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Canadian Association of Radiologists Statement on Planetary Health Education in Radiology

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Abstract

The health of Canadians is already impacted by climate change due to wildfire smoke, heat domes, floods, droughts, and the changing distribution of vector borne disease. The healthcare sector contributes to climate change, accounting for approximately 4.6% of annual greenhouse gas emissions in Canada. Healthcare teams have a responsibility and opportunity to reduce harm by limiting emissions and waste, and engaging the public in understanding the planetary health links between clean air and water, a stable climate, a healthy planet and human health. Transformation of Canadian healthcare to a low carbon, climate resilient system will be enhanced by physician engagement and leadership. Cornerstones to physician participation include knowledge of the anthropogenic etiology of the climate crisis, the human health impacts, and the contribution providing healthcare makes to the climate crisis. Integration of climate change knowledge into the Canadian Radiology educational curricula is essential to position radiologists to lead transformative change in mitigation and adaptation of the healthcare system to the climate crisis. This statement is intended to provide guidelines to optimize education and research for current and future Canadian radiologists, and builds on existing planetary healthcare education publications and the Canadian Association of Radiologists Statement on Environmental Sustainability in Medical Imaging.

Résumé

La santé de la population canadienne subit déjà les effets du changement climatique par l'intermédiaire de la fumée causée par les feux de forêt, des dômes de chaleur, des inondations, des sécheresses et de la modification de la distribution des maladies à transmission vectorielle. Le secteur de la santé, qui représente 4,6 % des émissions annuelles de gaz à effet de serre au Canada, contribue au changement climatique. Les équipes de soins de santé ont la responsabilité et la possibilité de réduire les effets négatifs en limitant les émissions de gaz et les déchets et en incitant le public à établir des liens entre la propreté de l'air et de l'eau, un climat stable, une planète saine et la santé humaine à l'échelle planétaire. La transition

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des soins de santé canadiens vers un système à faible émission de GES et résilient au changement climatique sera plus efficace si elle peut compter sur l'engagement et le pouvoir d'influence des médecins. Cette participation des médecins repose sur la compréhension de l'étiologie anthropique de la crise climatique, des répercussions de celle-ci sur la santé humaine et de la contribution des soins de santé à la crise climatique. L'intégration de notions en matière de changement climatique dans les programmes de formation en radiologie au Canada est essentielle. Ainsi, les radiologistes seraient en mesure de mener un changement transformateur dans le cadre de la crise climatique afin d'adapter le système de soins de santé et d'atténuer ses effets néfastes. Le présent énoncé de position vise à fournir des lignes directrices en vue d'optimiser l'enseignement et la recherche pour les radiologistes canadiens d'aujourd'hui et de demain. Il s'appuie sur des articles publiés portant sur l'enseignement des soins de santé à l'échelle mondiale, ainsi que sur la déclaration de la CAR sur la durabilité environnementale en radiologie.

Keywords
Planetary Health, climate change, education, diagnostic imaging, environmental sustainability

"Climate change is recognized as the greatest threat to health in the 21st century. Academic health institutions have a distinct responsibility to educate, train and prepare health professionals to respond to and advocate for the health needs of society, from the individual to the population level, and from a local to a global level"

Association of Faculties of Medicine of Canada, April 2023

Introduction

Climate change threatens healthcare systems and impacts human health directly and indirectly.[1] The health of Canadians is already directly impacted by poor air quality due to wildfire smoke, heat domes, storms, floods, drought leading to crop loss, and changing distribution of vector borne disease.[2] Indirect impacts to physical and mental health occur through climate related population displacement and migration, reduced access to potable water, food insecurity, and increased interpersonal and international violence.[1] The Lancet Countdown on health and climate change has called climate change the greatest health threat facing the world, and the greatest opportunity to redefine social and environmental determinants of health.[3]

The healthcare sector contributes significantly to climate change, accounting for 5% to 8.5% of greenhouse gas emissions globally, and 4.6% of Canadian emissions.[4] Moreover, medical imaging is estimated to contribute approximately 0.8% of annual global greenhouse gas emissions, making radiology a critical field to consider in sustainability endeavours.[5] The Canadian Federal government has committed to delivering a climate-resilient, low carbon healthcare system as a signatory to Alliance for Transformative Action on Climate and Health (ATACH) led by the World Health Organization (WHO), and co-chairs the Climate-Resilient Health Systems Working Group of the ATACH.[6,7] Transformation of Canadian healthcare to a low carbon, climate resilient system will require physician engagement and leadership. Integration of climate change knowledge into Canadian Radiology curricula is essential to position radiologists to lead transformative change in mitigation and adaptation of the healthcare system to the climate crisis.[8-11]

