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Review Article

Canadian Association of Radiologists Statement on Environmental Sustainability in Medical Imaging

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Abstract

Immediate and strategic action is needed to improve environmental sustainability and reduce the detrimental effects of climate change. Climate change is already adversely affecting the health of Canadians related to worsening air pollution and wildfire smoke, increasing frequency and intensity of extreme weather events, and expansion of vector-borne and infectious illnesses. On one hand, radiology contributes to the climate crisis by generating greenhouse gas emissions and waste during the production, manufacture, transportation, and use of medical imaging equipment and supplies. On the other hand, radiology departments are also susceptible to equipment and infrastructure damage from flooding, extreme temperatures, and power failures, as well as workforce shortages due to injury and illness, potentially disrupting radiology services and increasing costs. The Canadian Association of Radiologists' (CAR) advocacy for environmentally sustainable radiology in Canada encompasses both minimizing the detrimental effects that delivery of radiology services has on the environment and optimizing the resilience of radiology departments to increasing health needs and changing patterns of disease on imaging related to climate change. This statement provides specific recommendations and pathways to help guide radiologists, medical imaging leadership teams, industry partners, governments, and other key stakeholders to transition to environmentally sustainable, net-zero, and climate-resilient radiology organizations. Specific consideration is given to unique aspects of medical imaging in Canada. Finally, environmentally sustainable radiology programs, policies, and achievements in Canada are highlighted.

Résumé

Une action stratégique immédiate est nécessaire en vue d'améliorer la durabilité de l'environnement et réduire les effets néfastes du changement climatique. Le changement climatique a déjà des effets néfastes sur la santé des Canadiens en raison de l'aggravation de la pollution atmosphérique et de la fumée des incendies de forêt, de l'augmentation de la fréquence et de l'intensité des phénomènes météorologiques extrêmes, ainsi que de la multiplication et de la propagation des maladies à transmission vectorielle et des maladies infectieuses. D'une part, la radiologie contribue à la crise climatique en générant des émissions de gaz à effet de serre et des déchets lors de la production, de la fabrication, du transport et de l'utilisation

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d'équipements et de fournitures d'imagerie médicale. D'autre part, les services de radiologie sont également exposés aux dommages causés aux équipements et aux infrastructures par les inondations, les températures extrêmes et les pannes de courant, ainsi qu'aux pénuries de main-d'œuvre dues aux blessures et aux maladies, ce qui risque de perturber les services de radiologie et d'augmenter les coûts. Le plaidoyer de l'Association canadienne des radiologistes (CAR) en faveur d'une radiologie durable sur le plan écologique au Canada englobe à la fois la réduction des effets néfastes de la prestation de services de radiologie sur l'environnement et l'optimisation de la capacité des services de radiologie à s'adapter à l'augmentation des besoins en matière de santé et à l'évolution des schémas pathologiques en matière d'imagerie liés au changement climatique. Le présent énoncé de position fournit des recommandations et des pistes précises visant à aider les radiologistes, les équipes de direction de services d'imagerie médicale, les partenaires du secteur, les gouvernements et d'autres parties prenantes majeures à assurer la transition vers des organisations de radiologie durables sur le plan environnemental, carboneutres et qui sauront faire face aux changements climatiques. Une attention particulière est accordée aux aspects uniques de l'imagerie médicale au Canada. Enfin, les programmes, les politiques et les réalisations du Canada en matière de radiologie respectueuse de l'environnement sont mis en évidence.

Keywords
climate change, environmental sustainability, diagnostic radiology, medical imaging, greenhouse gas emissions

Background and Rationale

Immediate and strategic action is needed across sectors to improve environmental sustainability and reduce the detrimental effects of climate change. The predominant driver of climate change is human activities related to burning fossil fuels, which increase atmospheric greenhouse gas (GHG) levels, leading to rising global temperatures and disruption of climate and weather systems. A 2018 life cycle analysis estimated that Canada's healthcare system was responsible for 33 million tons of carbon dioxide equivalents (CO_2e) annually, accounting for 4.6% of the national total of GHG emissions.[1]

