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Professional paper

ASSESSMENT OF AWARENESS AND UNDERSTANDING OF MEDICAL PHYSICS AND HEAVY PARTICLE THERAPY AMONG YOUTH IN NORTH MACEDONIA

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Abstract

This study examines the awareness and understanding of medical physics and heavy particle therapy among young people aged 15 to 30 in North Macedonia. Medical physics plays a vital role in modern healthcare, particularly in diagnostic imaging and advanced cancer treatments such as proton and carbon ion therapy. Despite its growing global significance, public awareness of this field remains limited, especially in developing countries. To address this knowledge gap, a structured survey was conducted with approximately 503 respondents from diverse regions. The results revealed a significant deficiency of awareness and limited formal education on medical physics. However, the study also highlighted a strong interest in learning more about these topics, indicating potential for educational development. The paper concludes with practical recommendations to incorporate medical physics into the national curriculum and enhance public understanding of modern medical technologies.

Keywords: Medical Physics, Heavy Particle Therapy, Youth Awareness, Science Education, North Macedonia

1. Introduction

Medical physics is a critical interdisciplinary field that merges principles of physics with medicine to improve patient diagnosis, treatment, and safety. It plays an essential role in modern healthcare systems through its contributions to diagnostic imaging technologies such as X-rays, CT scans, MRI and ultrasound. Furthermore, it is fundamental in the planning and delivery of radiation therapy for cancer patients, insure that treatments are both effective and safe. Medical physicists are also central in developing protocols and standards that minimize radiation risks, there by safeguarding patients and healthcare workers. As healthcare technologies continue to advance, the importance of medical physics grows, demanding greater public understanding and professional expertise.

Despite the global rise in the significance of medical physics, in North Macedonia, public awareness and formal education about this field remain considerably limited. Medical physics is rarely integrated into secondary or higher education curricula, and public discourse about advanced medical technologies like radiation therapy is minimal. This gap in knowledge is particularly concerning among the youth, who represent the future workforce and decision-makers. In developing nations such as North Macedonia, building awareness at an early stage is crucial for fostering scientific literacy, encouraging careers in healthcare and STEM fields, and supporting the adoption of innovative medical technologies that can improve national health outcomes.

This study aims to assess the current level of awareness and understanding of medical physics and heavy particle therapy among youth aged 15 to 30 in North Macedonia. By identifying

knowledge gaps and measuring interest in the field, the study seeks to highlight the educational shortcomings that need to be addressed.
Furthermore, based on the findings, the research will propose targeted strategies for integrating medical physics into the education system and designing public outreach initiatives. These efforts are intended to enhance scientific literacy, inspire future engagement in the field, and ultimately contribute to the development of a more informed and health-conscious society.

2. Literature Review

2.1 Global perspectives on Medical Physics Awareness: Medical physics is an essential interdisciplinary field that applies physics principles to medicine, particularly in diagnostic imaging and radiation therapy. In developed countries, there is a growing recognition of the importance of medical physics, leading to well-established educational programs and professional societies [1]. However, in many developing nations, awareness and formal education in medical physics remain limited. For instance, in several countries, medical physics is not recognized as a distinct profession, and there are no official education and training programs, which strangle the development of the field and the implementation of advanced medical technologies [6]. Efforts by international organizations, such as the International Centre for Theoretical Physics (ICTP), aim to raise awareness and provide training in medical physics to address these gaps [1].

2.2 Heavy Particle Therapy (Proton & Carbon Ion Therapy): Heavy particle therapy, including proton and carbon ion therapy, represents a significant advancement in cancer treatment. These therapies allow for precise targeting of tumors, minimizing damage to surrounding healthy tissues [2]. Proton therapy, for example, has been approved by the FDA and is supported by numerous clinical studies demonstrating its efficacy and reduced side effects compared to conventional radiotherapy [4]. Despite its benefits, the adoption of heavy particle therapy is limited by the high costs of establishing treatment centers and a lack of specialized training programs for healthcare professionals [5]. Educational initiatives, such as specialized modules and professional development courses, have been developed to provide across-the-board training on the physics, biology, and clinical applications of proton and carbon ion therapy [3]. However, access to such resources is often restricted in developing countries, highlighting the need for more inclusive educational strategies.