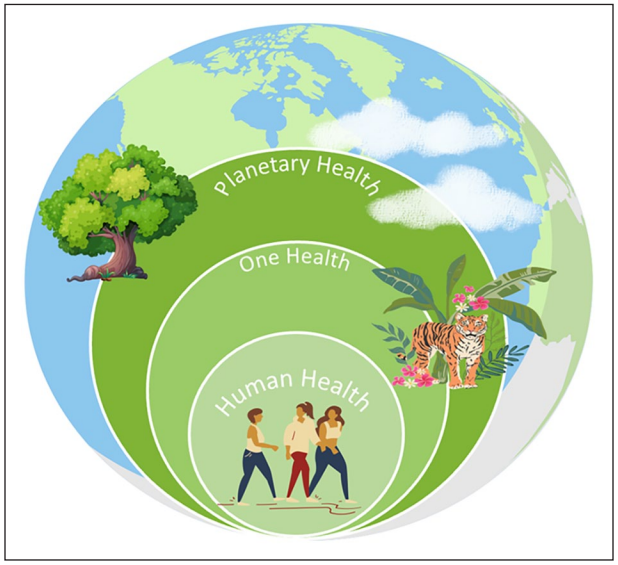

Figure 1. Planetary Health.[12]
One health is the health of all life on earth
Planetary health is the whole living and nonliving system and recognizes that human health is inextricably linked to the health of our planet. As human health is directly linked with planetary health, understanding and acting upon threats to planetary health is critical to our long-term well-being.

A recent review highlighted the importance of Planetary Health concepts in the 2025 CanMEDS physician competency framework update.[8] Planetary Health is defined as "a solutions-oriented, transdisciplinary field and social movement focused on analyzing and addressing the impacts of human disruptions to Earth's natural systems on human health and all life on Earth" (Figure 1).[12] Planetary healthcare encompasses reducing the impact of healthcare on the environment and the impact of the climate emergency on patient care.[13] As climate disruptions increase, the need to incorporate the understanding of complex adaptive systems to physician leadership and quality improvement innovation is identified for CanMEDS 2025.[9] This is particularly

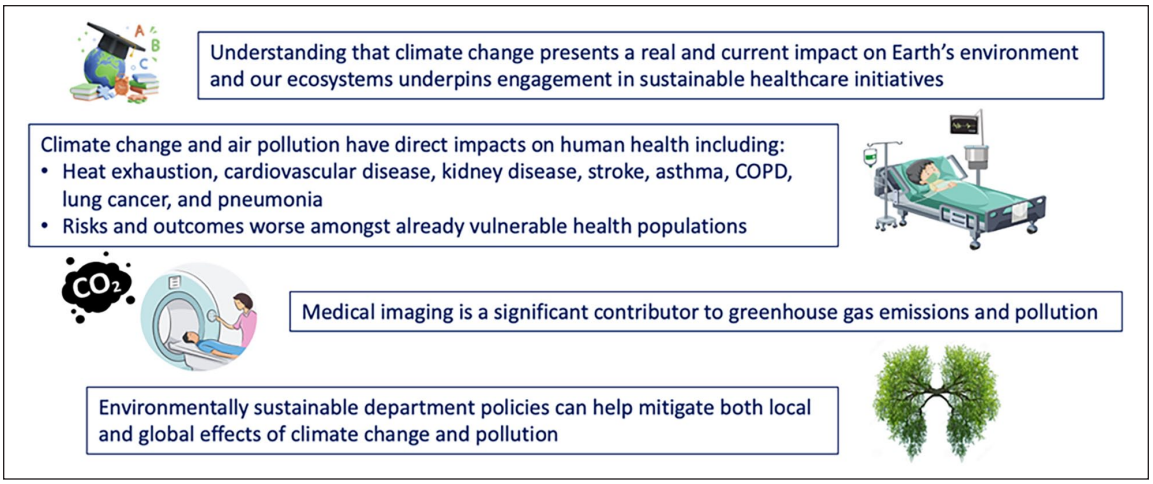

Figure 2. Education of radiology teams.
Action on reducing healthcare greenhouse gas emission requires sound understanding of the causes and health impacts of climate change, as well as the local and global health co-benefits of mitigation and adaptation opportunities.

