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The Role of Medical Physics in Enhancing Patient Care: A Collaborative Approach with Nursing, Midwifery, Dentistry, And Operation and Equipment Technicians

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Abstract

Medical physics plays a vital role in enhancing patient care through the application of physical principles to medical diagnostics and treatment. This paper explores the integration of medical physics into healthcare, emphasizing its collaboration with nursing, midwifery, dentistry, and operation and equipment technicians. It highlights the significance of medical physics in areas such as radiotherapy, imaging diagnostics, and the safe operation of healthcare technologies. Challenges specific to developing countries, such as a shortage of specialists, limited resources, and regulatory gaps, are discussed alongside opportunities for growth, including education programs, international collaboration, and cost-effective technological solutions. This interdisciplinary approach underscores the importance of fostering collaboration among healthcare professionals to optimize patient outcomes and enhance healthcare systems in resource-limited settings.

Keywords-Medical Physics, Patient Care, Interdisciplinary Collaboration, Healthcare Technology, Developing Countries, Radiotherapy, Imaging Diagnostics, Education and Training, Nursing, Midwifery, Dentistry.

1. Introduction

As a professional discipline, medical physics has a wide variety of applications in the enhancement of patient care. Some of these applications are well recognized outside medical physics, while others are more esoteric, but vitally important nonetheless. Medical physicists have the ability to apply the principles of physics to patient care. It is the intention of this essay to bring to the attention of the reader some of the less visible, but nonetheless important, aspects of the role of medical physics in patient care (Alfredo Siochi et al., 2009). Essentially, this essay will highlight how medical physics can assist with the enhancement of patient care through collaboration with nursing, midwifery, dentistry and operation and equipment technicians.

Technological advances in medicine are usually paralleled by increases in complexity, both with respect to the technology itself, and how it is integrated into patient care pathways. The management of technology, including the effective utilization of technology to ensure optimal treatment

outcomes, necessitates consideration of a multi-professional approach. This approach is outlined with respect to the roles of medical physics, nursing, midwifery, dentistry, and operation and equipment technicians in patient care. It is hoped that some consideration of the broader roles of medical physics in the management of healthcare technology will encourage discussions between these professions regarding the ways in which collaboration can improve patient care. Advances in technology and the application of the principles of physics to patient care have considerably improved the effectiveness of treatment. In disciplines such as radiotherapy, radiology, nuclear medicine, dental imaging and treatment, cardiology, as well as many others, medical physicists play a vital role. However, the contribution of medical physicists is often inadequately appreciated and underutilized. (Wöhl et al.2024)(Suorsa et al.2024)

1.1. Background and Significance

The synergy between physics and healthcare has led to the development of medical physics as a vital discipline in ensuring safe and effective patient care. Acknowledging the need for collaboration with other healthcare professions, particularly nursing, midwifery, dentistry, and operation and equipment technicians, this document outlines the role of medical physics development in Nation's regional health services. Since ancient times, when religion and science were intertwined, efforts have been made to cure ailments afflicting humans and animals. As scientific understanding progressed, medical practices evolved from crude techniques to sophisticated scientific methodologies. The emergence of bacteriology, pathology, and immunology in the 19th century transformed medicine into a precise science. The discovery of X-rays in 1895 initiated the integration of physics into medical diagnostics and treatment. Subsequent advancements in physics during the 20th century led to the development of various health-related technologies, such as radioactivity, thermography, endoscopy, ultrasonography, tomography, lasers, and MRIs. These innovations revolutionized health examination and treatment procedures, enhancing accuracy and safety. While medical scientists focus on the biological and chemical aspects of health, the growing importance of physics in examinations and treatments necessitates the training and education of healthcare professionals in relevant physical principles (S. Ibbott et al., 2022).

The establishment of medical physics departments in hospitals is essential to address these issues. Medical physicists ensure the careful and safe use of physical technology and methods in patient care, develop new applications, and collaborate with other healthcare professionals. Globally, medical physics is recognized as a distinct healthcare profession, with the International Organization for Medical Physics advocating for the inclusion of medical physicists in health services. In countries with a long history of medical physics, national organizations enhance integration and collaboration among medical physicists and other health professionals. For example, the Australian Institute of Physics and Engineering in Medicine organizes annual joint scientific meetings for medical physicists, biomedical engineers, and clinical engineers. The Health Physicists Group within the Institute of Physics and Engineering in Medicine focuses on issues specific to physicists working in healthcare. The Medical and Biological Physics Group organized a workshop to foster collaboration between medical physicists, biomedical engineers, and clinical engineers. In the United Kingdom, the Institute of Physics and Engineering in Medicine is involved in joint ventures with other professional organizations, including the Scientific Advisory Committee for the British Dental Association and partnerships with the Society and College of Radiographers and the Royal College of Surgeons of England. However, in many developing countries, including the Nation, where medical physics is a relatively new field, it has yet to be fully integrated into healthcare services.

