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Guest editorial

A European Federation of Radiographer Societies (EFRS) position statement on sustainability for the radiography profession

According to the European Federation of Radiographer Societies (EFRS) *Code of Ethics*, radiographers are committed to providing *a high standard of practice and care at all times*.[1] This commitment extends beyond maintaining high standards during examinations and treatments but also demonstrates a direct link with good healthcare policies and practices and the promotion of well-being whilst embracing sustainable practices to further support healthy living for all. This paper aims to raise awareness among radiographers in all fields of radiation medicine regarding the impact of healthcare on the environmental crisis and provide guidance on strategic actions to enhance environmental sustainability within practice.

The World Health Organisation (WHO) defines sustainability in healthcare as "a health system that improves, maintains or restores health, while minimising negative impacts on the environment and leveraging opportunities to restore and improve it, to the benefit of the health and well-being of current and future generations."[2] The United Nations (UN) has set Sustainable Goals that include "climate action", "good health and wellbeing", and "responsible consumption and production" among others.[3]

The WHO has recognised climate change and air pollution as major global health threats. Approximately 99% of people worldwide breathe polluted air every day,[4] significantly increasing mortality and morbidity[4,5] with the development of cancers,[6,7] and other chronic conditions such as respiratory and cardiovascular diseases. Additionally, the global rise in temperatures has escalated extreme weather events, such as hurricanes, floods, droughts, and wildfires which are becoming more frequent and severe with profound costs to people's lives.[8,9] With regards to medical imaging, nuclear medicine, and radiotherapy services, severe weather events may interrupt patients' care[10] thus negatively impacting survival.[11,6]

The environmental crisis has been largely driven by human activities that release pollutants such as carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxides (NO_x), and greenhouse gases including carbon dioxide (CO_2) and others into the atmosphere. The carbon footprint indicates the impact that these emissions have on the environment. While this is mostly attributed to industry, the healthcare sector has its own impact accounting for approximately 5% of global emissions,[12] which is larger than aviation and shipping.[13] If considered as a country, the global healthcare sector would rank as the 5th largest emitter of greenhouse gases on the planet.[12]

Medical imaging, nuclear medicine, and radiotherapy practices significantly contribute to the healthcare sector's environmental footprint mainly due to the high energy demands of sophisticated equipment, utilising ionising and non-ionising radiation, such as computed tomography (CT) scanners, magnetic resonance imaging (MRI) systems, interventional suites, and linear accelerators, extensive data handling and storage, the operational needs of the procedures, and waste management of single-use clinical consumables like gloves and gowns.[14,15] It has been reported that the manufacturing of linear accelerators and their operations are very energy-intensive, and alongside patient transportation, they are the largest contributors to the carbon footprint of radiotherapy departments.[14,16–18] A study conducted in a radiology facility found that two-thirds of the energy consumed by CT scanners occurred while the systems were in a nonproductive idle state.[19] Workstation energy consumption is also of concern when providing services 24 h, 7 days a week. A 5.6 % in energy saving has been reported when workstations were switched off after use but with staff costs increasing due to time needed to switch them back on.[15] Regarding data storage, the cloud option is more energy and carbon efficient than traditional on-premises solutions.[20] However, this comes with its own challenges concerning the sustainability of large-scale data centers and also data security.[21]

Moreover, there is a growing concern about water pollution by contrast media and radiopharmaceuticals used in medical imaging, nuclear medicine and radiotherapy. Although the environmental effects of their use are not fully understood, preliminary studies suggest that their degradation products could be toxic to the ecosystem and persist over time.[14] There have been efforts within the Greenwater Project to separate contrast media from patients' urine to prevent entering the water supply and potentially reuse it.[22]

Under this scope, environmental sustainability includes various dimensions such as energy, consumables and waste, travel, building design, water management, transportation of materials and equipment, green procurement of materials and equipment (manufacturing and life cycle), food, and behaviors.[23] Artificial Intelligence (AI) technology has the opportunity to offer innovative approaches to address environmental challenges and promote sustainable practices in various ways from improving the scheduling efficiency of equipment[21] to optimising waste and resource management.[24] Its clinical applications like enhancing workflow in medical imaging and radiotherapy departments, advancing diagnostics, and reducing CT/MRI scanning times,[25,26,27,28] also can enhance sustainability.[21] However, its use also requires addressing AI's carbon footprint in its development and implementation.[21]