2.3 Science Education and Youth Engagement: Early science education plays a crucial role in developing scientific literacy and fostering interest in STEM careers among youth. Studies have shown that exposure to scientific concepts from an early age significantly improves understanding and retention, and fosters a positive attitude towards science [1]. Programs that promote hands-on, inquiry-based learning, such as experiential science projects and youth science camps, have been proven effective in fostering scientific curiosity [4]. However, disparities in access to quality science education persist, particularly in underserved and rural communities [5]. Addressing these disparities is essential to ensure equitable opportunities for all young people to engage with and contribute to scientific advancements, including specialized fields like medical physics and radiation therapy.

3. Methodology

This research employed a cross-sectional survey design, which is widely recognized for its ability to capture a snapshot of the current level of awareness and understanding among a specific population at a particular point in time.

Cross-sectional studies are particularly suitable for assessing educational needs and public perceptions because they allow for the simultaneous analysis of multiple variables. The survey approach was chosen to efficiently gather data from a large number of respondents across diverse regions, providing a comprehensive overview of the youth's knowledge and attitudes towards medical physics and heavy particle therapy.

The target population for this study consisted of youth aged 15 - 30 years old residing in various urban and rural areas of North Macedonia. A total sample size of approximately 503 respondents was determined to ensure statistical power and to ensure the findings are representative. Participants were selected using a stratified random sampling method, ensuring proportional representation based on geographical location (urban vs rural), gender, and educational background. This approach was intended to minimize selection bias and provide a more accurate reflection of the broader youth demographic in North Macedonia. The survey was available in three languages (Albanian, Macedonian, and English) because North Macedonia is considered a multi ethnic country.

The primary data collection tool was a structured questionnaire designed specifically for this study. The questionnaire was divided into three main sections:

- Awareness: Assessing whether respondents had previously heard of medical physics or heavy particle therapy.
- Understanding: Evaluating the depth of knowledge related to the role of medical physics in healthcare and the principles behind heavy particle therapies like proton and carbon ion treatment.
- Educational Interest: Measuring the willingness of respondents to learn more about medical physics and participate in potential educational programs or initiatives. The survey instrument was piloted with a small group before full deployment to ensure clarity, reliability, and validity of the questions.

Data collection was conducted through both online platforms and paper-based questionnaires to maximize accessibility and respondent participation. Upon collection, all data were entered into SPSS (Statistical Package for the Social Sciences) version 26.0 for systematic analysis. Using SPSS ensures a scientifically rigorous and transparent analysis process, allowing for both basic descriptive insights and more advanced inferential statistical testing. This enhances the credibility and academic robustness of the study's findings.

4. Results

4.1 Demographics of respondents: This study included a total of 504 respondents, reflecting a diverse demographic background across several variables (shown in Figure 1): (a) Living Area: 60.3 % of respondents (304 individuals) reported living in rural areas, while 39.7 % (200 individuals) lived in urban areas.(b) Age of Participants: The majority of participants were aged 15–18 (435 participants, 86.5 %), followed by 19–22 (55 participants, 10.9 %), 23–26 (7 participants, 1.4 %), and 27–30 (6 participants, 1.2 %). (c) Participant's Gender: Most respondents were female (308, 61.2%), followed by male (107, 37.2 %), while 8 participants (1.6 %) did not declare their gender. (d) Participant's School: In terms of education level, the majority were high school students (457 participants, 90.9 %), followed by university students (36 participants, 7.2 %) and others (10 participants, 2.0 %). The sample covered over 22 different high schools and more than 6 universities. (e) City/Municipality: The study ensured geographic diversity, with respondents from more than 15 municipalities across North Macedonia. The highest representation was from Tetovo (181 participants, 36 %), followed by Kumanovo (72, 14.3 %), Skopje (67, 13.3 %), Gostivar (29, 5.8 %), htip (26, 5.2 %), Sveti Nikole (26, 5.2 %), and several others, including Bogovinje, Jegunovca, Poroj, Debar, Kicevo, Veles, Kumanovo, and Vrapciste.