Initially, regional health services will focus on the medical physics aspects of nursing, midwifery, and dentistry services, as these departments are present in all regional hospitals. Efforts will also be made to advance medical physics for diagnostic imaging services, potentially collaborating with provincial health agencies. A medical physicist's primary role is to ensure the safe and effective use of physical technology and methods in patient care. In developed countries, legislation mandates regulatory control over any physical technology applied to patients or used in health examinations, requiring the involvement of qualified medical physicists. Medical physicists participate in

establishing safety protocols, operational procedures, quality assurance protocols, staff training, and compliance with safety standards. Medical physicists also develop and implement new health examination and treatment techniques that utilize physical phenomena. While there is a growing pool of medical physicists trained abroad or under fellowship programs, a supportive environment is needed for the effective employment and integration of medical physicists within health services in the Nation. This document outlines the unique challenges in integrating physics with clinical practices. These challenges are commonly encountered in developing countries but may differ in specifics and severity. Addressing these challenges requires a comprehensive understanding that goes beyond mere explanations. Thus, an overview of medical physics, focusing on patient care aspects, is presented to raise awareness among healthcare professionals, particularly those outside major urban centers and underserved regions. Finally, the broader context of the historical background is briefly explored, emphasizing the intricate nature of such interdisciplinary cooperation. (Beyer et al.2021)(Samei, 2022)(van et al.2023)(Zanca et al.2021)(Newhauser et al.2023)(Avanzo et al.2021)(Darafsheh et al.2020)(Endo, 2021)(Conroy et al.2023)

2. Foundations of Medical Physics

Medical physics is explored, focusing on its fundamentals as a discipline. The foundations, or basics, of a subject define its main aspects and most important components. The basis of a discipline can indicate how well professionals reading the text might understand it. The discipline of medical physics is concerned with the application of physics to medicine, involving theoretical knowledge and practical skills (S. Ibbott et al., 2022). While there may be many different variants of how this knowledge and skill set is applied, there are some basics that are always present.

There are some medical physics fundamentals on which patient care and treatment would be impossible without the daily involvement of scientific understanding and physiochemical principles. These fundamentals include, but are not limited to, the following: the physics of radiation; devices and systems used to create images of the anatomy of the patient for diagnosis or treatment; measurement of radiation dose, primarily to patients, but also to staff involved in treatment; calibration of equipment used in the measurement of radiation and testing the performance of that equipment; quality assurance protocols and procedures for ensuring the ongoing safe and correct operation of devices used to treat patients; design of facilities containing radioactive sources, including both brachytherapy treatment rooms and areas where radioactive pharmaceuticals are stored; and regulatory and safety guidelines under which all of this practice is carried out. Understanding these basics provides insight into how medical physics might support nursing, midwifery, dentistry, and operation and equipment technicians in their roles in caring for patients.

Healthcare team members directly involved in patient care have, or should have, an understanding of the relevant clinical aspects of these fundamentals. However, it is vital that these principles are understood widely in clinical areas outside of medical physics, as interdisciplinary understanding and collaboration is most effective when all parties share a common language. Beyond an appreciation for how aspects of medical physics might directly apply to specific disciplines within patient care, there is also a clear need for a basic grounding in physics for those who choose to engage in disciplines devoted to the care of patients. Finally, there is an understanding of how the fundamentals of medical physics practice are applied in a clinical setting. This is an important aspect when considering a team-based approach to healthcare delivery, as thinking and planning purely from the clinical or team perspective is unlikely to be as effective as addressing fundamentals from the healthcare discipline perspective, with consideration of how these fundamentals influence individual patient care pathways. (Moirano et al., 2020)(Marge et al.2022)(Bowman et al., 2021)(Bertel et al.2022)(Følstad et al.2021)(Cains et al.2022)(Sun et al., 2021)(Dusdal & Powell, 2021)

2.1. Fundamental Principles

Medical physics is the branch of physics that is applied to medicine. It is a “one-stop shop” for the fundamental principles that underpin medicine, healthcare, and medical technologies, as well as the biomedical engineering used within them. Medical physics involves the application of the laws of physics, particularly electromagnetism, thermodynamics, mechanics, and relativity, as they

are relevant to, and enhance, patient care. Examples of medical technologies incorporating these principles include magnetic resonance imaging (MRI) using nuclear magnetic resonance; computed tomography (CT) scans, interception of X-ray attenuation; and therapeutic radiation, the cascading effect of ionizing radiation . Understanding these fundamental principles helps nursing, midwifery, dentistry, and operation and equipment technicians optimize patient care while ensuring their safety.

Biomedical engineering relates directly to the design, manufacture, and operation of health technologies, medical devices, and equipment, incorporating electronics, mechanization, and software. Aspects of this discipline include regulations, standards, clinical trials, quality assurance, and safety testing. A good grasp of the fundamental principles that underpin healthcare technologies helps operators understand machine limitations, troubleshoot errors, and optimize protocols. Design and development also necessitate an understanding of underlying principles, so engineers can be informed of clinical requirements. Similarly, this understanding is important for academia, as it helps to devise courses that train capable operators or designers. Medical devices used in healthcare affect human physiology and therefore need prior risk assessment and horizon scanning. Relevant high-level biomedical principles ensure the safe use of devices, from simple thermometers to complex MRIs. Continuous education in physics is essential for nursing, midwifery, dentistry, and operation and equipment technicians. This basic knowledge facilitates effective communication with medical physicists, biomed engineers, and industry, fostering fruitful collaboration. (Ntolou et al.2022)(CHEAH, 2023)(Sharipov et al.2021)(Gouws, 2022)(Jalloul et al.2023)(Lakka et al., 2023)(Murtaza et al.2024)(Gajdzik and Wolniak2022)