relevant to radiology education given the large energy requirements for medical imaging equipment and data servers, and the substantial waste generated in the delivery of diagnostic and interventional radiology services.[14,15]

This statement is centred on planetary health education for Canadian diagnostic and interventional radiology trainees, including medical students, residents, and fellows. It is intended to provide guidelines to optimize education and research in Planetary Health for current and future Canadian radiologists. The statement is loosely structured on the Planetary Health Education Framework proposed by the Planetary Health Alliance and the *Education for Sustainable Healthcare: A curriculum for the UK* and builds on the CAR statement on Environmental Sustainability in Medical Imaging.[16-18]

Education

Education of radiologists and trainees on the health harms of the climate crisis and co-benefits of reducing emissions and waste will be foundational in preparing radiologists for emerging threats to health and provision of health care (Figure 2).[11,19] Environmental and economic stewardship requires limiting waste of energy and single use plastics, as well as reducing low value imaging through interdisciplinary engagement with referring physicians, patients, and hospital administration.[20] Adaptation and resiliency requires trainees acquire literacy around the impact climate change will have on imaging services from changing patterns of disease and challenges to infrastructure integrity due to extreme weather events.[21]

1.1 Medical Schools to Integrate Learning on Planetary Health and Climate Change Throughout the Curriculum

Medical professionals must understand the health harms of the climate crisis and the co-benefits to local and global health of reducing greenhouse gas emissions. Efforts to mitigate the climate impact of providing healthcare will require that future providers understand the contribution healthcare itself makes to environmental degradation.[11,22,23]

1.2 Radiology Residency Programs to Educate on Planetary Health and the Environmental Impact of Radiology

Radiologists should be well versed in the changing patterns of disease, including vector borne disease, cardiovascular disease, cancer incidence and survivorship related to climate disruptions and environmental exposures. Radiologists should be aware of the potential impact of climate related environmental exposures on imaging demand, including poor air quality due to wildfire smoke, heat-related illness, and extreme weather events, which will be essential in workforce and infrastructure planning. These topics could be included in half-day didactic programs that align with CanMEDS competencies.[8,10] Radiology trainees and radiologists should also develop an understanding of the environmental impacts of providing radiology services including large energy requirements to power imaging equipment, water and energy requirements for data centres and radiology artificial intelligence (AI) tools, and generation of medical and non-medical waste.[24-26]

1.3 Radiology Residency Programs to Engage in Collaborative Efforts in Sustainable Radiology

The imaging and intervention community and training programs can optimize provincial and national contributions toward environmental sustainability through sharing of ideas, recognizing that we share many similar challenges. Cross-institutional and interdisciplinary sharing of Planetary Health resources will encourage curricular innovation and research with defined outcomes.[27] A record of departmental initiatives,

funded faculty positions and action in low carbon, sustainable healthcare should be available to medical students when selecting residency program. Alignment of academic radiology programs with a *Director of Planetary Health* suggested for Canadian Faculties of Medicine would promote engagement and collaboration within and between departments.[28]

1.4 Local, Provincial, and National Radiology Meetings and Conferences to Include Sustainability Content and Virtual Access

Inclusion of sustainability content in Radiology Residency curricula and departmental Continuing Professional Development (CPD) activities will ensure future and practicing radiologists are aware of the impacts of their practice on the environment, ways to minimize associated environmental harms, and options to advocate at a system level for more sustainable solutions and practices. To reduce the greenhouse emissions of educational and scientific meetings, collaboration with attendees and sponsors is required to encourage virtual participation with online engagement opportunities, accreditation, and promotion.

1.5 The Canadian Association of Radiology to Develop an Environmental Sustainability in Radiology Certificate

The Canadian Association of Radiologists (CAR) online teaching platform, RAD Academy, provides Continuing Medical Education (CME) courses to its members. Formal curricular content on Sustainable Radiology could include testable objectives on core concepts including the anthropogenic cause of the climate crisis, the health effects of climate change, the responsibility of healthcare providers to engage in reducing the impact of providing healthcare and specific actions radiologists can take personally and professionally.[8,23] The RAD Academy platform could be harnessed to create an Environmental Sustainability in Radiology Certificate upon completion of relevant modules, attendance of virtual lectures, and a personal reflection.