Radiology contributes to the climate crisis by generating GHG emissions and waste during the production, manufacture, transportation, and use of medical imaging equipment and supplies.[2-4] A cross-sectional analysis of a single large Canadian hospital-based radiology department demonstrated substantial GHG emissions of 3235 tons CO_2e annually, equivalent to the energy consumed by 422 single-family homes.[5] Mitigation strategies to reduce GHG emissions and achieve net-zero, environmentally sustainable radiology departments are needed. At the same time, radiology departments must also build resiliency to current and future impacts of the climate crisis.[6]

Climate change is already adversely affecting the health of Canadians related to worsening air pollution and wildfire smoke, increasing frequency and intensity of extreme weather events, and expansion of vector-borne and infectious illnesses.[7] These health effects result in higher health needs and healthcare utilization among the patients and populations served by medical imaging departments in Canada. Climate change affects everyone; however, vulnerable and disadvantaged individuals and groups are disproportionately affected due to health inequities.[8] Radiology departments are also susceptible to equipment and infrastructure damage from flooding, extreme temperatures, and power failures, as well as workforce shortages due to injury and illness, potentially disrupting radiology services and increasing costs.[9]

The Canadian Association of Radiologists' (CAR) advocacy for environmentally sustainable radiology in Canada encompasses both minimizing the detrimental effects that delivery of radiology services has on the environment and optimizing the resilience of radiology departments to increasing health needs and changing patterns of disease on imaging related to climate change (Figure 1). An overarching inclusive and integrated approach is needed to support environmentally sustainable radiology in Canada, inclusive of diverse perspectives and mindful of the linkages between social and environmental determinants of health.

This document was inspired by and modelled after the Canadian Medical Association's policy on Environmentally Sustainable Health Systems in Canada.[10] The CAR environmental sustainability statement provides specific recommendations and pathways to help guide radiologists, medical imaging leadership teams, industry partners, governments, and other key stakeholders to transition to environmentally sustainable, net-zero, and climate-resilient radiology organizations. Specific consideration is given to unique aspects of medical imaging in Canada including the public payor system administered in each province and the vast geography with implications related to equitable access to medical imaging in rural and remote communities.