In the efforts to promote environmental sustainability, the role of healthcare providers has been stressed as critical,[29,30] but there is an identified gap in education and training in relation to

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knowledge about how to achieve more sustainable working environments.[29,31]Findings from the SAFE Europe project, in which the EFRS was a partner,[32] identify radiotherapy radiographers' current behaviours and perceptions of sustainability.[31] Most radiotherapy radiographers have little knowledge of sustainability concepts such as *Green Skills* and *Circular Economy* and are unaware of local and national sustainability policies. They often focus on the concept of waste management (e.g. recycling), being poorly aware of other dimensions of sustainability, showing the importance of increasing interventions to increase knowledge and awareness. Many of them admit that they do not practice sustainably, however, additional research is needed to understand the reasons and existing barriers. More than half of radiotherapy radiographers use external combustion cars (petrol and diesel) to travel to work, followed by public transportation and walking. Nevertheless, they indicate that sustainability is important and are interested in learning more.[31]

Radiographers are key professionals in medical imaging, nuclear medicine, and radiotherapy services and also influence practice as advanced practitioners.[33–36] Additionally, they may hold decision-making roles serving on committees or within professional bodies and be able to influence the development of policies supporting sustainability in their workplaces or nationally. Moreover, their daily interaction with patients and carers gives them the unique opportunity to promote further sustainability by informing others. Their collective efforts in practicing sustainability while ensuring treatment quality, patient safety, and care, can set norms, shape behaviours, and drive policy shifts to green decisions contributing to substantial environmental benefits.

We encourage radiographers in all fields to reflect on their practice and adapt and promote sustainability practices in their professional and personal lives contributing to a better living.

Recommendations

Radiographers (as well as all other healthcare professionals) should be actively involved in improving the sustainability of their practice. A list of suggested actions, informed from the literature and the UK Radiotherapy Board,[37] are presented as follows:

Sustainability culture development

- Establish (or join) *green teams* within your facility with a radiographer Sustainability Champion to lead eco-friendly practices within the workflow.
- Display posters promoting sustainability practices for patients and staff, and consider adding relevant information to institutional websites.
- Promote social responsibility and sustainability by spreading public knowledge and fostering patient-centred care and a supportive working environment.

Transportation efficiency

- Inform patients and staff on transportation options and public transport.
- Facilitate patients' schedules to minimise traveling e.g. appointments to other specialties in the hospital within the same day and convenient time.
- Encourage remote working wherever applicable to reduce staff transportation.
- Encourage remote servicing and technical support by the manufacturers.

Energy efficiency

In most cases, electricity is used which is an indirect source of CO_2 emissions (purchased from a commercial provider).

- Consider minimising cooling (e.g., air conditioning) and heating times of a device as appropriate (e.g. switch the immobilisation shell bath off when not in use).
- Manage scheduling appointments for medical imaging and radiotherapy procedures to reduce machine working slots of non-use. Consult manufacturers to enable the best energy efficient mode (e.g., stand by, idle) tailored to the scheduling appointments. Also, consider the best energy-efficient mode for working stations when not active. Turn off equipment when is not in use. Automatic power-off/on solutions can be utilised.

Resource management

- Reduce the use of materials non-essential for the provision of care.
- Optimise digital solutions, go paper-light or paperless.
- Consider reusable materials e.g. thermoplastic shells, markers, reusable gowns instead of single-use gowns, or allow patients to enter the examination/treatment room with light clothing e.g., with a t-shirt for chest radiotherapy or CT, while always maintaining good infection control practices and protecting patients' dignity.
- Consider recycling (e.g., plastic, batteries, paper, with special bins also in the waiting rooms). Investigate if materials currently being disposed into landfills or incineration can be recycled.
- Prefer biodegradable materials as a preference to other materials.
- Ensure safe disposal of expired medication to prevent contamination of water systems and reduce the accumulation of contrast media and pharmaceuticals in the environment.
- Utilise AI to enhance efficiency in financial and administrative tasks, optimise resource allocation, improve communication with patients to reduce absences, establish guidelines for managing patient-related waste, and incorporate advanced imaging/therapy techniques to reduce costs and resource usage.