This broad geographic and educational distribution provides a comprehensive and balanced overview of youth perspectives across both urban and rural contexts in the Republic of North Macedonia.

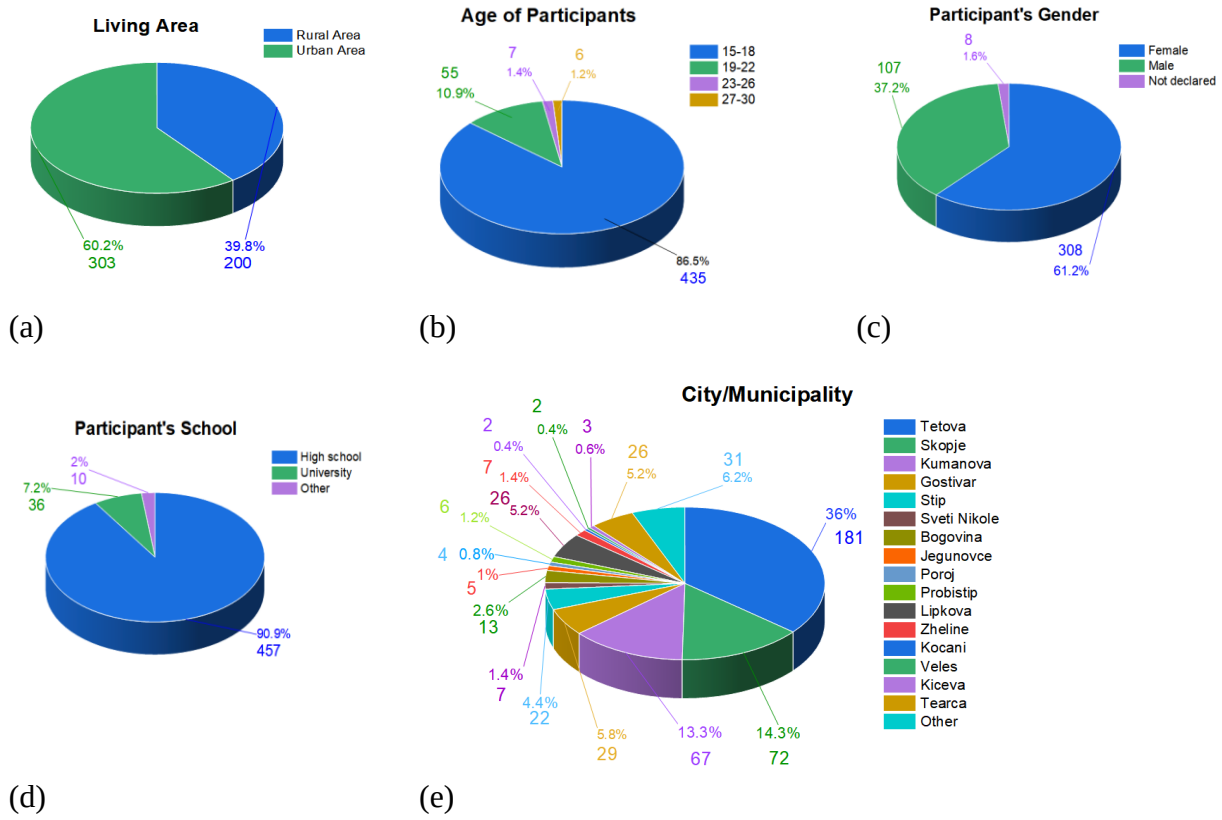

Figure 1. Demographic Characteristics of the Participants

4.2 Awareness levels of Medical Physics: Figure 2 illustrates the general awareness and perceptions of medical physics among 503 respondents:
Importance of Medical Physics: The vast majority (79.3%, 399 participants) consider medical physics important in modern medicine. A smaller portion (18.9%, 95 participants) were unsure, while only 1.8% (9 participants) believed it was not important. (b) Knowledge of the Role of a Medical Physicist: Nearly half of the respondents (46.5%, 234 individuals) reported they know a little about what a medical physicist does. In contrast, 9.5% (48) claimed they know the role very well, 35% (176) had only heard the term, and 8.9% (45) had no knowledge at all. (c) Fields Associated with Medical Physics: Most respondents (51.5%, 259) associated medical physics with cancer treatment. Other connections included nuclear medicine (13.9%, 70), X-ray and MRI imaging (7.2%, 36), and a small number (3.2%, 16) indicated other fields. A significant portion (24.3%, 122) did not know which fields it relates to. (d) Prior Awareness of Medical Physics: A majority of 67.4% (339 respondents) had heard of medical physics before, while 32.6% (164) had not.
These results suggest that while most participants recognize the importance of medical physics, many lack a comprehensive understanding of its applications or the role of medical physicists in healthcare.

