AFOMP, PAHO and WHO, it was decided to incorporate “medical physicist” to the list of “parties” that “shall have specified responsibilities in relation to protection and safety”. It was the first time such a term -as defined by the IOMP- appeared explicitly in a BSS.

3 Science diplomacy actions in medical physics across the continents

3.1 Education and training

All the IOMP regional organizations are involved in education and training activities. Because of their uniqueness, we will present here some of the efforts carried out by EFOMP, AFOMP, SEAFOMP and FAMPO.

In a European context, there are a number of issues pertaining to science diplomacy in medical physics that are worth mentioning in terms of education and training. The European Federation of Organisations for Medical Physics (EFOMP) is the umbrella organisation for all National Member Organisations (NMOs), currently including 36 European countries [16]. The European and International Matters Committee is one of EFOMP's six committees and its responsibility is to represent the interests of EFOMP to various European and international bodies related to medical physics. The main roles of this committee are: (i) to represent the interest of the Federation to various European and international bodies related to medical physics, (ii) to follow developments both within the European Union and internationally in relation to medical physics, (iii) to formulate proposals addressed to appropriate bodies of the European Union (including the European Parliament and Commission) on matters related to medical physics, and (iv) to liaise with European and International organisations through various professional activities for the common benefit of medical physicists.

To attain all the above goals, science diplomacy is a key aspect for successful collaborations and establishment of strong partnerships with the industry, research organisations and regulatory bodies. Medical physics across Europe presents a greatly varied landscape in terms of training, education, research and development, as well as the roles and responsibilities amid these professionals. EFOMP is working towards a more uniform platform by strengthening scientific and educational collaborations across its member countries, through implementation of various European Council directives across the continent, and most importantly, by gaining recognition of our profession on a European level in order to facilitate mobility across borders.

The Medical Physics College hosted by the International Centre for Theoretical Physics Abdus Salam in Trieste, Italy is a unique development targeting the global advances in and support for medical physics through education & training, capacity building, networking and collaboration. Among all the important activities related to the professional growth of the medical physicists, special focus is given to gender balance and leadership whereas recent statistics show some remarkable global achievements of the

Medical Physics College during its 30 years of history [17, 18]. It has educated more than 1000 students from around 100 Low-and-Middle-Income Countries (LMICs) applying train-the-trainer scheme which subsequently led to the creation of national educational programs, formation of national medical physics societies, and direct contribution to regulatory agencies and healthcare in those countries. 35 of the students educated during the period 2002–2018, 40% of which were women, took leadership positions at national and/or international level.

Medical physicists in Asian countries are under the umbrella of one of the three organisations encompassing countries from middle east (MEFOMP), southeast (SEAFOMP) and the larger geographical area (AFOMP). The Asia and Oceania region are home to 60% of the world's population, and it includes the world's most populous countries, China and India [19]. The region is popular for its vast diversity in demographic, economy, politics, languages, religions, social and cultural aspects. Therefore, AFOMP plays a vital role in connecting and enhancing the medical physics profession in the region via science diplomacy. In 2020, AFOMP celebrated its 20th anniversary with the theme of "Twenty Years of Teamwork" to mark cooperation for sustainable growth of medical physics in the region. The AFOMP Monthly Webinar Series and the AFOMP School were launched to provide free education and continuous professional development to the medical physicists in the region. Southeast Asia consists of eleven countries that are culturally and ethnically diverse. To strengthen regional collaboration and development, ten countries from the region have formed the Association of Southeast Asian Nations, a regional organization established for economic, political, social, cultural and educational partnership amongst its members [20]. Structured clinical training programmes such as Clinical Training of Medical Physicists Specializing in Radiation Oncology, Diagnostic Radiology and Nuclear Medicine are established under the IAEA Regional Cooperative Agreement. To further facilitate the clinical training in countries/areas with no clinical supervisors, IAEA also provides an online platform known as the Advanced Medical Physics Learning Environment. It is an e-learning tool developed by the IAEA to provide junior medical physicists with guided learning materials and remote mentorships to enhance their clinical training in hospitals. Using this platform, residents who are working at a hospital, but lack of a supervisor can share a clinical supervisor from other centre through remote supervision. One of the current active regional projects of SEAFOMP is the establishment of regional diagnostic reference levels (RDRLs). The project aimed to collect updated national DRLs on common radiological procedures from SEAFOMP countries, to establish RDRLs based on the clinical indications in diagnostic

