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MEDICAL PHYSICS EDUCATION: SELECTED CHALLENGES FOR UKRAINE

The training of specialists in medical physics, which is based on the combination of medicine and physics, has already developed stability in the world community. This is a new direction for Ukraine that requires standardization and harmonization with existing international practices. In the paper the analyzes of the publications of scientists in a combination of the tags "medical physics" and "education" with the aim of finding patterns regarding the support and development of the considered field throughout the world and in Ukraine. The peculiarities of international cooperation are considered, the circle of leading publications in scientific fields is outlined, and the factors influencing the institutions of different countries on the development of medical physics are analysed. The study is based on the results of data published in the international scientometric database Scopus. An overview analysis of some key approaches used in the universities of Ukraine and Poland in the development of this direction was carried out, and recommendations for Ukrainian specialists were formulated on their basis.

K e y w o r d s : ***medical physics, education, publications, Scopus, partnership in education for sustainable development.***

Introduction

The problem of training of the high-level specialists who can effectively apply the latest achievements of physics in medicine has its own history with features that depend on various factors, such as an economic capabilities of countries, on the needs of the market and the region, on the development of the scientific and technical progress of humanity as a whole. Now, the Qualification Framework for an expert in

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medical physics in the EU is defined in the European Commission Radiation Protection report No. 174 "European Guidelines on Medical Physics Expert" (European Commission, 2014). Similarly, standards of this type were previously developed in the U.S. Therefore, today medical physicist is a prestigious and necessary profession in most countries. However, for Ukraine, such direction has not yet been finally verified. Therefore, the research of this problem and the development of effective proposals aimed at helping Ukrainian universities to implement and make successful among applicants an educational program for the training of medical physicists are urgent.

The methodological development of the educational component for the training of medical physicists is high-important. Many papers in specialized peer-reviewed journals are devoted to this problem. It is based on such works that the authors of this study draw conclusions about trends in the world and in Ukraine. The research methodology is based on the analysis of publications according to the data of the scientific and metric database Scopus (www.scopus.com; Wisz et al., 2018). This approach has been tested for training students of applied physics (Nykyruy et al., 2021; 2022). For the analysis, the authors set the tags "medical physics" and "education" in the search simultaneously. The search was carried out by title, keywords and abstracts: TITLE-ABS-KEY ("medical physics") AND TITLE-ABS-KEY (education). The Scopus database was chosen due the high standards of publications and the international dissemination of research. So, as of July 1, 2024, the 2,048 publications were published for the specified search query. In addition, the most cited papers were analysed separately, which made it possible to form conclusions about the trends generally accepted in the professional society, about their development, and the latest papers from various publications were also analysed, which allowed to highlight the latest trends in the development of the field this research. At the same time, the authors of the study rejected materials that are not related to the training programs of specialists in the field of medical physics. Also, on certain aspects, the authors of this work make a comparative analysis of the publications of researchers from Poland and Ukraine. This choice is determined primarily by the fact that the countries border each other and have a lot in general in cultural or communication aspects. And, the most important thing is that Poland is a member of the EU, and Ukraine is applying for membership, which requires standardization in many areas with the EU, including the development and implementation of medical physics.

Based on the results of the analysis of the combination of selected tags, 2,048 documents were recorded in the Scopus database. h-index of the studied group of publications was $h = 58$, which is a high indicator for such a number of published materials and indicates the relevance of this direction.

In historical perspective, the first publications date back to 1931, but the first papers with justification of the training process of medical physicists date back to 1947 (Schmitt, 1947) and 1948 (Stead, 1948). Unfortunately, the full text are not available online, nor are the abstracts (including the original journal's web and the

Scopus database). However, the main direction, which today is decisive for the development of medical physics, is indicated as the importance of training specialists in the field of radiology in medicine.

Based on the results of the published papers, a brief historical description of the development of this area was made based on the search results (www.scopus.com). After the discovery and explanation of new physical phenomena, researchers actively tried to find their application in various applied fields, especially in medicine. Accordingly, the development of the first methodical materials were reasonably aimed at improving the knowledge of the doctors themselves in related fields, such as physics, biology, biochemistry, etc. Even the first article purely on the importance of studying medical physics was aimed at medical students (Rauser, 1954).