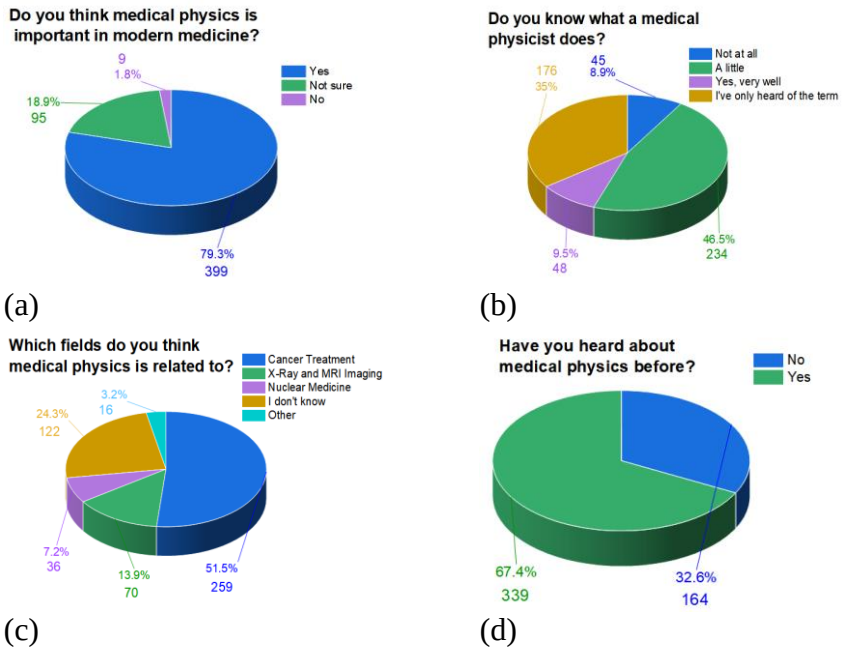

Figure 2. Awareness and Perceptions of Medical Physics among Respondents

4.3 Understanding of Heavy Particle Therapy:

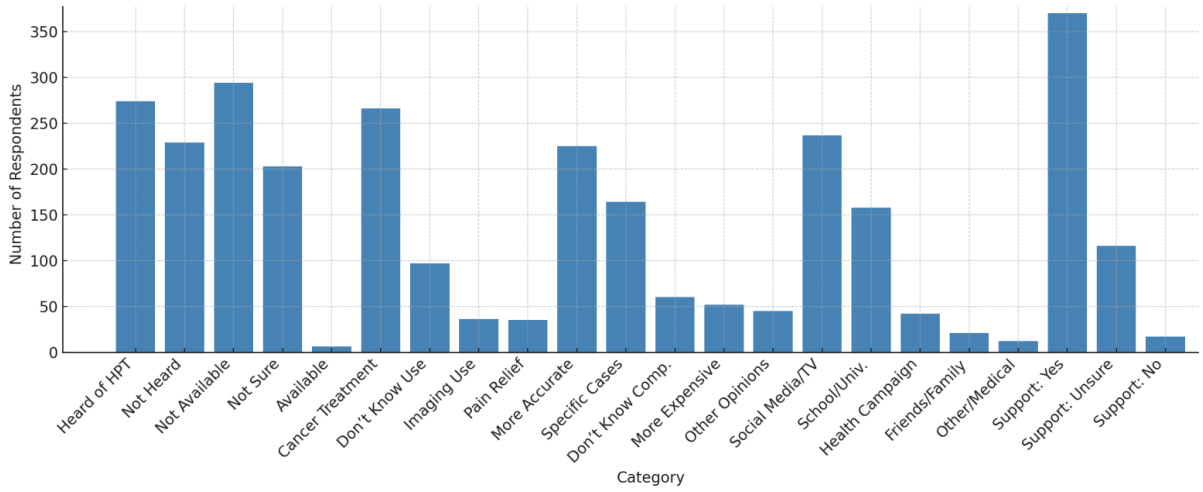

Figure 3. Public Awareness, Perception, and Attitudes Toward Heavy Particle Therapy

This chart in Figure 3 visually represents the knowledge, perceptions, and attitudes of 503 respondents regarding heavy particle therapy (HPT), an advanced form of cancer treatment. The results provide insight into public understanding and support for integrating such medical innovations into the national healthcare system.

- General Awareness: Over half of the participants (54.5 %) had heard about heavy particle therapy, indicating a moderate level of awareness among the surveyed population.
- Availability in North Macedonia: A majority (58.4 %) correctly recognized that this technology is not yet available in the country, while a considerable portion (41.6 %) were either unsure or misinformed.
- Perceived Medical Use: Most respondents (52.9 %) correctly identified its use in cancer treatment, though a notable number were uncertain or held misconceptions, associating it with imaging or pain relief.

- Comparative Perception: 44.7 % believed HPT is more accurate and has fewer side effects than traditional radiotherapy, while 32.6 % viewed it as more suitable in specific clinical contexts. Others expressed uncertainty or misconceptions.
- Sources of Information: Social media and television were the primary sources of knowledge (47.2 %), followed by educational institutions (31.5 %) and health campaigns.
- Public Support: An overwhelming 73.6 % of participants supported the introduction and public funding of heavy particle therapy in North Macedonia, highlighting strong public backing for technological advancement in oncology, despite limited in-depth knowledge.

This figure highlights the importance of broader public education on cutting-edge medical treatments and the potential societal benefits of incorporating them into national healthcare frameworks.