Fig. 1 Number of collaboration links established by high-income countries within H2020 (data from [25])

Top Collaborations

Collaboration links in the projects.

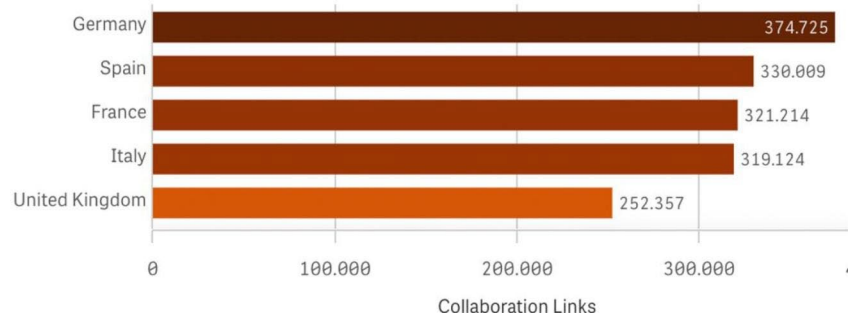
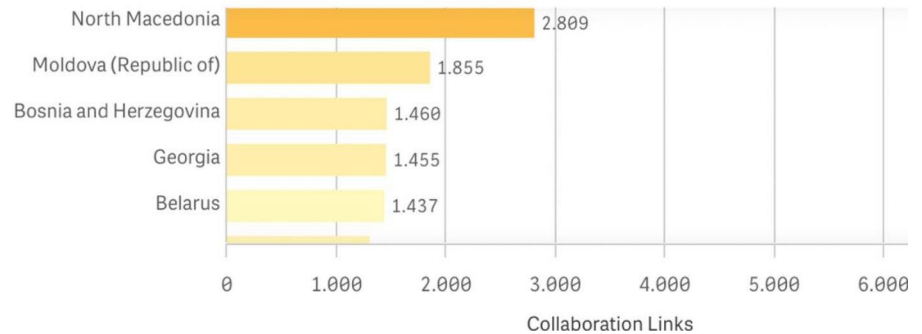


Fig. 2 Number of collaboration links established by lower-income countries within H2020 (data from [25])

Collaboration links in the projects.



radiology, interventional radiology and nuclear medicine procedures, and to review the progress on implementation of RDRLs in each country.

In African settings, a harmonized syllabus for academic and clinical medical physics training programmes was developed through regional projects under the African Regional Co-Operative Agreement for Research, Development and Training Related to Nuclear Science and Technology in collaboration with the IAEA [21]. Academic training is currently happening in only ten African countries, while only seven offer clinical training. An urgent expansion of these training programmes is required, potentially through the use of regionally designated centres that train in certain or all aspects of medical physics. IAEA and African experts established the first harmonized imaging quality control protocols for Africa in 2020 to help achieve a minimum standard throughout the region [22]. An initial study on regional diagnostic reference levels for computed tomography included data from Ghana, Kenya, Namibia, and Senegal [23] indicating that regional collaboration is expanding. Results of studies like these may eventually trickle down into national regulations or similar. One of the major issues in African countries regarding medical physics is the recognition of the profession. In the field of science diplomacy, a national society can offer a powerful tool to engage with a national Health Professions Council to promote the registration of medical physicists as healthcare professionals, while at the same time this opens up an avenue to offer advice

into regulatory and legislative developments as experts in the field.