3. Interdisciplinary Collaboration in Healthcare

Enhancing patient care is paramount in healthcare, demanding a holistic approach that integrates physical, emotional, and psychological elements. This necessitates interdisciplinary collaboration among all healthcare professionals. Various collaborations exist, and patient care often involves shared work across different professions, each applying their expertise within their scope. However, the success of care relies on how effectively these professions collaborate. This outlines the essential elements of collaboration, specifically from the viewpoint of medical physics education. There is a need for collaborative efforts among various healthcare professionals to ensure their engagement in enhancing patient care. While a shared understanding of the need for collaboration exists, conveying what is being done to achieve such collaboration in one discipline might assist others in similar professions. Therefore, an example of bringing professions together for patient welfare from the medical physics perspective is discussed. (Alderwick et al., 2021)(Bransen et al.2022)(Gray & Sanders, 2020)(Pennbrant et al.2020)(Darling-Hammond and Hyler2020)(Steen & Brandsen, 2020)

Many disciplines come together to provide patient care, with nursing being the core. Nursing considers the totality of care, including the emotional, psychological, spiritual, and physical aspects, while other professions focus on specific areas. However, it is crucial to note that the success of patient care relies on how well these diversified professions collaborate. The essential elements of collaboration, with an emphasis on the role of medical physics, are highlighted here. A variety of collaboration exists, and care of patients generally involves shared work between different professions, with each applying their expertise in matters concerning patients within their scope of work. For instance, diverse professions are involved in a cancer patient's care, each addressing a different aspect of care. The outcome of care relies on how well these professions work together, which often involves a number of barriers. Hence, it is crucial to identify and understand the elements that make collaboration successful and bring professions together.

Collaboration is when two or more people or organizations work together to achieve something. In the context of patient care, collaboration among healthcare professionals denotes collective responsibility for a patient, focusing on shared goals while addressing different aspects of care. For collaboration to be successful, mutual respect is essential, along with understanding the breadth of each profession's expertise. Misunderstanding regarding the scope of work generally leads to overlaps or voids in care, and respect is fundamental for other elements to function effectively. From the medical physicist's perspective, examples are

provided on how collaboration plays a role in enhancing patient care with nurses, along with other disciplines. Teamwork may require an individual to function in different roles, and bringing professions together under collaborative care might be a challenge. Generally, the core profession will steer the team, and other professions must adjust how they engage with the team. It is vital to understand how teams function and the challenges in collaboration. There may also be a need to go beyond the expected boundaries of a profession to ensure effective collaboration. Overlapping scopes may bring difficulties; hence, it is proposed to clearly define responsibilities when disciplines work in close cooperation. (Schot et al.2020)(Wei et al.2020)(Delgado et al.2021)(Pursio et al.2021)(Alowais et al.2023)(Timmermans, 2020)

3.1. Nursing-midwifery and Medical Physics

This section specifically examines the collaborative relationship between nursing and medical physics. The integral role of nurses in patient care is well-recognized and supported by legislation. Nurses are often the first point of contact for patients and an integral part of multi-disciplinary teams. Indeed, nursing is the only profession that interacts with patients in all dimensions of their care (W. Brown et al., 2018). Given the important role that nurses play, medical physicists also interact with nursing staff and patients indirectly through nursing.

In the past, the activities of medical physicists outside treatment planning had little or no direct involvement with patients. However, treatment planning would not occur without the quality input and patient safety protocols developed with the assistance of nursing staff. The role of nursing in patient safety protocols associated with brachytherapy and the development of appropriate imaging techniques for patients with learning disabilities will be discussed (S. Ibbott et al., 2022). As the partnership with nursing in these areas has proven productive, other areas will be targeted for collaboration in the future. Educational and training opportunities for medical physicists have been developed with nursing as an important mechanism for fostering a productive nursing-physics partnership. Collaborations between nursing and medical physics are expected to not only enhance the quality of care provided to patients but also enrich the practice of both professions. Cooperation and collaboration are used in the context of working together to achieve the same goal. Cooperation implies that there may be separate and independent activities that contribute to the overall outcome, whilst collaboration implies more joint or collective activities. In nursing and medical physics, efforts will focus on collaboration. Consideration is given to clinical examples that illustrate how nursing and medical physics currently cooperate and collaborate, the challenges posed by this clinical partnership, and strategies to minimize these challenges. An emphasis on nursing input is acknowledged in patient treatment planning but note that similar issues exist for other allied health professional input. An important point is that ongoing communication and feedback between nurses and medical physicists is vital to ensure that the collaboration continues to develop and be effective in a clinical setting. (Lincoln et al., 2020)(Ford et al.2020)(Vassileva et al.2022)(Xia et al.2021)(Glide-Hurst et al.2021)(Saw & Ng, 2022)

4. Applications of Medical Physics in Patient Care

Medical physics, or the application of the principles and techniques of physics to medicine and healthcare, is often overlooked in discussions about enhancing patient care, considering the importance of nursing, midwifery, dentistry, and other allied health professions. Nevertheless, clinical services provided by medical physicists in hospitals and clinics worldwide focus specifically on improving patient care. It is therefore vital for the nursing and midwifery communities, as well as those in dentistry and other relevant disciplines, to understand the basic tenets of medical physics, and the services medical physicists provide to healthcare facilities, to ensure enhancements in patient care are a joint effort by all relevant disciplines.