4.4 Interest in further education:

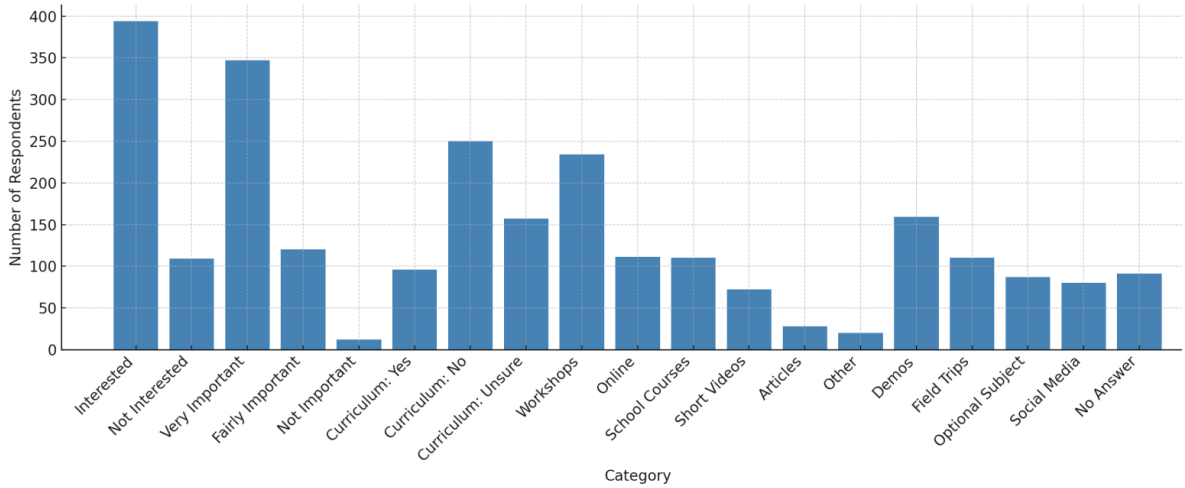

Figure 4. Attitudes and suggestions on learning Medical Physics Among Youth

This figure summarizes the attitudes of 503 respondents regarding the inclusion of medical physics education in schools and their preferred learning methods. The findings highlight a strong openness among young people toward gaining more knowledge in this scientific field:

- Interest in Learning: A significant majority (78.3 %) expressed interest in learning more about medical physics, indicating readiness for further engagement when provided with appropriate educational formats.
- Perceived Importance: 69 % of respondents considered it very important to teach medical physics and cancer treatment technologies in schools, with only a minimal number (2.4 %) considering it unimportant.
- Current Curriculum Gaps: Nearly half (49.7 %) of participants felt that current school or university curricula do not offer sufficient information about medical physics, while 31.2 % were unsure.