To further the profession through a common platform, the International Medical Physics Certification Board was established in 2010, by eleven medical physics organizations across the world that served as Charter Members. The goals were to establish minimum professional standards and advance the practice of medical physics. The main objective of this board is to continue education and professional development for certified medical physicists to generate qualified medical physicists across the globe [24].

3.2 Research and development

An important aspect of science diplomacy for advancing research in medical physics and adjacent fields is scientific collaboration across nations. This requires a diplomatic approach on several levels resulting in equitable project calls, evaluation, and funding for all European countries. Horizon 2020 (H2020) was the European Union's research and innovation funding programme (2014–2020) with a generous budget that aimed to foster scientific collaborations by financing multinational projects [25]. Differences of over two orders of magnitude between high and lower-income European countries were found when comparing the number of collaboration links established via H2020 (Figs. 1 and 2). These large discrepancies are linked to the already mentioned varied landscapes in terms of training,

research priorities, staffing levels, and professional expertise. Science diplomacy could narrow science and research-related disparities across European countries through the establishment of a common training and education framework in medical physics and other biomedical fields and broader collaborations on all aspects of research and professional development.

It should be noted that EFOMP's role extends beyond EU-based countries in Europe and aims to involve all NMO's in the organisation of local and regional meetings in the "four corners of Europe". EFOMP also endeavours to keep fees for the European congresses to a low level, facilitating access from lower income European countries, thus supporting the aims of EFOMP to communicate, integrate and educate.

Early career professionals play a key role in the progress and expansion of any profession, as the young scientists of today will become the specialists and leaders of tomorrow, and the future science diplomats. To fulfil this goal, they require continuous motivation and an adequate environment to develop. In view of this EFOMP is establishing a Special Interest Group (SIG) encompassing early career medical physicists from all European member countries to provide an official platform for educational and professional networking covering all aspects of the profession [26]. Most importantly, it is expected that the SIG will stimulate the development of much needed soft skills among young professionals, including strategic planning, marketing, communication, and pedagogical skills, but also skills in conflict resolution, organizational politics, negotiation, and team-building [27]. The creation of the SIG was received with great enthusiasm by young and senior professionals alike, foreseeing fruitful collaborations among European countries in biomedical fields, by stimulating young minds, fostering new ideas and employing science diplomacy across the borders. It is hoped that the involvement of early career researchers in science diplomacy will accelerate collaborations between low- and high-income countries and will facilitate scientific mobilities within Europe to achieve a more unified training, education and research platform in medical physics and related biomedical fields.

3.3 Communicating to public

Increasing the visibility of the profession is directly connected with the organization of large-scale events that attract medical physicists and the public. The International Day of Medical Physics and the International Week of Medical Physics are celebrated annually and medical physicists throughout the world celebrate it through various activities related to the profession.

Health professionals must explain the benefits and risks of medical imaging to policy makers, care providers, patients, family members, and the public. In an effort to provide guidance in this area, AAPM has published a communication guide "Radiation and Medical Imaging: Communicating Clear Answers to Top Questions" [28].

3.4 Enabling equitable access of patients to healthcare

Biomedical diplomacy is gaining importance in low and middle-income countries to abate health challenges by using resources, streamlining procedures, fostering collaboration, promoting innovative and sensitive approaches, developing education, professional training, capacity-building plans, sharing experience through worldwide networks [29]. Through collaborative activities, one nation can achieve better outcomes in diagnosis, treatment, quality control, and policy development [30]. The significance of science diplomacy is better acknowledged in LMICs now, especially since the COVID-19 situation, which disrupted the global health system [31]. At that time, it was difficult to upgrade imaging technology, use medical devices and continue radiotherapy services [29]. Without collaborative activities, it was not possible to develop and maintain medical physics services in some LMICs.