1.6 Royal College of Physicians and Surgeons of Canada and Academic Radiology Department Leadership to Develop Planetary Health Concepts Within the CanMEDS Competencies

Physician competencies around Planetary Health include minimizing the impact of healthcare on the climate crisis and the impact of the climate crisis on human health and patient care.[8] Lifelong learning and continuous quality improvement as climate change impacts evolve will be supported by inclusion of sustainable radiology in CanMEDS competencies.[29] Radiologists, as consultants, play a central role in engaging and educating allied healthcare teams in the appropriate use of imaging tests, as outlined in a framework for sustainable healthcare.[13] Reducing low value exams limits waste of imaging resources and associated emissions from patient travel and data storage. Equally important is to ensure medically necessary imaging is performed within appropriate benchmarks, as delays in care may lead to more advanced disease presentations requiring more resource intensive healthcare.[13]

1.7 Radiology Residency Programs to Collaborate on Design of a Canadian Radiology Fellowship in Sustainable Imaging

The relationship between human health and the environment is complex, with rapidly evolving knowledge and research about the impacts of the climate crisis on health and the contribution healthcare makes to emissions and waste. Canadian radiologists will require expertise in specific Canadian health challenges of the climate crisis, including poor air quality due to wildfire smoke, changing geography of vector borne disease, and disaster response to extreme weather events. A Canadian Radiology Fellowship in Sustainable Imaging would provide critical knowledge and leadership skills to ensure future radiologists are engaged in the health system transformation at the intersection of climate and health policy development, problem solving and action.

Research and Sustainable Quality Improvement

The integration of sustainability-focused leadership roles within residency and fellowship programs is valuable in engaging learners and radiology programs in sustainability-related research and quality improvement (QI).

2.1 The CAR Sustainable Radiology Committee to Conduct a Needs Assessment Survey of Current Trainees to Guide Education Curriculum Development

Prior to planning a sustainable radiology engagement and education program, a needs assessment survey should be conducted with trainees. This could include evaluation of current knowledge around climate and health, the contribution that imaging services make to facility emissions and waste, and what barriers may exist to trainee engagement.

2.2 Radiology Residency Programs to Identify a Sustainability Lead for Research and Quality Improvement

Formal identification of "sustainability champion" leadership roles for radiologists to provide mentorship for trainees would acknowledge program sustainability efforts and encourage trainee-led initiatives.[28] Sustainable quality improvement is a cornerstone to transformative low carbon

sustainable healthcare.[29] Guidance and support for trainee publication of QI initiatives will foster individual and program growth.[30] Such collaboration between trainees and radiology program administration would be valuable to facilitate funding, protected time, and formal supervision.

2.3 The CAR and Academic Radiology Programs to Create a National Database of Sustainable Imaging Quality Improvement Projects, Research Opportunities, and Shared Resources

Creating a national database for sustainable imaging quality improvement projects would facilitate knowledge sharing and collaboration amongst radiologists and trainees, while improving efficiency by preventing duplication of efforts. Key steps to implementation would include a centralized platform, collaboration with multiple stakeholders across Canada including Choosing Wisely Canada, and monitoring usage to ensure high quality projects and continuous improvement.[29,30]

2.4 Radiology Research Days to Include Sustainability Topics

Attending research days broadens trainees' understanding of current controversies and issues affecting their practice in a particular medical specialty. Including sustainability content on research days highlights the climate crisis as an area of concern within the professional scope of the radiologist and encourages trainees to take an active role in research and publication.[28-30]

2.5 Radiology Research on the Environmental Impacts of Artificial Intelligence

Given the increasingly important role of AI in healthcare and radiology, it is important to consider the environmental impact of AI development and applications. Training AI models on thousands of medical images for 100 hours produces the carbon emissions of an average European citizen in a single day.[31] Meanwhile, the potential environmental benefits of their applications can be immense. One example is deep-learning reconstruction of magnetic resonance imaging, which allows images to be taken over a shorter time and with lower-strength magnets, thereby significantly reducing the carbon footprint of imaging machines in a scalable way.[32,33] Since radiology is thought to contribute to 0.8% of global carbon emissions, fostering research on the environmental implications of AI could highlight new ways to advance sustainability in radiology.[5]

Trainee Interest Groups

While progress has been made in education about the climate crisis in some domains of healthcare, there is a need for greater involvement from radiology trainees.

3.1 Radiology Residency Programs to Establish Green Teams With Emphasis on Cross-Disciplinary Collaboration

At the trainee level, creating "green teams" can establish a foundation for advocating sustainable healthcare and fostering collaboration across disciplines. These student-led teams can serve as platforms for residents and medical students to plan and engage in initiatives, including and not limited to, sustainability workshops, energy conservation campaigns, planetary health awareness day, and community engagement.

