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Annual Training Program in Radiological Protection in a Radiotherapy Service – A Case Study

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Abstract: The safety and radiological protection in radiotherapy services are essential to ensure the safe use of ionizing radiation for the benefit of patients and involved professionals. Evaluative research on multidisciplinary teams regarding annual training in radiological protection in radiotherapy is scarce. It is crucial to understand how professionals from each area assess the acquired knowledge and apply theoretical precepts in the radiotherapy service. This study aimed to analyze the annual radiological protection training offered in a radiotherapy service, and as specific objectives, to map the knowledge of professionals from each area regarding radiological protection applied during training. This is a qualitative research of the case study type. Data collection occurred through semi-structured interviews, simple observation, and documentary analysis, organized in the ATLAS.ti software version 24. The results indicate significant challenges, including the lack of understanding of basic principles by professionals, the absence of integration between the team and supervisors, and the lack of clear definition of the training format in current regulations. The results were categorized into: professionals' knowledge of radiological protection; training weaknesses; training strengths; suggestions for training delivery methods and topics in radiological protection. More effective educational strategies, along with precise guidance on the training format, emerge as promising solutions to overcome these challenges.

Keywords: Annual Training, Radiological Protection, Radiotherapy, Multidisciplinary Team, Ionizing Radiation.

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Programa de Treinamento Anual em Proteção Radiológica em um Serviço de Radioterapia – Um Estudo de Caso

Resumo: A segurança e proteção radiológica em serviços de radioterapia são fundamentais para garantir o uso seguro da radiação ionizante em benefício dos pacientes e profissionais envolvidos. Pesquisas avaliativas com equipes multidisciplinares sobre o treinamento anual em proteção radiológica em radioterapia ainda são escassas. É crucial entender como os profissionais de cada área avaliam os conhecimentos adquiridos e aplicam os preceitos teóricos no serviço de radioterapia. Este estudo teve como objetivo analisar o treinamento anual de proteção radiológica oferecido em um serviço de radioterapia e como objetivos específicos, mapear o conhecimento dos profissionais de cada área em relação à proteção radiológica aplicada durante o treinamento. Trata-se de uma pesquisa qualitativa do tipo estudo de caso. A coleta dos dados ocorreu por meio de entrevistas semiestruturadas, observação simples e análise documental, organizados no software ATLAS.ti versão 24. Os resultados apontam desafios significativos, incluindo a falta de compreensão dos princípios básicos pelos profissionais, a ausência de integração entre equipe e supervisores, e a falta de definição clara do formato do treinamento nas normativas atuais. Os resultados foram categorizados em: conhecimento dos profissionais sobre proteção radiológica; fragilidades do treinamento; potencialidades do treinamento; sugestões de formas de oferta e temas do treinamento em proteção radiológica. Estratégias educacionais mais eficazes, juntamente com orientações precisas sobre o formato do treinamento, emergem como soluções promissoras para superar esses desafios.

Palavras-chave: Treinamento Anual, proteção radiológica, radioterapia, equipe multidisciplinar, radiação ionizante.

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1. INTRODUCTION

In the context of Radiotherapy in Brazil, two historical milestones highlight the importance of safety policies in practices involving ionizing radiation sources. The first milestone dates back to 1987, when the largest radiological accident in an urban area in the world occurred in Goiânia, involving a cesium-137 source due to the improper handling of an abandoned Radiotherapy device [1]. The second accident, documented by Fagundes [2] and occurring in 2012 in Rio de Janeiro, resulted in a 7-year-old child being exposed to high doses of radiation due to human error during radiotherapy treatment, leading to the child's death.

Brazil responded to these significant adverse events by establishing robust regulatory frameworks for radiological protection in radiotherapy. The guidelines issued by the National Nuclear Energy Commission (CNEN) establish a critical regulatory framework for safety and radiological protection in Radiotherapy services.

The CNEN Norm NN 3.01 [3] defines general principles and basic requirements for radioprotection and radiological safety. The CNEN Norm NN 6.10 [4] establishes specific safety and radiological protection requirements for radiotherapy services. Additionally, Resolution-RDC No. 20, published by the National Health Surveillance Agency (ANVISA) [5], regulates the operation of radiotherapy services, aiming to protect the health of patients, professionals, and the general public.

As stipulated in article 20 of CNEN Norm NN 6.10 [4], Radiotherapy services are required to develop and supervise, through the Radiological Protection Supervisor, annual radiological protection training programs for occupationally exposed individuals in the service, as well as inform all professionals in the facility about the inherent risks of using ionizing radiation.

As noted by Rego and Peralta [6], high school students often struggle to differentiate between types of radiation and understand the effects of radiation on matter. Coelho [7] identified confusing and misleading explanations in physics textbooks

In light of this, as emphasized by Paiva [8], integrating Medical Physics content into high school curricula would not only enhance the understanding of radiation principles but also strengthen the essential educational foundation for consistent and integrated training from the early stages of education through to technical and higher education levels in fields related to radiotherapy.

Ohno and Kaori [9] highlight the need to implement educational programs that enable nursing staff to understand the importance of radiological diagnosis, treatments, and the effects of radiation exposure in their daily practice in radiology.