- Preferred Educational Methods: The most favored learning method was interactive workshops or seminars (46.5 %), followed by online learning (22.1 %) and formal school-based courses (21.9 %). This demonstrates a clear preference for experiential and flexible approaches.
- Student-Driven Suggestions: In terms of improving the appeal of medical physics, respondents most frequently suggested practical demonstrations in schools (31.6 %), followed by field trips to hospitals or medical labs (21.9 %), and offering it as an optional subject (17.3 %).

These results highlight the importance of reforming educational strategies to incorporate hands-on, engaging, and accessible methods for teaching medical physics, thereby bridging the gap between interest and understanding in future generations.

5. Discussion

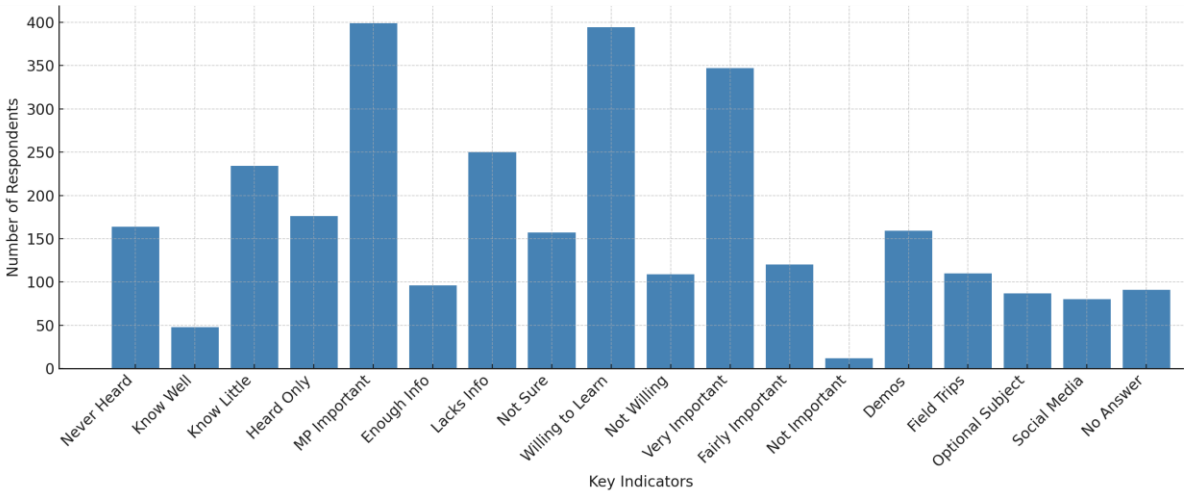

Figure 5. Summary of Awareness, Educational Gaps, and Suggestions Regarding Medical Physics

Figure 5 presents a synthesized overview of key findings from the survey, structured around four main discussion points: awareness, educational gaps, willingness to learn, and student-driven suggestions.