The Federation of African Medical Physics Organizations revealed that for radiology and nuclear medicine medical physics, the number of clinically qualified medical physicists is inadequate by at least a factor of 20 in almost all countries in the region, to cover existing services adequately [32]. The Lancet Oncology Commission for Sub-Saharan Africa estimated that at least 5000 additional megavoltage radiotherapy machines are required in Africa over the next 15 years to ensure equity in cancer care [33] and each of these will require adequate medical physics support as well. It is thus very clear that scientific collaborations across borders are required to address this need.

IAEA establishes a milestone for cancer management with a focus on initiatives to advance radiotherapy globally. IAEA expands their services to improve the Member States' capacity to meet needs related to the prevention, diagnosis, and treatment of health disorders. Both the developed and developing worlds benefit from using nuclear and radiation procedures within a framework of quality assurance by the IAEA [34]. The IAEA assist the Member States in the Asia and Pacific region to plan, launching, and expand radiotherapy services in a safe and effective manner. This support is provided in collaboration with the Regional Cooperative Agreement (RCA) for research, development, and training related to nuclear science and technology. IAEA-RCA projects provide a variety of online and offline activities [35].

LMICs highly benefited from IAEA Technical Cooperation (TC) project, e-learning, and regional training. IAEA Marie Sklodowska-Curie Fellowship Programme contributes to women in the nuclear field by driving global scientific and technological innovation [36]. On December 6, 2022, the IAEA entered into a “Practical Arrangements on Cooperation in the Area of Radiation Oncology, Imaging and Medical Physics” with 11 professional organizations [37]. This is a significant partnership to improve access to radiotherapy services and reduce the global inequities in cancer treatment.

Additionally, both international and many national organizations have their own special committees that work in the area of supporting low to middle income countries in regard to education and training of medical physicists, or support during implementation of new medical technologies. This in turn improves patient access to safe medical technologies. For example, the AAPM, has an international library program where a number of LMIC medical physicists can get free access to medical physics educational materials, guidelines and/or publications [38]. The Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM) has its own charitable foundation, The Better Healthcare Technology [39] that communicates the complex medical technology in simpler lay terms to broader public, including patients and their families. The foundation is also home to Asia-Pacific Special Interest Group (APSIG) that over the years sponsored visits of volunteer medical physics experts for training and support assignments to Papua New Guinea, Vietnam, Philippines, Myanmar, Cambodia, Laos and Mongolia. These assignments ranged from 8 to 10 weeks to 12 months. The group also regularly organizes fundraising events to support its international outreach activities.

Another example is a volunteer organization Medical Physics for World Benefit [40], which, according to their mission statement, they aim “to provide Medical Physics support with the goal of improving the effectiveness and safety in the use of physics and technologies in medicine, especially in low-to-middle income countries. To support activities which will yield effective and safe use of physics and technologies in medicine through advising, training, demonstrating, and/or participating in medical physics-related activities, especially in low to middle income countries.”

3.5 Gender equity in MP and healthcare provision

The IOMP focuses on diversity and inclusion as evidenced by IOMP’s structure and activities [41, 42]. The recently established IOMP Women Subcommittee coordinates tasks related to the role of women in medical physics, popularizing the profession and encouraging female medical physicists to advance in the profession. IOMP Women works in

close collaboration with the IUPESM Women in Medical Physics and Biomedical Engineering (WiMPBME) group [43].

4 Conclusions

There are several aspects of science diplomacy that can assist with the progress of a profession, such as medical physics. Whether through international or national organisations, science diplomats have an important role of initiating and substantiating projects and activities that would lead to the benefit of medical physicists worldwide. With the growing need of oncological patient care through novel technology and well-trained staff, it is essential for the medical physics community to continuously improve their skills and help those peers with limited access to the latest technology and knowledge. This way, the large gap between countries and continents concerning cancer patient care, will be reduced and high-quality healthcare will be offered to all.