Considering that radiotherapy teams are composed of multidisciplinary professionals and the importance of a solid understanding of radiation principles, this study aimed to analyze the annual radiological protection training offered in a radiotherapy service and evaluate how these professionals comprehend the knowledge acquired about radiological protection.

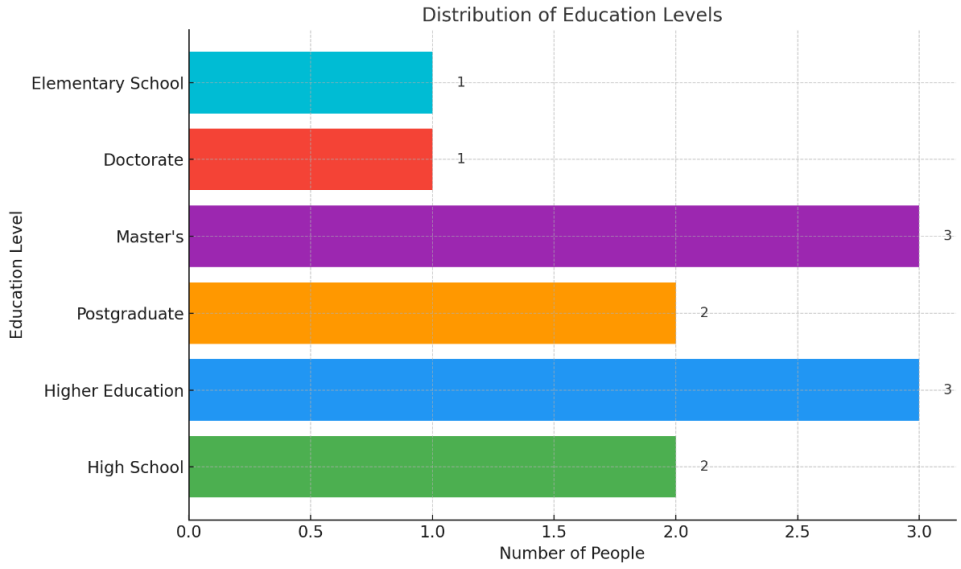
2. MATERIALS AND METHODS

This study adopted a qualitative approach, specifically a case study type, as proposed by Yin [10]. The method is distinguished by its ability to explore real-world situations characterized by the absence of clear boundaries between the phenomenon under study and the surrounding circumstances. In this context, the research was designed to investigate in detail how annual radiological protection training programs are developed and perceived in radiotherapy practice, considering the complexity of the context and the interaction among the various professionals involved.

The research was conducted in a radiotherapy service at an institution located in the South of Brazil. This healthcare service offers care to a diverse patient base, including private patients, health insurance beneficiaries, and individuals covered by the Unified Health System (SUS). The scope of care includes a variety of therapeutic modalities, including cranial and body stereotactic radiotherapy (for treating tumors in the lung, pancreas, and spine), 3D conformal radiotherapy, intensity-modulated radiotherapy (IMRT), and image-guided radiotherapy. The service is equipped with a linear accelerator (LA) and has a complete planning system for radiotherapy treatment.

The service in question has a main facility and two branches, totaling 53 professionals. However, for the purposes of this research, only the 28 professionals working at the main facility were considered. Of these, 12 professionals agreed to actively participate in this research. Each was assigned a code according to the International Phonetic Alphabet: Delta for dosimetrist, Echo for nurses, Foxtrot for medical physicists, Mike for radiation oncologists, Alpha for administrative professionals, Romeo for receptionist, Sierra for general services, November for nursing technician, and Tango for radiation therapist. Figure 1 shows the distribution of education levels among the multidisciplinary team.

Figure 1: Distribution of Education Levels Among the Multidisciplinary Team.



Source: Research data extracted from ATLAS.ti 24 software.

Data collection took place from April to May 2023 through interviews, observation, and document analysis. According to Yin [10], this data triangulation was implemented to validate and enrich the understanding of the case study.

In the interviews, we sought to identify the professionals' understanding of radiological protection in the radiotherapy service. These interviews were conducted individually, in person, following a semi-structured script with open-ended questions about radiological protection, ionizing radiation, safety, and applicability in daily work, allowing the interviewees to freely express their perceptions and understandings of the topics addressed. These interviews were recorded and transcribed by the responsible researcher.

Observation was conducted based on a previously prepared script and recorded in field notes by the researcher, occurring during classes and/or training sessions, as well as access to didactic material and the learning platform used.

The research was approved by the Research Ethics Committee of the Federal Institute of Santa Catarina, approval number 5.966269.

Document analysis provided information from national, international, and institutional documents related to radiological protection in radiotherapy. These documents represent valuable data sources, providing a comprehensive view of guidelines, regulations, and practices related to radiological protection in this specific context.

All collected data were organized using ATLAS.ti software licensed version 24. Developed by the Technical University of Berlin, the software is widely recognized for its effectiveness in the qualitative analysis of information [11].

ATLAS.ti allowed the management of various types of files, such as text and images, facilitating the control of codes and comments created by the researcher during data analysis. Additionally, the software offers a set of tools that enable the selection of excerpts from files,

their division into quotations, and the generation of a list of descriptive codes, guiding the researcher throughout the analysis [11].