- Awareness: A substantial portion of participants had limited or no familiarity with medical physics. While 67.4% had at least heard of the term, only 9.5% reported knowing very well what a medical physicist does, and 32.6% had never heard of it.
- Educational Gaps: Nearly half of the respondents (49.7%) stated that their current school or university programs do not provide sufficient information on medical physics and cancer treatment technologies. Only 19.1% believed the education was adequate, while 31.2% were unsure.
- Willingness to Learn and Perceived Importance: Despite low familiarity, students showed strong openness to gaining more knowledge—78.3% expressed willingness to learn more. Moreover, 69% considered it very important to educate youth about these topics, confirming the relevance of this field in modern education.
- Student Suggestions: Respondents recommended various methods to improve engagement, including practical demonstrations (31.6%), field trips to medical institutions (21.9%), and the introduction of elective subjects (17.3%). These findings point to a strong preference for interactive, hands-on learning environments.

This figure supports the need for formal curriculum reform and national awareness campaigns to make medical physics more accessible, practical, and engaging for the next generation of healthcare professionals and informed citizens.

Table 1 presents a comparative analysis between the level of awareness and educational exposure to medical physics among youth in the Republic of North Macedonia and students from more developed Western European countries such as Germany, the United Kingdom, and the Netherlands [6-8]. The data indicate that while general awareness and interest in medical physics are relatively high among respondents in North Macedonia, detailed understanding and formal educational support remain significantly lower compared to their Western European peers. This gap highlights the urgent need for curriculum enhancement and national awareness campaigns to promote medical physics more effectively in the region's educational systems.

Table 1. Comparative analysis of Awareness and Education in Medical Physics

Category	**North Macedonia (%)**	**Germany / UK / Netherlands (%)**[1]
Have heard about Medical Physics	67.4%	85%
Consider Medical Physics important	79.3%	90%
Know very well what a Medical Physicist does	9.5%	70%
Education provides sufficient information	19.1%	80%
Want to learn more about Medical Physics	78.3%	85%

6. Recommendations

To improve awareness of medical physics among youth in North Macedonia, it is recommended to integrate medical physics topic into secondary and tertiary education curricula. Additionally, national outreach campaigns should be organized through media and university collaborations to engage and educate the public. Further research is needed, including longitudinal studies and educational impact assessments, to monitor progress and refine strategies. These actions will help build a more scientifically informed and future - ready society.

7. Conclusion

The findings of this study reveal a strong interest among youth in learning about medical physics and advanced cancer therapies, despite limited prior awareness and existing educational gaps. While, many respondents acknowledged the importance of the field and demonstrated a willingness to learn more, the data highlight a noticeable lack of structured exposure within current school and university programs. This emphasizes the urgent need to bridge these gaps by integrating medical physics into formal education systems—through interactive teaching approaches and partnerships with scientific institutions. Coordinated action from educators, policymakers, and scientific experts is essential in developing inclusive, accessible, and forward-looking educational strategies that will equip the next generation with the knowledge and skills required to address future healthcare challenges.

[1] European Federation of Organisations for Medical Physics (EFOMP), Annual Report 2022
UK Institute of Physics and Engineering in Medicine (IPEM), Education and Training Survey 2021
Netherlands Association for Medical Physics (NVKF), National Awareness Programs Summary 2020

Appendix

The leading part presents the format of the questionnaire used in this study.

SCIENTIFIC SURVEY QUESTIONNAIRE

Section 1: General Information and Consent

1. **Participant ID: _____**
2. **Date of Participation: _____**
3. **Consent:**
   ☐ I voluntarily agree to participate in this scientific survey.
   ☐ I confirm that I am between **15 and 30 years old**.