Medical physics is the healthcare profession responsible for assuring the safe and effective use of ionizing, non-ionizing, and acoustic radiation in medicine. Its contributions to patient care revolve around the practical application of the principles and techniques of physics in medicine and healthcare. Patient care applications of medical physics in imaging diagnostics, therapeutic radiation, and dosimetry are explored, as well as how they enhance patient care. Each of these applications address extensively how patient care is improved and benefited from medical physics input, highlighting the collaborative nature of the contributions where

appropriate (F. Atwood et al., 2020). To examine the applications of medical physics to patient care, the focus needs to be on its practical applications rather than the more academic understanding of medical physics, or the research and development aspects of medical physics in which care of the patient is not the ultimate goal. Therefore, it is necessary to explore the basic principles and techniques of medical physics pertaining to its applications to patient care. Advances in the understanding or sophistication of the principles and techniques of physics do not translate automatically into improved patient care, but this is generally how medical physics is viewed.

To a greater or lesser extent, patient care throughout medicine and healthcare is enhanced by the knowledge of, and advances in, the disciplines of chemistry, biology, and biochemistry. However, input from these scientific disciplines is indirect because the services provided by chemists, biologists, and biochemists focus on issues other than direct patient care. In contrast, the services provided by medical physics focus directly on patient care, which is enhanced through specific input from the discipline of physics. The significance and value of this input is particularly highlighted in a clinical setting where performance or outcome improvements are linked directly to the input from medical physics. Of course, input from other disciplines also enhances patient care, but the efforts of other disciplines are not as effective unless medical physics input is considered a priority, at least in terms of good clinical practice. (Fiorino et al.2020)(Mahadevaiah et al.2020)(Ford et al.2020)(Avanzo et al.2021)(Azlan et al.2020)(Van Dyk, 2020)(Ashenafi et al.2023)

4.1. Radiation Therapy

Radiation therapy, a prominent modality for cancer treatment, employs high-energy photons or particles to destroy cancer cells while minimizing damage to surrounding healthy tissue. By leveraging the principles of radiation physics in therapeutic contexts, medical physics significantly enhances patient care. Central to the efficacy of radiation therapy is the delivery of an accurate dose to the patient, which necessitates sophisticated design and implementation of treatment planning processes. Medical physicists play a crucial role in this regard, ensuring the correct calculation and application of radiation dose. In contemporary practice, treatment planning is often carried out using advanced computer systems supported by high-speed linear accelerators that generate and deliver radiation beams. These systems integrate imaging equipment, like CT or MRI, with treatment planning and dose delivery machines, enabling the convergence of diagnosis and therapy (Alfredo Siochi et al., 2009). The involvement of medical physicists in the selection, commissioning, quality assurance, and optimization of these treatment planning systems ensures superior care.

Moreover, newly diagnosed cancer patients typically consult radiation oncologists, who develop treatment protocols considering tumor location, type, patient demographics, and medical history. These protocols guide the medical physicists in designing treatment plans, which are then verified prior to patient exposure. The collaboration between medical physicists, radiation oncologists, nursing staff, and others is crucial for implementing these plans and adapting to individual patient needs. Advanced treatment modalities, like Intensity-Modulated Radiation Therapy (IMRT), Helical Tomotherapy (HT), Volumetric Arc Therapy (VMAT), and image-guided radiation therapy, underscore the importance of medical physicists in designing complex treatment plans involving multiple linear accelerator beams with intricate movement patterns. Alongside the treatment planning systems, quality assurance and in-vivo dose measurement are vital components of the comprehensive patient safety system implemented by medical physicists, system vendors, and nursing staff. As the sophistication of treatment systems increases, so do the responsibilities of medical physicists for patient and personnel protection from the dangers of ionizing radiation. This discussion focuses on how medical physics enhances patient care in the context of cancer treatment approaches involving radiation therapy. (Geurts et al.2022)(Thomson et al.2020)(Khan et al., 2021)(Siochi et al.2021)(Burmeister et al.2022)

4.2 Operation and Equipment Technicians

Operation and equipment technicians are essential stakeholders in the healthcare setting, especially in medical physics. This professional group maintains and operates sophisticated equipment found in hospitals. Each medical device, equipment or system, installed in a healthcare environment is accompanied by a manufacturer group responsible