List of Abbreviations

AAPM	American Association of Physicists in Medicine
AFOMP	Asia–Oceania Federation of Organizations for Medical Physics
ALFIM	Asociación Latinoamericana de Física Médica
EFOMP	European Federation of Organisations for Medical Physics
FAMPO	Federation of African Medical Physics Organizations
IAEA	International Atomic Energy Agency
ILO	International Labour Office
IOMP	International Organization for Medical Physics
IUPESM	International Union for Physical and Engineering Sciences in Medicine
LMICs	Low-and-Middle-Income Countries
MEFOMP	Middle East Federation of Medical Physics
NMOs	National Member Organizations
PAHO	Pan American Health Organization
SD	Science diplomacy
SEAFOMP	South East Asian Federation of Organizations for Medical Physics
WHO	World Health Organization
WiMPBME	Women in Medical Physics and Biomedical Engineering

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References

- International Organization for Medical Physics. - <https://www.iomp.org/>.
- Rehani MM, Damilakis J, Bezak E, et al. The International Organization for Medical physics – a driving force for the global development of medical physics. *Health Technol.* 2022;12:617–31.
- ISCO-08. Structure, index correspondence with ISCO-88, ISCO - International Standard Classification of Occupations (ilo.org), Last visited 12.02.2023.
- Medical Physicists now classified by ILO as a profession, e-Zine IOMP. April 2012, <http://www.emerald2.eu/ezine/education.html>, Last visited 12.02.2023.
- Pan American Health Organization. : <https://www.paho.org/en/topics/radiation-protection>.
- International Atomic Energy Agency. :<https://iaea.org>.
- The European Union Science Diplomacy Alliance. <https://www.science-diplomacy.eu/>. 2022 [cited 2022 September].
- Hennessey E. What is science diplomacy? *The Biologist.* 2022, Royal Society of Biology: UK. p. 26–29.
- American Association for the Advancement of Science., <https://www.aaas.org/programs/center-science-diplomacy/introduction>. [cited 2022 10 September].
- S4D4C Project. The Madrid Declaration on Science Diplomacy, V 1.12 Public, <https://www.s4d4c.eu/s4d4c-1st-global-meeting/the-madrid-declaration-on-science-diplomacy> Eur Union's Horizon 2020, grant agreement no 770342 2019 [cited Sept 2022].
- Epping E. Lifting the smokescreen of science diplomacy: comparing the political instrumentation of science and innovation centres. *Humanit Social Sci Commun* 2020;7(1).
- Fedoroff NV. Science diplomacy in the 21st century. *Cell.* 2009;136(1):9–11.
- Melchor L. What is a Science Diplomat? *Hague J Dipl.* 2020;15(3):409–23.
- Mauduit J-C, Gual Soler M. Building a science Diplomacy Curriculum. *Front Educ.* 2020;5:138.
- International Atomic Energy Agency, Radiation Protection and Safety of Radiation Sources. International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3. Vienna: IAEA; 2014.
- European Federation of Organisations for Medical Physics. : <https://www.efomp.org/>.
- Tabakov S, Sprawls P, Benini A, Bertocchi L, Milano F, DeDenaro M. International College on Medical Physics at ICTP – 30 years support for the colleagues in Low and Middle Income Countries. *J Med Phys Int.* 2019;6:314–8. <http://www.mpijournal.org/pdf/2019-01/MPI-2019-01-p011.pdf>. Last visited 12.02.2023.
- ICTP College on Medical Physics Celebrating. 30 years, http://www.emerald2.eu/mep/e-book-ictp/ICTP_College_on_Medical_Physics_Celebrates_30_years_s.pdf, Last visited 12.02.2023.
- <https://asiapacific.unfpa.org/en/populationtrends>.
- <https://asean.org/what-we-do/>.