Clinical sustainability

- Consider evidence based hypofractionation schemes in radiotherapy when appropriate. This would reduce both patient transportation and linear accelerator energy consumption.
- Minimise the time interval between CT simulation and the initiation of the radiotherapy course to reduce the need for additional assessments and interventions (e.g., restaging exams, repeated CT simulations, and new immobilisation devices) due to disease progression or changes in patient anatomy. This enhances patient care and also contributes to achieving sustainability goals.
- Consider referral guidelines and justification to reduce unnecessary procedures through organisational-level analysis. Using AI where available to analyse data trends and to support standardisation of protocols.
- Careful use of contrast agents in CT and MRI can reduce costs, waste production, and the environmental impact of imaging and radiotherapy departments.
- Implement green radiopharmacy practices, including the use of advanced imaging techniques, onsite radionuclide production,

and strict protocols for recycling and safe disposal of radioactive materials to minimise environmental impact.

Decision and policy-making

- Consider renewable energy sources in the hospital, such as photovoltaic panels or wind turbines.
- Facilitate the eco and user-friendly design in the rooms to improve energy efficiency, such as improved insulation or natural light and a single switch or sensor to turn off all the lights.
- Reduce water consumption without compromising patient care or infection control. For example, caudal reduction in taps, automatic taps, or foot-controlled taps can be installed.
- Include a life-cycle evaluation of the carbon footprint of all consumables and equipment during procurement, including the origin of the product (contributing to transportation), materials and energy used in its production, energy consumption during its lifetime, and disposal. Promoting, for example, equipment that lasts longer even if they are slightly more expensive.
- Consider maintenance options for spare parts and refurbished options, while always guaranteeing the quality of the equipment.
- Prioritise procurement of energy-efficient equipment and upgrade to energy-efficient systems when necessary.
- Contract and work with companies that follow 'green principles' and have values that support and prioritise sustainability.

Sustainability education

- Educational institutions should incorporate eco-related training modules and embed sustainability as a core concept. In addition, clinical practice should also inform about sustainable practices in imaging, nuclear medicine, and radiotherapy departments.

National societies' sustainability efforts

- National radiographers' societies should include sustainability in their agenda to take action and raise awareness among their members and the public.

The list above are some examples of measures that can be taken, many other actions can be used to achieve the same goals. The EFRS strongly encourages further research to identify the most efficient and effective methods to decrease the carbon emission of imaging and radiotherapy departments to inform best practices for sustainability.

It is important to note that many of these recommendations may require an initial investment, but they all bring financial benefits to hospitals resulting from the reduction in energy, water, and materials consumption, and a decrease in incineration and transportation costs, among others. Financial benefits and time-saving benefits also apply to patients.

Lastly, it is essential to point out that sustainability in healthcare is especially challenging since it is imperative that the journey to sustainability cannot compromise the quality of care, patient safety, nor infection control.

Conclusion

As the impact of the environmental crisis escalates, Radiographers hold a unique position in medical imaging, nuclear medicine, and radiotherapy departments to drive sustainable practices. By implementing and advocating for green solutions, radiographers can significantly decrease the carbon footprint associated within their services. Moreover, their role enables them to influence the public's perceptions and encourage engagement in sustainability efforts contributing further to the environmental benefits. Further research is needed to support sustainability actions in radiation medicine while training and education are paramount to raise awareness and make sustainability a default practice. The EFRS recommends that radiographers embrace sustainability throughout their practice and raise awareness in the public domain. The EFRS will continue to promote and support sustainability in medical imaging, nuclear medicine and radiotherapy through its activities.