For data analysis, the principles of thematic content analysis proposed by Bardin [12] were applied, contributing to a deep understanding of the data and the identification of relevant thematic patterns.

ATLAS.ti enabled the creation and application of codes, allowing the identification and classification of relevant text excerpts. This was done flexibly and interactively, allowing detailed and context-sensitive analysis. Additionally, the software provided visualization features that helped explore and interpret the data more dynamically, such as the generation of concept networks through illustrative images and the visualization of code frequencies.

3. RESULTS AND DISCUSSIONS

3.1. Knowledge of professionals on radiological protection

Within the multidisciplinary radiotherapy team, there is a notable disparity in the level of knowledge about radiological protection. In particular, professionals such as the medical physicist, dosimetrist, radiation oncologist, and radiation therapist demonstrate a solid and accurate understanding of this crucial topic to ensure the safety and effectiveness of radiotherapy procedures.

Mike, a radiation oncologist, offers a comprehensive perspective on radiological protection. He emphasizes the importance of considering radiological protection during treatment planning, especially when dealing with at-risk organs near the irradiation area and also for the professionals involved in the treatment.

Other professionals, such as those in administration, the receptionist, nurse, and nursing technician, present a more superficial and, in some cases, mistaken understanding,

associating radiological protection, in a limited manner, with the use of personal protective equipment (PPE) or dosimeters.

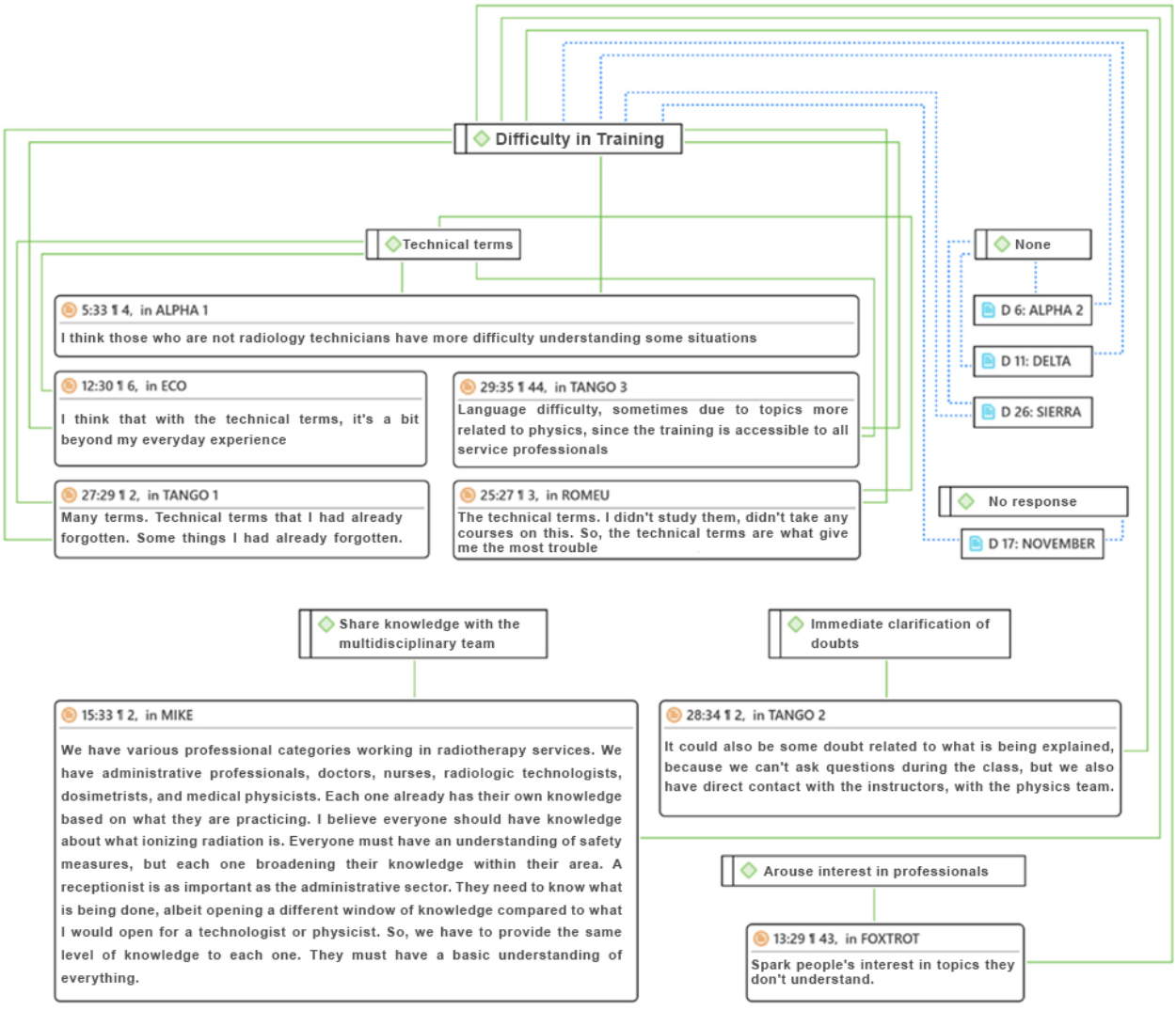
While the radiation oncologist already had prior training before joining the team, other participants, such as the nurse, medical physicist, radiation therapists II and III, as well as the dosimetrist, acquired substantial knowledge in radiological protection only after entering the field of radiotherapy, which represents approximately 42% of the team. On the other hand, 58% of the team did not seek qualification in radiological protection after entering the field of radiotherapy. Figure 2 illustrates the results of the analysis conducted, highlighting the division of professionals between those who opted to seek training in radiotherapy after entering the field and those who remained without additional qualification even after starting their activities in radiotherapy.