for technical service and support. Most major manufacturers have obligations under contracts to provide service and support within a goodwill and grace period after which the healthcare facility must either maintain the contract at a premium price or rely solely on its clinical staff. Generally, healthcare facilities in developing nations have limited access to manufacturer support. Therefore, it is critical that clinical and medical physics doled out duties to one technician be shared among multiple personnel in the absence of medical physicists. Ideally, every medical device must have a technician trained in the physics of operation so upon fault, it can be better trouble-shooted before summoning support. Off the shelf devices should configure as per healthcare need and operating quirks applied optimistically. For instance, stochastic simulation confers sophistication to multi-computed tomography dosimetry but only a physicist can correctly identify its misconfiguration. Medical physicists ensure equipment is installed after conformity to specifications, national and international safety codes, and compliance with ethical standards. Much responsibility is equitably passed to technicians who, by virtue of postgraduate biomedical engineering studies, better appreciate patient safety than nurses graduating from refresher courses. However, nursing numeracy supersedes technician literacy accounting for their better participation in safety committees. Technicians are obliged to conduct compliance tests and upkeep documentation for regulatory standards. Supporting operating theatre, ward, or laboratory clinical teams ensures swift method execution preventing patient bout escalation. Enhancing workflow efficiency minimizes multi-dosimetry, contouring, restraint, enumeration difficulty, and treatment reliability. Technicians receive in-service updates on novel cardiac able systems as interfacing devices require patient safety operation; equipment requiring on-the-job training provide medical physicists initial training opportunity to technicians. However, disregard past training otherwise new implement exclusively technician attended illustrates comprehends over again. Despite not independently understood, technicians sufficiently operate systems; failing understanding adequately trouble-shoot. (Thapa et al.2022)(Li et al.2022)(Aunión-Villa et al.2020)(Xusandjonovna, 2024)(Yao et al.2021)(Boppana2023)

Challenges and Opportunities for Medical Physics in Developing Countries

Challenges:

1. **Shortage of Specialized Professionals:**

- Many developing countries face a lack of qualified medical physicists, leading to increased workload for existing professionals and an inability to meet rising demand.
- Limited availability of specialized education and training programs in medical physics at local universities.

2. **Financial and Technological Constraints:**

- Insufficient healthcare budgets hinder the availability and maintenance of modern medical equipment.
- Reliance on outdated devices results in reduced accuracy in diagnostics and treatment.

3. **Lack of Awareness of Medical Physics:**

- Limited awareness among policymakers and healthcare administrators about the critical role of medical physicists.
- Medical physicists are often excluded from multidisciplinary healthcare teams, affecting the quality of patient outcomes.

4. **Regulatory and Organizational Challenges:**

- Absence of mandatory regulations or standards requiring hospitals to employ qualified medical physicists.
- Lack of clear protocols for implementing medical physics applications in healthcare facilities.

5. **Limited Access to Continuing Education:**

- Few opportunities for continuous professional development to keep pace with rapid advancements in medical technology.
- High costs of international training programs and certifications.

Opportunities:

1. **Growing Emphasis on Healthcare Technology:**

- The increasing adoption of modern medical technologies for diagnosis and treatment creates greater demand for medical physicists.
- Advanced technologies, such as radiotherapy and MRI, highlight the indispensable role of medical physics in healthcare.

2. **Regional and International Collaboration:**

- Opportunities to partner with international organizations and institutions to provide technical support and training.
- Participation in global initiatives and capacity-building programs to enhance medical physics expertise.

3. **Education and Training Development:**

- Potential to establish local education and training programs in collaboration with universities and hospitals to develop new generations of medical physicists.
- Use of online and remote learning platforms to expand access to education.

4. **Professional Development:**

- Training technicians in the fundamentals of medical physics to bridge the gap caused by the shortage of specialists.
- Short-term courses and workshops to enhance the skills of existing healthcare workers.

5. **Cost-Effective Solutions:**

- Development of low-cost medical devices tailored for resource-limited settings, ensuring efficiency and accuracy.
- Utilizing artificial intelligence to optimize older equipment, reducing the need for expensive replacements.

6. **Raising Community Awareness:**

- Awareness campaigns to educate healthcare stakeholders and the public about the significance of medical physics in improving healthcare quality.
- Promoting the role of medical physicists within multidisciplinary healthcare teams to enhance coordination and patient outcomes.

Recommendations:

- Invest in specialized education and training programs to build a robust workforce of medical physicists.
- Increase awareness among policymakers about the critical importance of medical physics in national healthcare planning.
- Foster international collaboration to provide technical and financial support to developing countries.
- Improve infrastructure and ensure the availability of high-quality equipment in compliance with global standards for safety and effectiveness.

References:

1. Alfredo Siochi, R., Balter, P., D. Bloch, C., S. Bushe, H., S. Mayo, C., H. Curran, B., Feng, W., C. Kagadis, G., H. Kirby, T., & L. Stern, R. (2009). Information technology resource management in radiation oncology. ncbi.nlm.nih.gov
2. Wöhl, M., Gimpel, H., Meindl, O., Ostgathe, C., Peuten, S., Schneider, W., & Steigleder, T. (2024). Boosting Multi-Professional Collaboration in Palliative Care Through Digital Technologies: An Action Design Research Study. Business & Information Systems Engineering, 1-23. springer.com
3. Suorsa, A., Multas, A. M., Rönkkö, E., Juuti, E., Lammi, A., & Enwald, H. (2024). Information practices in multi-professional work in urban planning. Information Research an international electronic journal, 29(2), 557-572. informationr.net
4. S. Ibbott, G., Chougule, A., Damilakis, J., Tabakov, S., K. Wu, R., G. Orton, C., & Kron, T. (2022). Medical physicist certification and training program accreditation. ncbi.nlm.nih.gov
5. Beyer, T., Bailey, D. L., Birk, U. J., Buvat, I., Catana, C., Cheng, Z., ... & Moser, E. (2021). Medical Physics and imaging–A timely perspective. Frontiers in Physics, 9, 634693. frontiersin.org