3.2 Radiology Residency Programs and Medical Schools to Create Funded Opportunities for Student-Led Planetary Health Initiatives

Barriers to engagement of healthcare providers in low-carbon, low waste projects include lack of time and project funding.[34,35] Providing seconded time and project funding for students to engage with low carbon healthcare, such as grants and research fellowships, will support trainee-led learning.

Stakeholder Engagement

Radiology residency programs should encourage trainee engagement with stakeholders in low carbon, high quality healthcare. Through broad engagement, radiology leaders can demonstrate a commitment to reducing the carbon footprint of radiology while inspiring stakeholders to take action alongside clinical healthcare providers.

4.1 Radiology Residency Programs to Encourage Resident Engagement With Vendors

The supply chain (Scope 3) accounts for 60% to 80% of healthcare greenhouse gas emissions.[13] Encouraging limited trainee engagement with vendors of medical imaging equipment and supplies, where directly related to environmental sustainability and within university and post-graduate trainee guidelines, ensures vendors benefit from a variety of perspectives, and future radiologists have the opportunity to contribute to development of sustainable medical imaging technology.[20]

4.2 Radiology Residency Programs to Support Student-Led Sustainable Quality Improvement With Patient Stakeholders

Promoting trainee engagement with the public through patient education initiatives helps to spread awareness about the carbon footprint of radiology and efforts being made to reduce environmental impact of imaging services.[36] This outreach can provide valuable insight to the public about the various considerations made prior to ordering imaging, including how the environment may factor into this decision-making process. As with any successful environmental initiative, garnering public interest through outreach and education is essential.

4.3 Radiology Residency Programs to Include Indigenous Health Education

Respect for the knowledge and culture of Indigenous Peoples who have lived in harmony with nature since time immemorial is fundamental to addressing climate change.[37] The health of Indigenous populations is disproportionately impacted by the climate crisis.[37] The Government of Canada includes addressing anti-indigenous racism in healthcare as a national priority.[38] Incorporation of anti-racism components through each CanMEDS competency is proposed for CanMEDS 2025.[39] Engagement with Indigenous communities would allow trainees to learn about the specific challenges these communities face, including vulnerabilities due to systemic racism, social and environmental determinants of health.

4.4 Radiology Residency Programs to Encourage Engagement of Trainees in Global Health Equity Initiatives

Climate change inequitably impacts those who have contributed the least greenhouse gas emissions within and between countries, including those vulnerable due to social and environmental determinants of health.[39,40] Participation in the global radiology community in a two-way flow of information to learn from resourceful, safe practices in the global south and ensure a global supportive idea sharing community is developed is essential in ensuring fair and equitable access to care and global health.[41]

Conclusion

Radiologists are well positioned within the healthcare system to lead transformative change to low-carbon, high quality, climate resilient healthcare.[42,43] Providing trainees with sound understanding of the anthropogenic etiology of the climate crisis, the impacts on human health, the contribution providing healthcare makes to the climate crisis and the risks to stability of the healthcare system due to extreme weather events will equip future radiologists to lead mitigation and adaptation efforts. Academic radiology departments have a responsibility to provide leadership in environmentally sustainable radiology, including dedicated time and project funding, to enable incorporation of sustainability concepts throughout Diagnostic Radiology CanMEDS competencies.

Planetary Healthcare Education as a Component of Diagnostic Radiology CanMEDS Competencies.[8,42]

Diagnostic Radiology Royal College CanMEDS roles[42]	Planetary Healthcare education referenced to CanMEDS roles included in sections listed	Relevance to sustainable radiology
Medical Expert As Medical Experts, diagnostic radiologists integrate the CanMEDs roles, applying medical knowledge, clinical skills, and professional values in their provision of high-quality and safe patient-centred care. Medical Expert is the central physician role in the CanMEDS framework and defines the physician's clinical scope of practice.	1.1 Medical schools to integrate learning on Planetary Health (PH) throughout the curriculum.[11,22] 1.2 Residency training to integrate learning on planetary health into CanMEDS competencies.[8,10] 1.5 Develop a Certificate in Environmentally Sustainable Imaging to align with CanMEDS competencies.[8,23] 2.2 Residency programs to establish Sustainability lead for research and QI.[28-30] 2.4 Research days to include sustainability content.[28-30]	Environmental sustainability and responsible resource use is recognized as a domain of quality improvement, and essential to patient and public health.[30]
Communicator As Communicators, diagnostic radiologists form relationships with patients and their families that facilitate the gathering and sharing of essential information for effective healthcare	4.2 Engagement of patients as stakeholders in sustainable healthcare.[36] 4.3 Incorporation of Indigenous Health education throughout medical learning.[37-39] 4.4 Engagement of the Canadian radiology community in global health initiatives.[39-41]	Climate change will impact all patients and healthcare, however, will disproportionately impact individuals and communities vulnerable to adverse social and environmental determinants of health
Collaborator As Collaborators, diagnostic radiologists work effectively with other healthcare professionals to provide safe, high-quality, patient-centred care.	1.3 Residency program cross-institutional sharing of ideas.[27,28] 2.3 Creation of a national database of Sustainable QI projects in Radiology.[29,30] 3.1 Develop trainee led green teams to encourage interdisciplinary problem solving. 4.1 Residency programs to encourage trainee engagement with vendors in projects supporting sustainable technology.[20]	Interdisciplinary collaboration will support the role of diagnostic imaging in transformative low carbon, sustainable, climate resilient healthcare.