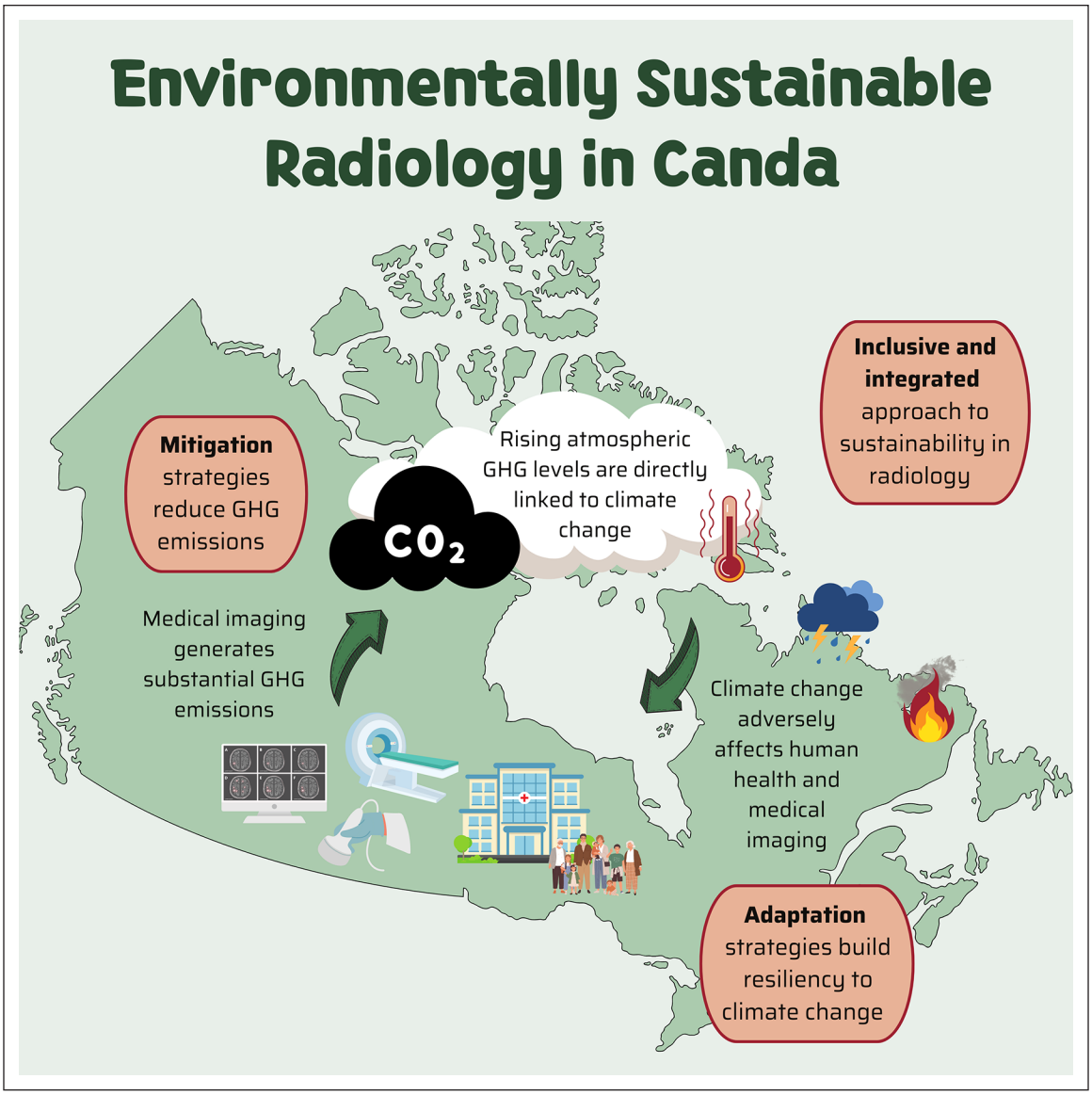


Figure 1. Interconnected relationship between radiology, climate change, and environmental sustainability in Canada. Mitigation strategies reduce greenhouse gas (GHG) emissions. Adaptation strategies build resiliency to current and future impacts of the climate crisis. An inclusive and integrated approach is needed to support environmentally sustainable radiology, inclusive of diverse perspectives and mindful of the linkages between social and environmental determinants of health.

Environmentally sustainable radiology programs, policies, and achievements in Canada are highlighted including energy and cost-savings associated with powering down CT units when not in use in Vancouver (Figure 2),[11] unnecessary repeat imaging avoided with implementation of a provincial-wide clinical information and picture archiving and communication system in Alberta and other provinces (Figure 3),[12] implementation and evaluation of remotely controlled, robotic ultrasound in remote northern communities in Saskatchewan (Figure 4),[13] GHG emission and cost savings associated with implementation of portable low-field MRI in a remote Ontario community (Figure 5),[14] and energy and GHG emission savings associated with implementation of abbreviated MRI protocols in Toronto (Figure 6).[15] However, further action is needed to achieve sustainable and climate-resilient radiology departments in Canada and to ensure a healthy and sustainable future for current and future generations.