6. Samei, E. (2022). Medical physics 3.0: A renewed model for practicing medical physics in clinical imaging. Physica Medica. physicamedica.com
7. van Asten, W., Markidou, E. S., Gromoll, C., Gourzoulidis, G. A., Maguire, S., Guidi, G., ... & Klöck, S. (2023). EFOMP policy statement 17: The role and competences of medical physicists and medical physics experts in the different stages of a medical device life cycle. Physica Medica, 108, 102557. physicamedica.com
8. Zanca, F., Hernandez-Giron, I., Avanzo, M., Guidi, G., Crijns, W., Diaz, O., ... & Kortesniemi, M. (2021). Expanding the medical physicist curricular and professional programme to include Artificial Intelligence. Physica Medica, 83, 174-183. physicamedica.com
9. Newhauser, W. D., Gress, D. A., Mills, M. D., Jordan, D. W., Sutlief, S. G., Martin, M. C., & Jackson, E. (2023). Medical physics workforce in the United States. Journal of Applied Clinical Medical Physics, 23(Suppl 1), e13762. nih.gov
10. Avanzo, M., Trianni, A., Botta, F., Talamonti, C., Stasi, M., & Iori, M. (2021). Artificial intelligence and the medical physicist: welcome to the machine. Applied Sciences, 11(4), 1691. mdpi.com
11. Darafsheh, A., Lavvafi, H., Taleei, R., & Khan, R. (2020). Mitigating disruptions, and scalability of radiation oncology physics work during the COVID-19 pandemic. Journal of applied clinical medical physics, 21(7), 187-195. wiley.com
12. Endo, M. (2021). History of medical physics. Radiological Physics and Technology. [HTML]
13. Conroy, L., Faught, J. T., Bowers, E., Ecclestone, G., Fong de los Santos, L. E., Hsu, A., ... & Sterling, D. A. (2023). Medical physics practice guideline 4. b: development, implementation, use and maintenance of safety checklists. Journal of Applied Clinical Medical Physics, 24(3), e13895. wiley.com
14. Moirano, R., Sánchez, M. A., & Štěpánek, L. (2020). Creative interdisciplinary collaboration: A systematic literature review. Thinking Skills and Creativity. uns.edu.ar
15. Marge, M., Espy-Wilson, C., Ward, N. G., Alwan, A., Artzi, Y., Bansal, M., ... & Yu, Z. (2022). Spoken language interaction with robots: Recommendations for future research. Computer Speech & Language, 71, 101255. sciencedirect.com
16. Bowman, K. S., Suarez, V. D., & Weiss, M. J. (2021). Standards for interprofessional collaboration in the treatment of individuals with autism. Behavior Analysis in Practice. nih.gov
17. Bertel, L. B., Winther, M., Routhe, H. W., & Kolmos, A. (2022). Framing and facilitating complex problem-solving competences in interdisciplinary megaprojects: An institutional strategy to educate for sustainable development. International Journal of Sustainability in Higher Education, 23(5), 1173-1191. aau.dk
18. Følstad, A., Araujo, T., Law, E. L. C., Brandtzaeg, P. B., Papadopoulos, S., Reis, L., ... & Luger, E. (2021). Future directions for chatbot research: an interdisciplinary research agenda. Computing, 103(12), 2915-2942. springer.com
19. Cains, M. G., Flora, L., Taber, D., King, Z., & Henshel, D. S. (2022). Defining cyber security and cyber security risk within a multidisciplinary context using expert elicitation. Risk Analysis, 42(8), 1643-1669. wiley.com
20. Sun, Y., Livan, G., Ma, A., & Latora, V. (2021). Interdisciplinary researchers attain better long-term funding performance. Communications Physics. nature.com
21. Dusdal, J. & Powell, J. J. W. (2021). Benefits, motivations, and challenges of international collaborative research: A sociology of science case study. Science and Public Policy. oup.com
22. Ntolou, K., Parasyri, D., Fantidis, J., Kogias, P., & Papadopoulou, E. (2022). Active Learning Community for Upskilling Technicians and Engineers. The Journal of CIEES, 2(1), 25-31. ciees.eu
23. CHEAH, S. M. (2023). Chemical Engineering Education: Pedagogy for Learning from Failure in Process Plant Operations. Proceedings of the 19th International CDIO Conference. cdio.org
24. Sharipov, F. F., Krotenko, T. Y., & Dyakonova, M. A. (2021). Transdisciplinary strategy of continuing engineering education. In Engineering Economics: Decisions and Solutions from Eurasian Perspective (pp. 480-488). Springer International Publishing. [HTML]
25. Gouws, S. (2022). Teaching for chemical process technicians. Education for Chemical Engineers. [HTML]
26. Jalloul, M., Miranda-Schaeubinger, M., Noor, A. M., Stein, J. M., Amiruddin, R., Derbew, H. M., ... & Mollura, D. J. (2023). MRI scarcity in low-