A special starting point for the development of medical physics in the 1950s and 1960s was the achievements in radiation therapy and nuclear medicine. And already in 1958, the American Association of Medical Physicists (AAPM) was founded, and American universities began to offer separate courses related to medical physics.

Education programs in medical physics began to appear at leading universities in the United States, Canada, and Europe in the 1970s. And in the 1980s, Master's programs in medical physics were opened in Great Britain and Germany. In the 1990s, such programs began to emerge in Asia and Australia, prompting a demand for standardization and accreditation of educational programs and harmonization of curricula. And since the 2000s, this problem has acquired a large-scale character, which caused a real surge in publishing activity on the subject (Fig. 1). Various international organizations have begun to provide accreditation for such programs based on developed methods. One of the most well-known is the Commission on Accreditation of Educational Programs in Medical Physics (CAMPEP) (https://www.campep.org/).

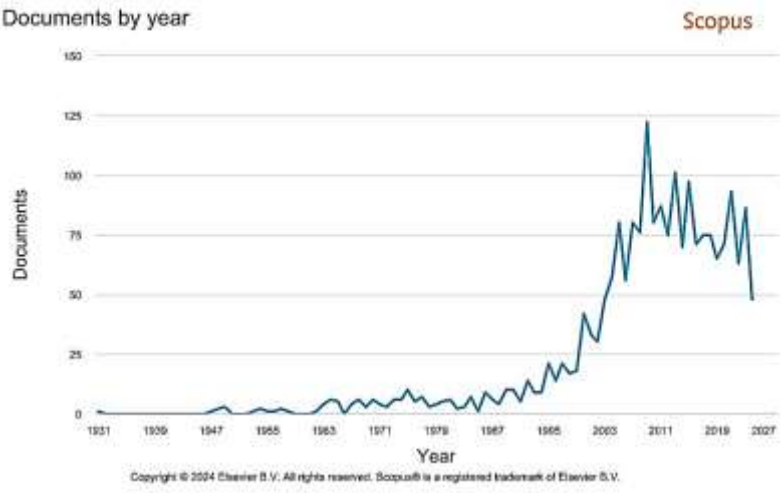


Fig. 1. Dynamics of publication activity in the field of "Medical Physics" over the years

And since the 2010s, such programs have experienced new challenges associated with an emphasis on interdisciplinarity, including additionally engineering, computer science, and biology (Starkschall, Beckham, & Hendee, 2013). At this time, a significant number of review materials have been published, which demonstrate various stages of the development of medical physics throughout the world, as well as features that are characteristic of individual countries. For example, review articles (Shen et al., 2020; Fiorino et al., 2020; Kurz et al., 2020; Podgoršak, 2006), although there are much more of them.

Let's consider the main trends regarding the scientific justification of the development of the educational component of medical physics. As indicated above, the pioneers in the development of medical physics were the universities of the USA, which have remained in the leading positions even today (Table 1). However, if they are unequivocal leaders in terms of the number of papers, then the citations level (right column) shows that universities in Europe, Canada and China competitively offer their current approaches.

Table 1

List of the most cited and institutions and those that published the largest number of scientific and methodological materials dedicated to medical physics

Leading institutions (most publications)	**The most cited scientific centers**
University of Texas MD Anderson Cancer Center, U.S.	Harvard Medical School, Boston, MA, **U.S.**
Harvard Medical School, U.S.	Institute of Cancer Research, Royal Marsden NHS Foundation Trust, **UK**
University of Washington, U.S.	McGill University, Montreal General Hospital, **Canada**
University of Wisconsin-Madison, U.S.	University Medical Centre Maastricht, **Netherlands**
University of Michigan, U.S.	University of Macau, **China**
Mayo Clinic, U.S.	University of Illinois, **U.S.**
International Atomic Energy Agency, Austria	University of Texas Health Sciences Center, **U.S.**
Massachusetts General Hospital, U.S.	Pennsylvania State University College of Medicine, MS Hershey Medical Center, **U.S.**
Medical College of Wisconsin, U.S.	Mayo Clinic, **U.S.**
University of Washington School of Medicine, U.S.	University of Southern California, **U.S.**