Section 2: About You

4. **Age Group:**
   ☐ 15–18 ☐ 19–22 ☐ 23–26 ☐ 27–30
5. **Gender:**
   ☐ Male ☐ Female ☐ Prefer not to say
6. **City/Municipality: _____**
7. **Where do you live?**
   ☐ Urban ☐ Rural
8. **Highest Level of Education Completed:**
   ☐ Secondary School ☐ Bachelor's Degree ☐ Master's or Higher ☐ Other
9. **If studying, what is your field oaf study? _____**

Section 3: Awareness of Medical Physics

10. **Have you heard of medical physics before?**
    ☐ Yes ☐ No
11. **Do you know what a medical physicist does?**
    ☐ Yes, very well ☐ Somewhat ☐ I've only heard the term ☐ Not at all
12. **Which fields do you think medical physics is related to? (Choose all that apply)**
    ☐ Cancer treatment ☐ X-ray and MRI imaging ☐ Nuclear medicine ☐ Other: _____ ☐ I don't know
13. **Do you think medical physics is important in modern medicine?**
    ☐ Yes ☐ No ☐ Not Sure
14. **Where have you heard about medical physics?**
    ☐ School ☐ Social Media ☐ TV/News ☐ Friends/Family ☐ Other: _____

Section 4: Understanding Heavy Particle Therapy

(Heavy particle therapy is an advanced type of cancer treatment that uses proton or carbon ion beams instead of traditional X-rays. It is known for being highly precise and causing less damage to surrounding healthy tissue.)

15. Have you ever heard about heavy particle therapy before?
☐ Yes ☐ No

16. If yes, where did you first hear about heavy particle therapy?
☐ At school or university ☐ On television or social media ☐ At a health-related event or campaign ☐ Other:

17. In your opinion, what is the main medical use of heavy particle therapy?
☐ To treat cancer more effectively

☐ To help with medical imaging (like X-rays or MRI)

☐ To relieve pain or inflammation ☐ I don't know

18. Compared to traditional radiation therapy for cancer, how do you think heavy particle therapy performs?

☐ It is more accurate and causes fewer side effects

☐ It is more expensive but potentially more effective

☐ It causes more side effects than traditional methods ☐ I don't know enough to compare

19. As far as you know, is heavy particle therapy currently available in North Macedonia?

☐ Yes ☐ No ☐ I'm not sure

20. Do you think heavy particle therapy should be introduced and funded in the public healthcare system of North Macedonia?

☐ Yes, definitely ☐ No, it's not necessary ☐ I'm not sure

Section 5: Interest in Learning More

21. Would you personally be interested in learning more about medical physics and its uses in healthcare?

☐ Yes ☐ No

22. How important do you think it is to teach young people about medical physics and new cancer treatments?

☐ Very important ☐ Somewhat important ☐ Not important at all

23. Do you think that current school or university programs provide enough information about medical physics and cancer treatment technologies?

☐ Yes ☐ No ☐ I'm not sure

24. What do you think is the best way for young people to learn about modern medical technologies?

☐ Through short videos or social media content

☐ By attending interactive workshops or seminars

☐ As part of regular university or school courses

☐ By reading articles or blogs online

☐ Other: _____

25. If a workshop or seminar about medical physics and cancer treatment was organized near you, would you be interested in attending?

☐ Yes, I would definitely attend ☐ No, I'm not interested ☐ Maybe, depending on my schedule or the topic

Section 6: Your Thoughts (Optional)

21. In one sentence, how would you personally define or describe what medical physics means?

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22. What do you think could be done to make learning about medical physics more interesting or exciting for students your age?

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THANK YOU FOR PARTICIPATING!
YOUR ANSWERS WILL HELP IMPROVE SCIENCE EDUCATION AND AWARENESS OF MEDICAL PHYSICS IN NORTH MACEDONIA

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