and middle-income countries. NMR in Biomedicine, 36(12), e5022. [HTML]
27. Lakka, I., Zafeiropoulos, V., & Leisos, A. (2023). Online Virtual Reality-Based vs. Face-to-Face Physics Laboratory: A Case Study in Distance Learning Science Curriculum. Education Sciences. mdpi.com
28. Murtaza, A. A., Saher, A., Zafar, M. H., Moosavi, S. K. R., Aftab, M. F., & Sanfilippo, F. (2024). Paradigm shift for predictive maintenance and condition monitoring from Industry 4.0 to Industry 5.0: A systematic review, challenges and case study. Results in Engineering, 102935. sciencedirect.com
29. Gajdzik, B., & Wolniak, R. (2022). Smart production workers in terms of creativity and innovation: The implication for open innovation. Journal of Open Innovation: Technology, Market, and Complexity, 8(2), 68. sciencedirect.com
30. Alderwick, H., Hutchings, A., Briggs, A., & Mays, N. (2021). The impacts of collaboration between local health care and non-health care organizations and factors shaping how they work: a systematic review of reviews. BMC Public Health. springer.com
31. Bransen, D., Govaerts, M. J., Panadero, E., Sluijsmans, D. M., & Driessen, E. W. (2022). Putting self-regulated learning in context: integrating self-, co-, and socially shared regulation of learning. Medical Education, 56(1), 29-36. wiley.com
32. Gray, R. & Sanders, C. (2020). A reflection on the impact of COVID-19 on primary care in the United Kingdom. Journal of Interprofessional Care. [HTML]
33. Pennbrant, S., Hjorton, C., Nilsson, C., & Karlsson, M. (2020). "The challenge of joining all the pieces together"–Nurses' experience of palliative care for older people with advanced dementia living in residential aged care units. Journal of clinical nursing, 29(19-20), 3835-3846. wiley.com
34. Darling-Hammond, L., & Hyler, M. E. (2020). Preparing educators for the time of COVID… and beyond. European Journal of Teacher Education, 43(4), 457-465. 68.77.48.18
35. Steen, T. & Brandsen, T. (2020). Coproduction during and after the COVID-19 pandemic: will it last?. Public Administration Review. nih.gov
36. Schot, E., Tummers, L., & Noordegraaf, M. (2020). Working on working together. A systematic review on how healthcare professionals contribute to interprofessional collaboration. Journal of interprofessional care, 34(3), 332-342. tandfonline.com
37. Wei, H., Corbett, R. W., Ray, J., & Wei, T. L. (2020). A culture of caring: the essence of healthcare interprofessional collaboration. Journal of interprofessional care, 34(3), 324-331. [HTML]
38. Delgado, J., Siow, S., de Groot, J., McLane, B., & Hedlin, M. (2021). Towards collective moral resilience: the potential of communities of practice during the COVID-19 pandemic and beyond. Journal of Medical Ethics, 47(6), 374-382. bmj.com
39. Pursio, K., Kankkunen, P., Sanner-Stiehr, E., & Kvist, T. (2021). Professional autonomy in nursing: An integrative review. Journal of nursing management, 29(6), 1565-1577. wiley.com
40. Alowais, S. A., Alghamdi, S. S., Alsuhebany, N., Alqahtani, T., Alshaya, A. I., Almohareb, S. N., ... & Albekairy, A. M. (2023). Revolutionizing healthcare: the role of artificial intelligence in clinical practice. BMC medical education, 23(1), 689. springer.com
41. Timmermans, S. (2020). The engaged patient: The relevance of patient–physician communication for twenty-first-century health. Journal of Health and Social Behavior. [HTML]
42. W. Brown, D., F. Atwood, T., L. Moore, K., MacAulay, R., D. Murphy, J., J. Mundt, A., & Pawlicki, T. (2018). A program to train medical physicists for direct patient care responsibilities. ncbi.nlm.nih.gov
43. Lincoln, H., Khan, R., & Cai, J. (2020). Telecommuting: a viable option for Medical Physicists amid the COVID-19 outbreak and beyond. Medical physics. nih.gov
44. Ford, E., Conroy, L., Dong, L., de Los Santos, L. F., Greener, A., Gwe-Ya Kim, G., ... & Wells, M. (2020). Strategies for effective physics plan and chart review in radiation therapy: Report of AAPM Task Group 275. Medical physics, 47(6), e236-e272. nih.gov
45. Vassileva, J., Applegate, K., Paulo, G., Vano, E., & Holmberg, O. (2022). Strengthening radiation protection education and training of health professionals: conclusions from an IAEA