Figure 2: Distribution of professionals who have undergone training and professionals who have never sought training in radiotherapy after entering the field.

Source: Research data extracted from ATLAS.ti 24 software.

Some professionals, including two radiation therapists, reported difficulties in understanding the technical terms used during radiological protection training, as evidenced in figure 3.

Figure 3: The professionals' feedback on the difficulties encountered during training in radiological protection.

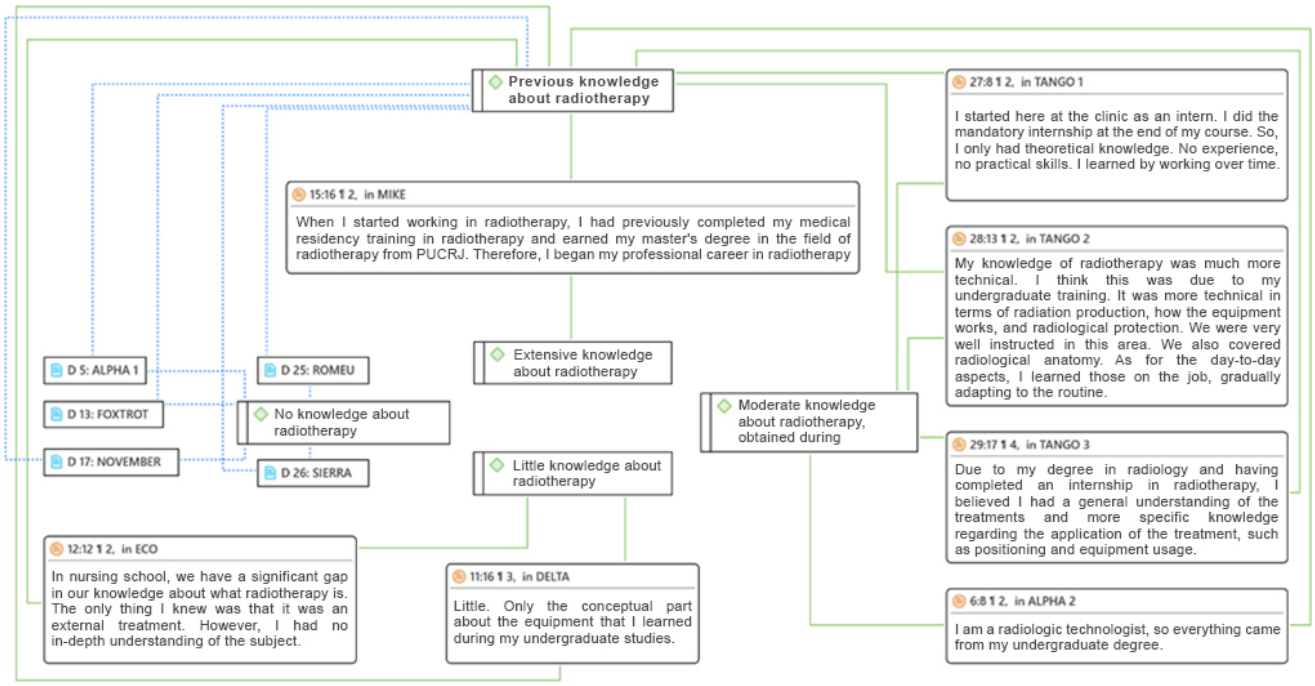


Source: Research data extracted from ATLAS.ti 24 software.

Some members of the multidisciplinary team entered the field of radiotherapy without any prior familiarity with radiological protection or even basic concepts of radiotherapy. November, when asked about her knowledge of radiotherapy when she started working in

the field, highlighted: "None, because my background was as a nursing technician." Furthermore, she could not answer what her understanding of ionizing radiation was. Sierra also reported that she "had no knowledge about radiotherapy." Figure 4 illustrates the professionals' perception of their prior knowledge in radiotherapy before entering the field.