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Diagnostic Radiology Royal College CanMEDS roles[42]	Planetary Healthcare education referenced to CanMEDS roles included in sections listed	Relevance to sustainable radiology
Leader As Leaders, diagnostic radiologists engage with others to contribute to a high-quality healthcare system and take responsibility for the delivery of excellent patient care through their activities as clinicians, administrators, scholars, or teachers	1.6 Inclusion of Sustainability in CanMEDS competencies.[8,28] 2.2 Residency programs to establish Sustainability lead for research and QI.[28-30] 3.2 Residency programs to create funded opportunities for student led PH initiatives.	Commitment from radiology residency programs to support engagement of trainees in PH initiatives is required to remove barriers and embed sustainability as foundational to QI
Health Advocate As Health Advocates, diagnostic radiologists contribute their expertise and influence as they work with communities or patient populations to improve health. They work with those they serve to determine and understand needs, speak on behalf of others when required, and support the mobilization of resources to effect change.	1.2 Residency training to integrate learning on planetary health into CanMEDS competencies.[8,10] 4.2 Engagement of patients as stakeholders in sustainable healthcare.[36] 4.3 Incorporation of Indigenous health education throughout medical learning.[37-39] 4.4 Engagement of the Canadian radiology community in global health initiatives pertaining to imaging services.[40,41]	The importance of social and environmental determinants of health are recognized in creating inequity and vulnerability to climate change. Engaging vulnerable communities in solutions to their specific vulnerabilities is an important component of QI
Scholar As Scholars, diagnostic radiologists demonstrate a lifelong commitment to excellence in practice through continuous learning, and by teaching others, evaluating evidence and contributing to scholarship	1.2 Residency training to integrate learning on PH into CanMEDS roles.[8,10] 1.4 Local, provincial, and national radiology meetings to include sustainability content and virtual access. 2.1 Educational needs assessment performed by survey of trainees. 2.2 Residency programs to establish sustainability lead for research and QI.[28-30] 2.4 Research days to include sustainability content.[28-30] 2.5 Collaboration with artificial intelligence, machine learning, and deep learning researchers in radiology to analyze the environmental impacts of their innovations.[31-33]	Inclusion of PH content in all aspects of education, research, and QI is necessary to establish robust database to support low-carbon, high-quality, climate resilient radiology in Canada
Professional As Professionals, diagnostic radiologists are committed to the health and well-being of individual patients and society through ethical practice, high personal standards of behaviour, accountability to the profession and society, physician-led regulation, and maintenance of personal health.	1.2 Radiology residency programs to educate on planetary health and the environmental impact of radiology.[8,10] 1.6 Residency training to integrate learning on Planetary Health into CanMEDS competencies.[8,28] 1.7 Radiology residency programs to collaborate on design of a Canadian Radiology Fellowship in Sustainable imaging.	Environmentally sustainable radiology is complex and rapidly evolving. A commitment to lifelong learning about PH will enable rapid response and leadership as the climate crisis evolves.

Note. Table is inspired by Green et al. [8]

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: MJB: Co-Chair CAR Environmental Sustainability Working Group; Co-Chair BC Cancer Planetary Health Unit; Member, AUR Sustainability Committee; Member, Canadian Association of Physicians for the Environment. KH: Co-Chair CAR Environmental Sustainability Working Group; Chair, ISMRM Environmental Sustainability Working Group; Deputy Lead Sustainability Joint Department of Medical Imaging.

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