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References

1. European Federation of Radiographers Societies. *Code of Ethics*. 2010.
2. WHO Regional Office for Europe. *Environmentally sustainable health systems : a strategic document*. 2017. Copenhagen.
3. United Nations. *THE 17 GOALS | Sustain Development*. Available from: https://sdgs.un.org/goals. [Accessed 26 April 2024].
4. World Health Organisation. *Air pollution: The invisible health threat*. Available from: https://www.who.int/news-room/feature-stories/detail/air-pollution–the-invisible-health-threat. [Accessed 27 April 2024].
5. European Environment Agency. *Air pollution and children's health*. Available from: https://www.eea.europa.eu/publications/air-pollution-and-childrens-health. [Accessed 27 April 2024].
6. Bernicker E, Averbuch SD, Edge S, Kamboj J, Khuri FR, Pierce JY, et al. Climate change and cancer care: a policy statement from ASCO. *JCO Oncol Pract* 2024;**20**(2):178–86. https://doi.org/10.1200/op.23.00637.
7. *How Can Air Pollution Cause Cancer? | Lung Cancer And Air Pollution*. Available from: https://www.cancerresearchuk.org/about-cancer/causes-of-cancer/air-pollution-radon-gas-and-cancer/how-can-air-pollution-cause-cancer. [Accessed 28 April 2024].
8. World Health Organisation. *Climate crisis - extreme weather*. Available from: https://www.who.int/europe/emergencies/situations/climate-crisis-extreme-weather. [Accessed 27 April 2024].
9. Ballester J, Quijal-Zamorano M, Méndez Turrubiates RF, Pegenaute F, Herrmann FR, Robine JM, et al. Heat-related mortality in Europe during the summer of 2022. *Nat Med* 2023;**29**(7):1857–66. https://doi.org/10.1038/s41591-023-02419-z.
10. Man RXG, Lack DA, Wyatt CE, Murray V. The effect of natural disasters on cancer care: a systematic review. *Lancet Oncol* 2018;**19**(9):e482–99. https://doi.org/10.1016/S1470-2045(18)30412-1.
11. Nogueira LM, Sahar L, Efstathiou JA, Jemal A, Yabroff KR. Association between declared hurricane disasters and survival of patients with lung cancer undergoing radiation treatment. *JAMA* 2019;**322**(3):269–71. https://doi.org/10.1001/JAMA.2019.7657.
12. Karliner J, Slotterback S, Boyd R, Ashby B, Steele K. Health Care's Climate Footprint: how the health sector contributes to the global climate crisis and opportunities for action. Health Care without Harm; Climate-smart health care series Green Paper Number One. *Heal Care Without Harm* 2019:1–48. September.
13. Ritchie H. Sector by sector: where do global greenhouse gas emissions come from? *Our World in Data* 2024. Available from: https://ourworldindata.org/ghg-emissions-by-sector. [Accessed 28 April 2024].
14. Anudjo MNK, Vitale C, Elshami W, Hancock A, Adeleke S, Franklin JM, et al. Considerations for environmental sustainability in clinical radiology and radiotherapy practice: a systematic literature review and recommendations for a greener practice. *Radiography* 2023;**29**(6):1077–92. https://doi.org/10.1016/j.radi.2023.09.006.
15. Büttner L, Posch H, Auer T, Jonczyk M, Fehrenbach U, Hamm B, et al. Switching off for future—cost estimate and a simple approach to improving the ecological footprint of radiological departments. *Eur J Radiol Open* 2021;**8**:100320. https://doi.org/10.1016/J.EJRO.2020.100320.
16. Ali D, Piffoux M. Methodological guide for assessing the carbon footprint of external beam radiotherapy: a single-center study with quantified mitigation strategies. *Clin Transl Radiat Oncol* 2024;**46**:100768. https://doi.org/10.1016/j.ctro.2024.100768.