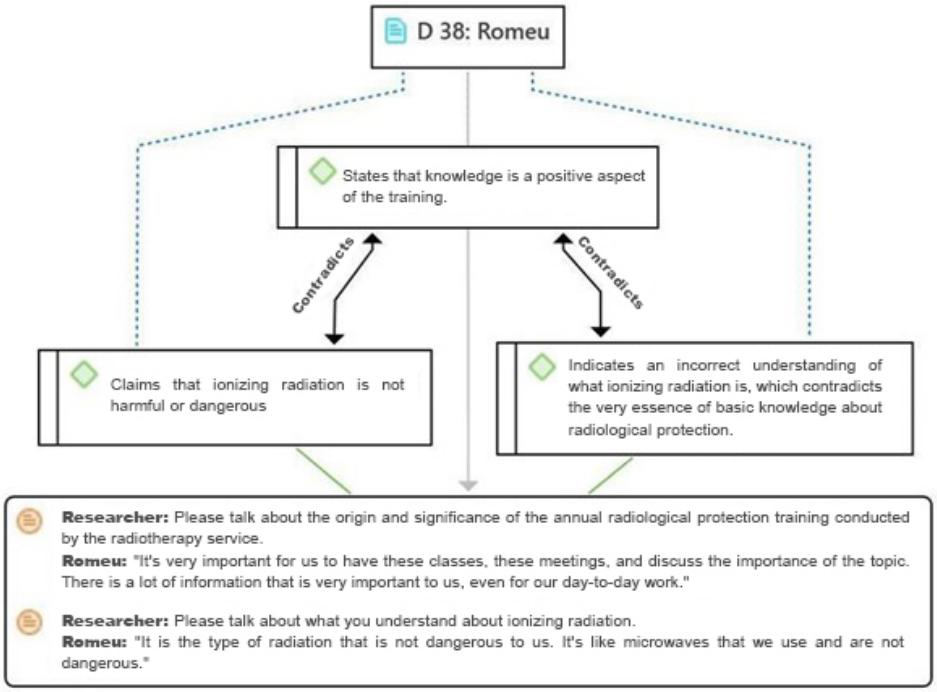
Figure 4: Level of knowledge of professionals before entering the field of radiotherapy.



Source: Research data extracted from ATLAS.ti 24 software.

Romeu perceives the knowledge acquired in radiological protection training as a positive point. However, it is crucial to emphasize that, at the same time, he presents an incorrect understanding of the nature of ionizing radiation. Believing that ionizing radiation is not harmful or dangerous contradicts the very essence of the necessary knowledge about radiological protection. Figure 5 illustrates the participant's speech and this contradiction.

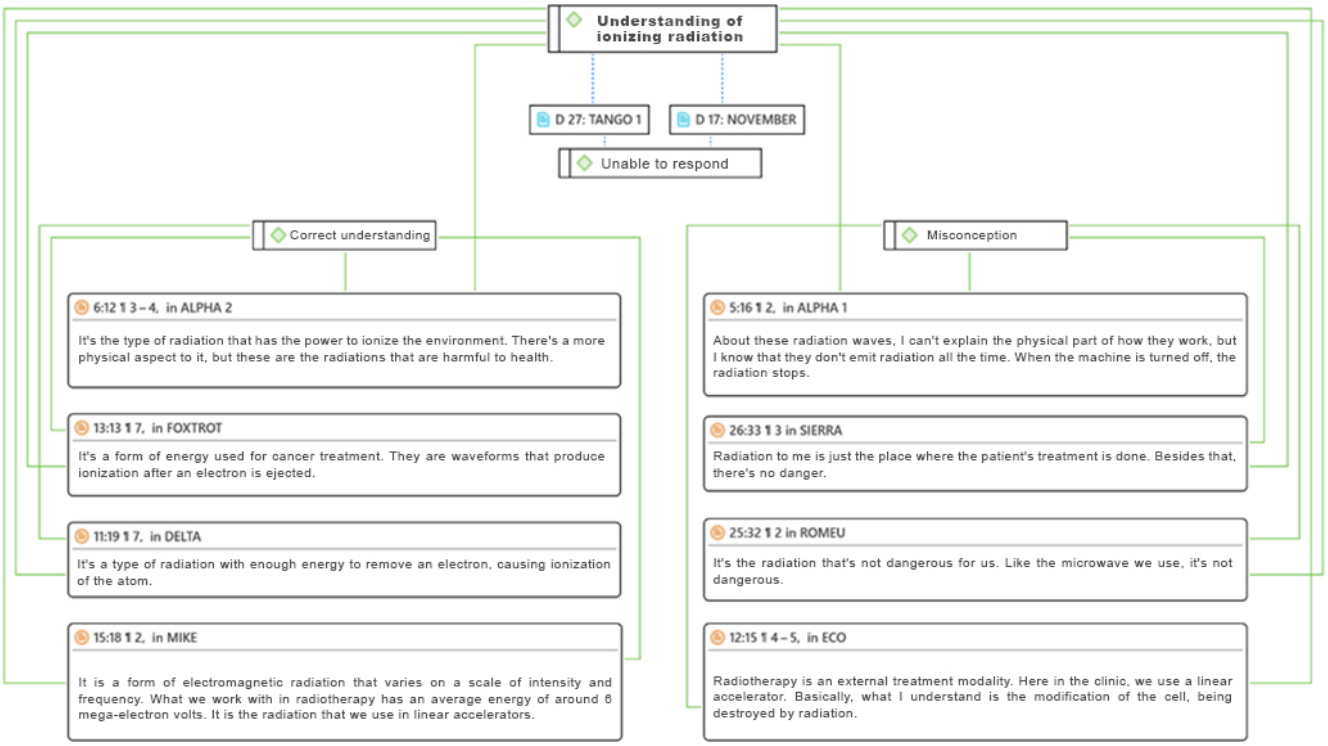
Figure 5: Contradictory perception and understanding of the risks of ionizing radiation.