Another aspect worth analysing and from which conclusions can be drawn concerns the scientific journals in which research is published on the subject under consideration (Table 2). Unequivocal leaders are specialized journals in medical physics, which have a good CiteScore indicator. Moreover, it is worth noting that scientific publications of this level (table 2, positions 1–8) are undoubtedly available

for the publication of results of a high scientific level, which are obtained by researchers from Ukraine or Poland. Positions 9 and 10 are top journals, indicating a clear recognition of the need for this type of research for the global community. Thus, Nature and Science Journal's publish generalized new materials that were previously studied by powerful scientific groups in large international scientific centres and research consortia. Such published results shape the directions of human development.

Table 2

The list of the most cited scientific publications in the scientific community regarding the development of the methodology of training medical physicists

Journal title	CiteScore 2023
Medical Physics	6.8
Ifmbe Proceedings	1.0
Health Physics	4.2
Physica Medica	6.8
Journal of Applied Clinical Medical Physics	3.6
International Journal of Radiation Oncology Biology Physics	11.0
Journal of the American College of Radiology	6.3
Australasian Physical and Engineering Sciences in Medicine	2.0
Nature	90.0
Science	61.1

Fig. 2 demonstrates the interdisciplinary nature of the training of medical physicists. Moreover, in our case, it is not only medicine and physics, but also a set of areas such as biochemistry, engineering, IT, etc. This paper does not address the new and promising current aspect of interdisciplinary research related to AI. But, according to new publications with high citations, it is AI that will significantly expand the development of interdisciplinary research in medical physics in the coming years (Xu et al., 2021; Thompson et al., 2018).

Now we will very briefly consider the most general publications in which specialists from Poland and Ukraine publish their research works on the development of medical physics (Table 3).

The analysis of Table 3 shows that successful papers of university scientists from Poland are published in Journals that are rated significantly higher than the world average (Table 2). Most of these publications focus on radiation oncology. And this direction fully meets the European standards for specialists in medical physics "Medical Physics Expert". The top publications for Ukrainian researchers, as can be seen from the same table, is the Ukrainian Physical Journal (UPJ), which is primarily focused on research in physics. Among the international editions, conference Proceedings are the top ones, moreover, most of the conferences took place in Ukraine, although they had international status. On the one hand, UPJ is an open access journal, however, the world community of medical physicists is more focused on highly specialized publications (Table 2), which makes the ideas or proposals of Ukrainian scientists, although open, but little known to the world community.

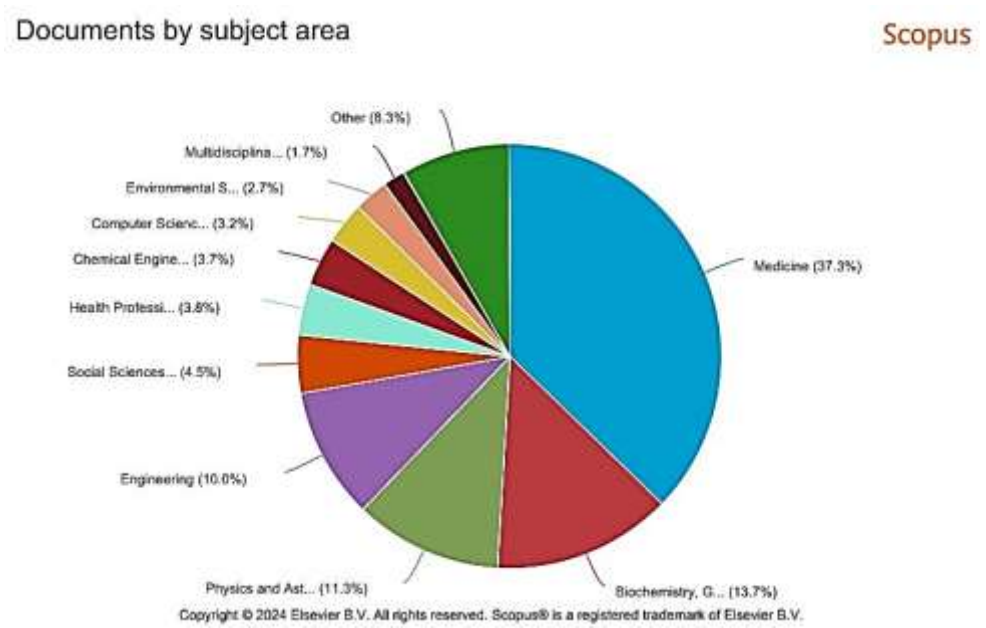


Fig. 2. The subject area of research on methodology for the training of medical physicists