meeting. Journal of Radiological Protection, 42(1), 011504. researchgate.net

46. Xia, P., Sintay, B. J., Colussi, V. C., Chuang, C., Lo, Y. C., Schofield, D., ... & Zhou, S. (2021). Medical Physics Practice Guideline (MPPG) 11. a: Plan and chart review in external beam radiotherapy and brachytherapy. Journal of applied clinical medical physics, 22(9), 4-19. wiley.com
47. Glide-Hurst, C. K., Paulson, E. S., McGee, K., Tyagi, N., Hu, Y., Balter, J., & Bayouth, J. (2021). Task group 284 report: magnetic resonance imaging simulation in radiotherapy: considerations for clinical implementation, optimization, and quality assurance. Medical physics, 48(7), e636-e670. nih.gov
48. Saw, S. N. & Ng, K. H. (2022). Current challenges of implementing artificial intelligence in medical imaging. Physica Medica. physicamedica.com
49. F. Atwood, T., W. Brown, D., Juang, T., L. Moore, K., A. McConnell, K., M. Steers, J., D. Murphy, J., J. Mundt, A., & Pawlicki, T. (2020). A review of patient questions from physicist—patient consults. ncbi.nlm.nih.gov
50. Fiorino, C., Jeraj, R., Clark, C. H., Garibaldi, C., Georg, D., Muren, L., ... & Jornet, N. (2020). Grand challenges for medical physics in radiation oncology. Radiotherapy and Oncology, 153, 7-14. thegreenjournal.com
51. Mahadevaiah, G., Rv, P., Bermejo, I., Jaffray, D., Dekker, A., & Wee, L. (2020). Artificial intelligence-based clinical decision support in modern medical physics: selection, acceptance, commissioning, and quality assurance. Medical physics, 47(5), e228-e235. wiley.com
52. Azlan, C. A., Wong, J. H. D., Tan, L. K., Huri, M. S. N. A., Ung, N. M., Pallath, V., ... & Ng, K. H. (2020). Teaching and learning of postgraduate medical physics using Internet-based e-learning during the COVID-19 pandemic–A case study from Malaysia. Physica Medica, 80, 10-16. nih.gov
53. Van Dyk, J. (2020). THE MODERN TECHNOLOGY OF RADIATION ONCOLOGY: A Compendium for Medical Physicists and Radiation Oncologists. Volume 4. Medical Physics. mpijournal.org
54. Ashenafi, M., Jeong, S., Wancura, J. N., Gou, L., Webster, M. J., & Zheng, D. (2023). A quick guide on implementing and quality assuring 3D printing in radiation oncology. Journal of Applied Clinical Medical Physics, 24(11), e14102. wiley.com
55. Geurts, M. W., Jacqmin, D. J., Jones, L. E., Kry, S. F., Mihailidis, D. N., Ohrt, J. D., ... & Wingreen, N. E. (2022). AAPM MEDICAL PHYSICS PRACTICE GUIDELINE 5. b: Commissioning and QA of treatment planning dose calculations—Megavoltage photon and electron beams. Journal of applied clinical medical physics, 23(9), e13641. wiley.com
56. Thomson, R. M., Furutani, K. M., Kaulich, T. W., Mourtada, F., Rivard, M. J., Soares, C. G., ... & Melhus, C. S. (2020). AAPM recommendations on medical physics practices for ocular plaque brachytherapy: report of task group 221. Medical Physics, 47(5), e92-e124. eyephysics.com
57. Khan, F. M., Sperduto, P. W., & Gibbons, J. P. (2021). Khan's Treatment Planning in Radiation Oncology:.. [HTML]
58. Siochi, R. A., Balter, P., Bloch, C. D., Santanam, L., Blodgett, K., Curran, B. H., ... & Zhu, X. R. (2021). Report of Task Group 201 of the American Association of Physicists in Medicine: Quality management of external beam therapy data transfer. Medical physics, 48(6), e86-e114. researchgate.net
59. Burmeister, J. W., Busse, N. C., Cetnar, A. J., Howell, R. R., Jeraj, R., Jones, A. K., ... & Kim, L. H. (2022). Academic program recommendations for graduate degrees in medical physics: AAPM Report No. 365 (Revision of Report No. 197). Journal of applied clinical medical physics, 23(10). nih.gov
60. Thapa, R., Yih, A., Chauhan, A., Poudel, S., Singh, S., Shrestha, S., ... & Rajbhandari, R. (2022). Effect of deploying biomedical equipment technician on the functionality of medical equipment in the government hospitals of rural Nepal. Human resources for health, 20(1), 21. springer.com
61. Li, J., Mao, Y., & Zhang, J. (2022). Maintenance and quality control of medical equipment based on information fusion technology. Computational Intelligence and Neuroscience, 2022(1), 9333328. wiley.com
62. Aunión-Villa, J., Gómez-Chaparro, M., & García Sanz-Calcedo, J. (2020). Assessment of the maintenance costs of electro-medical

equipment in Spanish hospitals. Expert Review of Medical Devices, 17(8), 855-865. unex.es

63. Xusandjonovna, M. N. (2024). … MANAGEMENT TO ENSURE THAT MEDICAL AND TECHNICAL EMPLOYEES CAN CONSCIOUSLY CARRY OUT THE MAINTENANCE OF MEDICAL EQUIPMENT. World Bulletin of Public Health. scholarexpress.net
64. Yao, L., Shang, D., Zhao, H., & Hu, S. (2021). [Retracted] Medical Equipment Comprehensive Management System Based on Cloud Computing and Internet of Things. Journal of Healthcare Engineering, 2021(1), 6685456. wiley.com
65. Boppana, V. R. (2023). Data Analytics for Predictive Maintenance in Healthcare Equipment. EPH-International Journal of Business & Management Science, 9(2), 26-36. eijbms.com