Source: Research data extracted from ATLAS.ti 24 software.

Some members of the multidisciplinary team, such as the dosimetrist, physician, one of the administrative professionals, and a radiation therapist, demonstrated a correct and in-depth understanding of what radiological protection entails. Their responses reflect substantial knowledge acquired through their academic backgrounds, undergraduate courses, training sessions, and radiological protection training itself. In Figure 6, a comparison of the professionals' responses when questioned about their understanding of ionizing radiation is depicted.

Figure 6: Statements from professionals about what ionizing radiation is.



Source: Research data extracted from ATLAS.ti 24 software.

3.2. Training weaknesses

In the process of annual radiological protection training, some difficulties were identified.

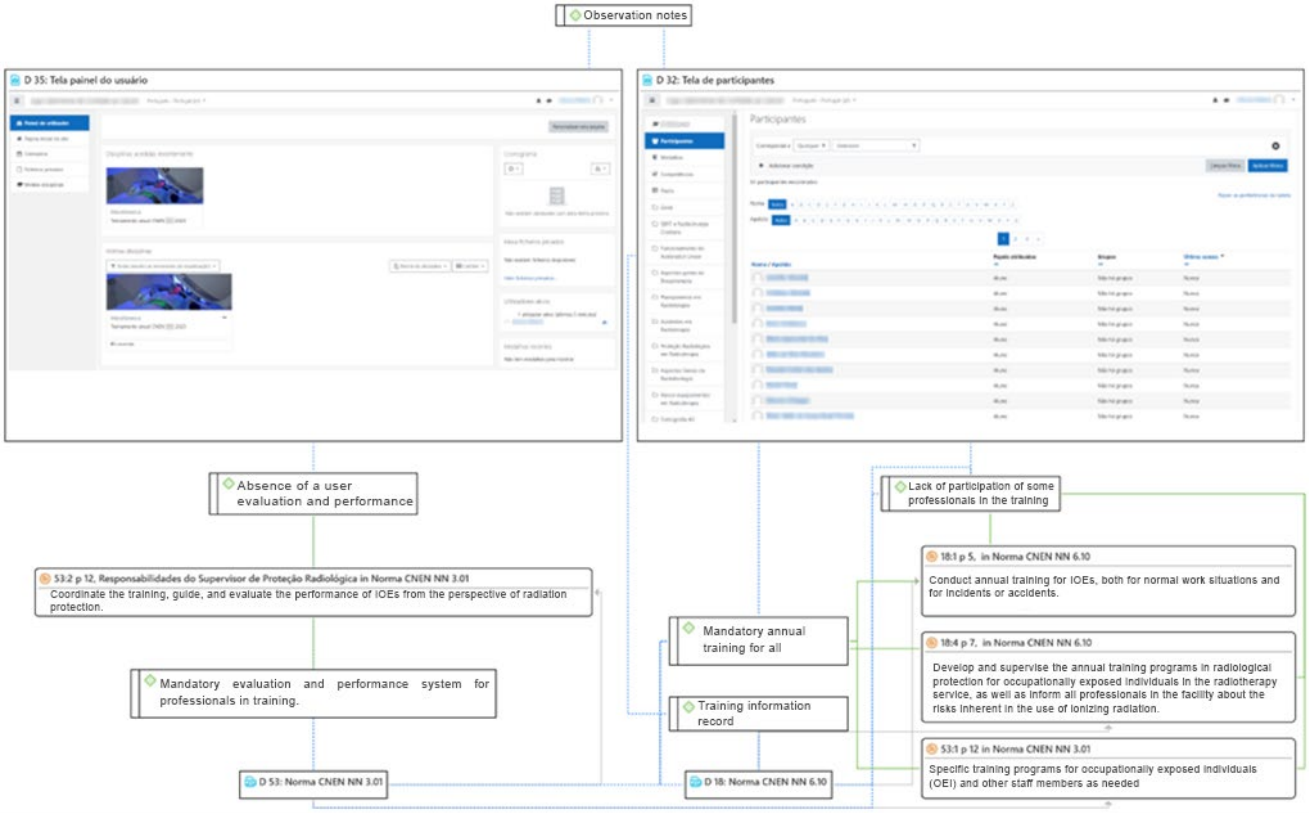
Foxtrot, one of the medical physicists responsible for content development and training supervision, along with Mike, highlight the complexity of engaging professionals from various backgrounds in topics that are not part of their training or daily practice. According to them, it is a challenge to involve the team comprehensively, ensuring that everyone understands the importance of and applies the concepts in the context of radiotherapy.

Another perspective presented by Foxtrot highlights the negative aspect of using E-learning: "the lack of socialization of the entire team." This observation underscores the importance of promoting face-to-face contact to facilitate interaction among team members, allowing for the exchange of experiences and strengthening professional bonds.

Alpha 1 also mentioned that "when it is online, we are usually not all participating at the same time. And sometimes, one person's question clarifies another person's doubt, who is too embarrassed to ask," and that "those who are not technicians have more difficulty understanding some situations."