17. Larios D, Dunn SA, Li JH, Saraf A, Guthier CV, Gierga D, et al. The carbon footprint of radiation oncology on climate change: a model in early-stage breast cancer. *Int J Radiat Oncol* 2022;**114**(3):S129. https://doi.org/10.1016/J.IJROBP.2022.07.582.
18. Chuter R, Stanford-Edwards C, Cummings J, Taylor C, Lowe G, Holden E, et al. Towards estimating the carbon footprint of external beam radiotherapy. *Phys Medica* 2023;**112**:102652. https://doi.org/10.1016/J.EJMP.2023.102652.
19. Heye T, Knoerl R, Wehrle T, Mangold D, Cerminara A, Loser M, et al. The energy consumption of Radiology: energy- and cost-saving opportunities for CT and MRI operation. *Radiology* 2020;**295**(3):593–605. https://doi.org/10.1148/RADIOL.2020192084.
20. Microsoft. *The carbon benefits of cloud computing A study on the Microsoft Cloud in partnership with WSP*. 2020.
21. Doo FX, Vosshenrich J, Cook TS, Moy L, Almeida EPRP, Woolen SA, et al. Environmental sustainability and AI in radiology: a double-edged sword. *Radiology* 2024;**310**(2). https://doi.org/10.1148/RADIOL.232030.
22. Zanardo M, Cozzi A, Cardani R, Renna LV, Pomati F, Asmundo L, et al. Reducing contrast agent residuals in hospital wastewater: the GREENWATER study protocol. *Eur Radiol Exp* 2023;**7**(1):1–7. https://doi.org/10.1186/S41747-023-00337-W/FIGURES/2.
23. Soares AL, Buttigieg SC, Bak B, McFadden S, Hughes C, McClure P, et al. A review of the applicability of current green practices in healthcare facilities. *Int J Health Pol Manag* 2023;**12**(Issue 1):1–15. https://doi.org/10.34172/IJHPM.2023.6947.
24. Sohana Akter M. Harnessing technology for environmental sustainability: utilizing AI to tackle global ecological challenges. *J Artif Intell Gen Sci* 2024;**2**(1):49–57. https://doi.org/10.60087/JAIGS.V2I1.P57. ISSN3006-4023.
25. Manson EN, Mumuni AN, Fiagbedzi EW, Shirazu I, Sulemana H. A narrative review on radiotherapy practice in the era of artificial intelligence: how relevant is the medical physicist? *J Med Artif Intell* 2022;**5**(December):3. https://doi.org/10.21037/jmai-22-27. 0–.
26. Santoro M, Strolin S, Paolani G, Giuseppe DG, Bartoloni A, Giacometti C, et al. Recent applications of artificial intelligence in radiotherapy: where we are and beyond. *Appl Sci* 2022;**12**(7):3223. https://doi.org/10.3390/APP12073223/S1.
27. Piorkowski A, Obuchowicz R, Najjar R. Redefining radiology: a review of artificial intelligence integration in medical imaging. *Diagnostics* 2023;**13**(17):2760. https://doi.org/10.3390/DIAGNOSTICS13172760. Vol 13, Page 2760 2023.
28. Currie GM, Hawk KE, Rohren EM. *The potential role of artificial intelligence in sustainability of nuclear medicine*. 2024. https://doi.org/10.1016/j.radi.2024.03.005.
29. World Health Organisation. *WHO launches groundbreaking air pollution training for health workers on International Day of Clean Air*. Available from: https://www.who.int/news/item/05-09-2023-who-launches-groundbreaking-air-pollution-training-for-health-workers-on-international-day-of-clean-air. [Accessed 27 April 2024].
30. World Health Organisation. *Communicating on climate change and health on climate change Toolkit for health professionals*. 2024. Geneva.
31. Soares AL, Buttigieg SC, Couto JG, Bak B, McFadden S, Hughes C, et al. An evaluation of knowledge of circular economy among Therapeutic Radiographers/Radiation Therapists (TR/RTTs): results of a European survey to inform curriculum design. *Radiography* 2023;**29**(2):274–83. https://doi.org/10.1016/j.radi.2022.12.006.
32. *Safe Europe | About SAFE EUROPE*. Available from: https://www.safeeurope.eu/about/. [Accessed 28 April 2024].
33. European Federation of Radiographers Societies. *EFRS statement. Radiographers in radiotherapy: practice across the radiotherapy pathway*. 2019.
34. Khine RNM, Stewart-Lord A. An examination of Advanced Clinical Practice: Qualitative insights from therapeutic radiography advanced and consultant practitioners based in England. Tech Innov Patient Support. *Radiat Oncol* 2021 Mar 18;**17**:97–101. https://doi.org/10.1016/j.tipsro.2020.12.003. PMID: 34007914; PMCID: PMC8110936.
35. Oliveira C, Barbosa B, Couto JG, Bravo I, Khine R, McNair H. Advanced practice roles of therapeutic radiographers/radiation therapists: A systematic literature review. *Radiography (Lond)* 2022;**28**(3):605–19. https://doi.org/10.1016/j.radi.2022.04.009.
36. Oliveira C, Barbosa B, Couto JG, et al. Advanced practice in radiotherapy across Europe: stakeholders' perceptions of implementation and evolution. *Radiography (Lond)* 2024;**30**(3):896–907. https://doi.org/10.1016/j.radi.2024.03.013.
37. The Radiotherapy Board. *Statement on climate change and environmental sustainability*. 2022.

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