Table 3

The most cited Journals in which scientists from Poland (left column) and Ukraine (right column) publish their research on the development of the educational component

Poland		Ukraine	
Journal	**CiteScore 2023**	**Journal**	**CiteScore 2023**
Journal of Translational Medicine	10.0	Ukrainian Journal of Physics	1.2
Radiotherapy and Oncology	10.3	2021 IEEE 2nd KhPI Week on Advanced Technology, Conference Proceedings	n/a
European Journal of Cancer	11.5	Proceedings of SPIE – The International Society for Optical Engineering	0.5

Therefore, one of the proposals for increasing the "visibility" of Ukrainian publications in the world, and therefore increasing their perception, is the need for national standardization of the direction and harmonization with standards already accepted in the world's one. In addition, the direction of internationalization of such developments is important for Ukraine. Joint publications will allow (1) to bring closer the decision regarding the standardization of the training program for medical physicists, and (2) to expand research opportunities due to the joint use of the material bases of each institution of such an international consortium. Therefore, one

of the solutions may be the beginning of the development and approval of joint educational programs in the field of "Medical Physics".

Discussion and conclusions

The publication of current results in purely "physical" or national journals does not contribute to the high rate of progress of medical physics in Ukraine. Instead, narrow-profile international publications, which are known to the world community in the field of medical physics, effectively contribute to the exchange of knowledge, experience and the creation of active partnerships.

The development of joint educational programs is an important direction for the development of medical physics in Ukraine. In particular, promising partners of such joint programs could be partner universities in Poland (geographical and cultural proximity), U.S. (pioneers of the development of medical physics).

Authors' contribution: Lyubomyr Nykyruy – conceptualization, methodology; Daria Khoma – data collection, formal analysis; Serhiy Fedosov – selection and data validation; Mirosław Łabuz – data analysis, writing – revision and editing; Krzysztof Kucab – data validation, editing.

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МЕДИЧНА ФІЗИКА В УНІВЕРСИТЕТСЬКИХ ПРОГРАМАХ: ВИКЛИКИ ДЛЯ УКРАЇНИ

Освітня програма "Медична фізика", яка виникла на поєднанні медицини та фізики, уже має вироблену сталість у світовому співтоваристві. Для України – це новий напрям, який потребує стандартизації та гармонізації із наявними міжнародними практиками. У статті проаналізовано публікації вчених за напрямом "Медична фізика" з метою знайти закономірності з підтримки та розвитку цього напряму у світі та в Україні. Розглянуто особливості міжнародної співпраці, окреслено коло провідних видань у наукових сферах, проаналізовано фактори впливовості інституцій різних країн на розвиток медичної фізики. Дослідження базується на результатах даних, що опубліковані у міжнародній наукометричній базі Scopus. Виконано короткий аналіз деяких ключових факторів, які суттєво впливають на розвиток медичної фізики, на прикладі України та Польщі. На основі цього аналізу сформульовано рекомендації для українських фахівців.

Ключові слова: ***медична фізика, освіта, публікації, Scopus, партнерство в освіті для сталого розвитку.***

Автори Д. Хома, С. Федосов, М. Лабуз та К. Куцаб заявляють про відсутність конфлікту інтересів. Член організаційного комітету Л. Никируй, заявляє про відсутність конфлікту інтересів та невтручання в процес оцінювання цієї статті відповідно до міжнародних стандартів публікаційної етики. Спонсори не брали участі в розробленні дослідження; у зборі, аналізі чи інтерпретації даних; у написанні рукопису; в рішенні про публікацію результатів.

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