During the observation of the online training platform, a total of 53 participants were identified as registered on the portal, corresponding to the total number of employees including the headquarters and branches. However, it was noted that 10 of these participants never accessed the platform, including radiation oncologists, nurses, radiation therapists, and receptionists. Also, no evaluative instruments were identified to monitor participants' understanding of the topics covered. Figure 7 correlates the weaknesses found in the online training platform with current national regulations.

Figure 7: Observing the training compared to legislation.



Source: Research data extracted from ATLAS.ti 24 software.

3.3. Training strengths

On the homepage of the training platform, the main objective is described as follows: "To promote updates in Radiotherapy for professionals who deal with occupational exposure to ionizing radiation," covering both the headquarters and branches of the Radiotherapy service.

The target audience is defined as "Dosimetrists, technicians, technologists, physicists, physicians, nurses, and other professionals working in radiotherapy." The information also points out that, regarding the program, "classes will be recorded and played at the workplace, with a maximum duration of 30 minutes; speakers will be available to answer questions after the classes, in person or remotely; and the program may be adjusted in terms of topics and dates as necessary."

Participants have access to a variety of topics essential for radiotherapy practice, organized in a calendar to facilitate content distribution. The topics cover: SBRT and Cranial Radiosurgery, Operation of the Linear Accelerator, General Aspects of Brachytherapy, Radiotherapy Planning, Accidents in Radiotherapy, Radiological Protection in Radiotherapy, General Aspects of Radiobiology, New Equipment in Radiotherapy, and 4D Tomography and IGRT with Exactrac.

The average time of the classes offered on the training platform is approximately 29 minutes, varying in duration, with some shorter classes around 5 minutes and others longer, lasting up to 48 minutes.

In the training approach through an online platform, some members of the multidisciplinary team demonstrated a smoother adaptation. The nurse and administrative professionals reported not having faced significant difficulties in using this type of platform to acquire knowledge in radiological protection. The radiation therapist, Tango 1, stated: "I only see advantages. I find it much easier, much more practical." Radiation therapist Tango 2 added: "I think it's very good because we can watch the classes at a more convenient time."

The standardization of training and the constant availability of materials through a platform, accessible anywhere and anytime, was also highlighted by professionals such as Mike and Delta. This approach ensures the same training standard across all units, particularly for clinics with multiple branches.

Familiarity with the virtual environment and the temporal flexibility offered by the online modality were aspects highlighted by professionals, reflecting a favorable adaptation to this training approach.

It became evident that training in radiological protection provides a series of significant benefits. Key professionals, such as radiation therapists, dosimetrists, and even some members of the administrative team with a background in radiology technology, highlight a crucial positive point: the acquisition of substantial knowledge.

3.4. Suggestions for training delivery methods and topics in radiological protection

Finally, professionals also shared valuable suggestions regarding the format and topics of the radiation protection training. Regarding the format, Mike suggested: "I think it should be recorded who eventually researched, looked at the platform to have an idea of who effectively and how often they were seeking".

Additionally, they emphasized the need for complementary in-person activities to the non-face-to-face teaching platform, recognizing the value of direct interaction and practical learning. Alpha 1 brings the suggestion "to bring practical examples, because we need to remember".

Tango 3 suggests "to bring the insertion of all functions of all professionals involved, with the identification of the role of each one, so that the professional can identify themselves".

Regarding the topics to be addressed more emphatically during the training, professionals highlighted the relevance of topics related to patient care, emphasizing the importance of a humanized and patient-centered approach during radiation therapy procedures.

They also emphasized the fundamental understanding of ionizing radiation, an essential pillar to ensure the safety and effectiveness of procedures. As stated by Eco "more subjects about radiation, modalities, which is what nursing has the most difficulty with".

Tango 1 suggested addressing topics related to "new technologies, new treatments".

On the other hand, some professionals considered the current content sufficient, indicating satisfaction with the scope and relevance of the topics already covered.

3.5. Systematic reviews

The training of professionals in the healthcare field, whether in higher education or technical courses, often lacks an adequate approach to education in radiation protection. Batista et al. [13] observed that the curricula of these courses rarely address the need for radiation protection education, and when they do, they tend to prioritize individual protection over the protection of patients, family members, and other individuals present in the hospital or healthcare environment. This gap in education can result in a disparity in previous experience in radiation protection among members of the multidisciplinary radiotherapy team.

The difficulty of learning in this field is notable, requiring all professionals, from the most experienced to beginners, to diligently instruct themselves in specific skills in this area of practice. Luz [14] emphasizes that professionals often demonstrate doubts and an incipient knowledge regarding radiation and radiation protection content. This underscores the relevance and necessity of continuous educational processes for these professionals, aiming to ensure correct and safe practices in the use of radiation.

The analysis of responses regarding the understanding of ionizing radiation highlights significant gaps in comprehension among some team members. As emphasized by Luz [14], topics such as ionizing radiation and its harmful nature, along with the importance of Personal Protective Equipment (PPE), often raise questions among professionals. While physicists, dosimetrists, and physicians demonstrate precise and in-depth understanding, others, such as receptionists and administrative professionals, exhibit superficial and, in some cases, erroneous comprehension.