- IAEA, Academic and clinical training programmes and portfolios for the regional training in medical physics. 2019; Available from https://humanhealth.iaea.org/HHW/MedicalPhysics/TheMedicalPhysicist/EducationandTrainingRequirements/Educationalrequirements/Harmonized_syllabus_for_Medical_Physicists_training_in_Africa.pdf [accessed on 19th November 2022].
- <https://www.iaea.org/newscenter/news/iaea-and-african-experts-establish-first-harmonized-imaging-quality-control-protocols-in-the-region> [accessed on 20 November 2022].
- Ushona V, Boadu M, Nyabanda R, Digne M, Inkoom S, Issahaku S, et al. Establishment of regional diagnostic reference levels in adult computed tomography for four african countries: a preliminary study. *Rad Prot Dosim.* 2022;198(7):414–22.
- <https://www.impcbdb.org/about/>.
- Horizon. 2020 website: <https://ec.europa.eu/>.
- Marcu L, Caruana C, Lopez-Medina A, Mazzoni L, Polycarpou I, Manetou A, et al. Early career medical physicist groups in Europe: an EFOMP survey. *Phys Med.* 2022;95:89–93.
- Caruana CJ, Damilakis J. Being an excellent scientist is not enough to succeed! Soft skills for Medical Physicists, *Eur J Radiol* 2021;110108.
- Mc Collough C, Jordan D, Dauer L, Fahey F, Hyer R, Covello V. Radiation and Medical Imaging: Communicating Clear Answers to Top Questions. <https://issuu.com/aapmdocs/docs/aapmradiationandmedicalimagingcommunicationguide> [last accessed on 2 April 2023].
- Adomako M, Kamiar A, Alshaikh A, et al. The burgeoning role of global health diplomacy to alleviate suffering of cancer patients in low- and middle-income countries. *Int Health.* 2020;12:231–3.
- Comprehensive Audits of Radiotherapy Practices. A Tool for Quality Improvement. Vienna: International Atomic Energy Agency (IAEA); 2007.
- Siavashpour Z, Goharpey N, Mobasheri M. Radiotherapy based management during Covid-19 pandemic - A systematic review of presented consensus and guidelines. *Crit Rev Oncol Hematol.* 2021;164:103402.
- Trauernicht C, Hasford F, Khelassi-Toutaoui N, Bentouhami I, Knoll P, Tzapaki V. Medical physics services in radiology and nuclear medicine in Africa: challenges and opportunities identified through workforce and infrastructure surveys. *Health and Technology.* 2022;12:729–37.
- Ngwa W, Addai B, Adewole I, Ainsworth V, Alaro J, Alatiste O, et al. Cancer in sub-saharan Africa: a Lancet Oncology Commission. *Lancet Oncol.* 2022;23(6):E251–E312.
- Salminen E, Izewska J, Andreo P. IAEA's role in the global management of cancer-focus on upgrading radiotherapy services. *Acta Oncol.* 2005;44(8):816–24.
- Prajogi GB, Loreti G, Zubizarreta E, van der Merwe D. Role of the IAEA in education and training of radiotherapy professionals in Asia Pacific. *J Med Imaging Radiat Oncol.* 2021;65(4):431–5.
- <https://www.iaea.org/about/overview/gender-at-the-iaea/iaea-marie-sklodowska-curie-fellowship-programme>.
- <https://www.iaea.org/newscenter/pressreleases/iaea-launches-worldwide-rays-of-hope-partnership-with-11-global-cancer-societies-in-cancer-care> [last accessed on 2 April 2023].
- <https://www.aapm.org/international/default.asp> [last accessed on 2 April 2023].
- <https://www.betterhealthcaretechnology.org/> [last accessed on 2 April 2023].
- <https://.mpwb.org/> [last accessed on 2 April 2023].

41. Tabakov S, Stoeva M. Collaborative networking and support for medical physics development in low and middle income (LMI) countries. *Health Technol.* 2021;11:963–9.
42. Tsapaki V, Tabakov S, Rehani M. Medical physics workforce: a global perspective. *Physica Med.* 2018;5:33–9.
43. IUPESM Women in Medical Physics and Biomedical Engineering (WiMPBME.), <https://iupesm.org/wimpbme/> [last accessed on 19 November 2022].

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