Zanzi [15] emphasizes that radiation protection is not limited to the examination or therapy itself but encompasses a much broader process. The topic involves all professionals in a healthcare institution, from the requesting physician for the examination/therapy, the administrative team responsible for scheduling the procedure and providing necessary instructions, to the team executing the examination/treatment. The understanding of the importance of radiation protection by all involved in this process is crucial to ensure the safety and effectiveness of radiological procedures.

The complexity of conveying specific knowledge about radiation protection, especially to professionals whose specialties are not directly related, has been identified as a challenge. In this context, Lima [16] emphasizes the importance of understanding in the educational process, emphasizing that both educators and learners aim to comprehend a particular subject.

To comprehensively engage the team, it is necessary to offer training adapted to the diverse backgrounds of its members. Lima [16] emphasizes that language plays a crucial role in mediating social interaction, serving as an interactive link between communicating individuals, ensuring the understanding and effective application of radiological protection principles.

The diversity of perspectives on the format and topics of training suggests that a single approach may not fully meet the needs of the multidisciplinary team. While some professionals express the need for practical examples and in-person activities, others are satisfied with the existing format. In this context, Moran [17] discusses various educational

approaches aimed at enhancing student engagement, such as hybrid learning. He also highlights more innovative and disruptive models that do not adhere to the traditional format of disciplines but prioritize activities, challenges, and problems to promote individualized and collaborative learning.

The introduction of educational methods in training, including education through a non-presential platform, has proven to be an effective approach for some team members. Professionals such as radiation therapists, dosimetrists, and nurses reported a smoother adaptation to this training modality. The temporal flexibility and familiarity with virtual learning environments were positive aspects highlighted by these professionals. This perception is supported by recent studies, as evidenced by Cezar et al. [18], where the ability to access course material from anywhere is cited as one of the main advantages of Distance Learning (DL).

However, it is essential to recognize that the receptivity to non-presential education varies among team members, indicating the importance of offering varied options to meet individual preferences and needs. As discussed by Signorini et al. [20], the absence of in-person classes can result in communication difficulties, reporting a significant disadvantage compared to in-person disciplines.

The lack of participation by some professionals in radiation protection training not only compromises the program's effectiveness but can also directly impact the safety of procedures performed in radiotherapy. As emphasized by Macêdo et al. [21], the lack of training and updating is a contributing factor to the occurrence of occupational accidents. Despite the training platform offering resources to facilitate progress monitoring and participant lists, the finding that some professionals have never accessed the platform raises serious concerns about the scope and effectiveness of virtual training.

This lack of engagement can be attributed to various factors, such as lack of motivation, insufficient encouragement from managers, non-release by management to participate in training due to conflicts with work schedules, intense work routines, lack of

time for team meetings, some professionals' lack of motivation to participate in training, task overlap, and an insufficient number of professionals [21]. These challenges highlight the need for more effective strategies to promote professional engagement and ensure the scope and quality of radiation protection training.

The lack of uniformity in the duration of video lectures can also contribute to demotivating professionals to access the content. Mendonça and Carvalho [22] suggested that the maximum time for audiovisual materials should be 15 minutes, which can be divided into two or three parts. This is justified by the fact that longer production periods, along with the characteristic isolation of distance learning environments, can discourage students. .

The suggestions from professionals to address topics related to patient care during training are relevant. Emphasizing the importance of a humanized and patient-centered approach during radiotherapeutic procedures not only strengthens the connection between the team and the patient but also emphasizes the inherent ethical responsibility in radiotherapy practice.

As discussed by Santos and Brito Neto [23], humanization encompasses aspects such as sympathy, affection, and respect, essential for patients to feel comfortable during the treatment process. Through humanized care, professionals can create an environment conducive to welcoming and providing emotional support to patients, contributing to the reduction of anxiety and stress associated with cancer diagnosis and treatment. Additionally, by understanding each patient's history and experiences, professionals can establish an empathetic connection, conveying confidence and optimism regarding treatment success.

4. CONCLUSIONS

Although there is potential for the use of non-presential educational methods, it is necessary to overcome the weaknesses of the current training to ensure the effectiveness and scope of the program.

Regardless of the professional qualifications of members of the multidisciplinary team, both the most qualified and the least qualified faced significant challenges during training in radiological protection. These difficulties were evident both in training adherence and in knowledge of basic principles of radiological protection.

The lack of participation of key team members in the training raises concerns about the effectiveness of the training program, highlighting the urgent need for more effective engagement strategies. Additionally, there was a lack of integration between radiological protection supervisors and the team, as well as among the team members themselves in general.

Faced with this challenging scenario, it becomes imperative to seek solutions that strengthen and improve training programs. In this context, the creation of additional guidelines that provide precise and clear guidance on the training format emerges as a promising solution.

Additionally, the involvement of experts in education and radiological protection in the development of training programs is essential to ensure the quality and effectiveness of these programs. An example of guidance in this regard is the IAEA Quick Guide Q&A series, a set of informative brochures developed by the IAEA to address frequently asked questions on various topics related to radiological protection.

CONFLICT OF INTEREST

All authors declare that they have no conflicts of interest.

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