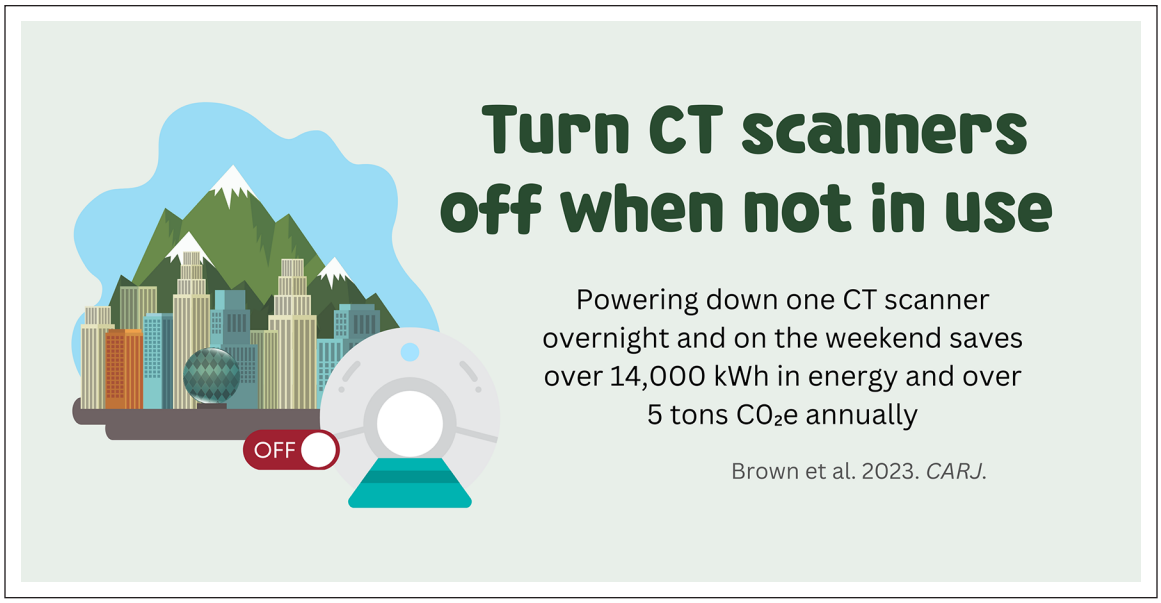


Figure 2. Energy and cost-savings associated with powering down CT units when not in use.[11]

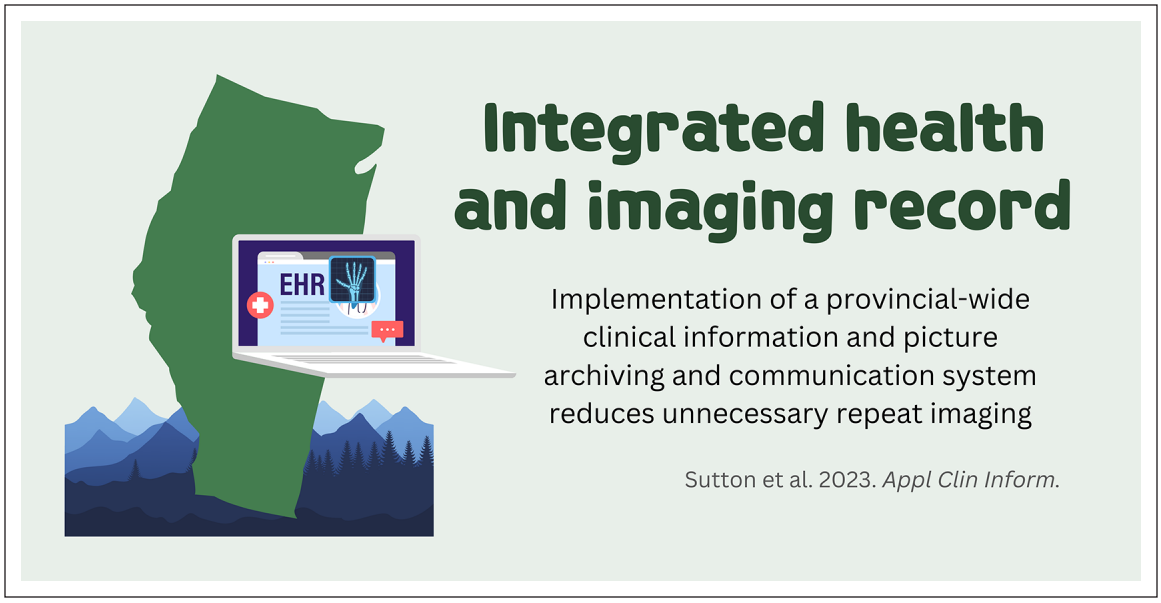


Figure 3. Integrated provincial-wide clinical information and picture archiving and communication system can reduce the need for repeat imaging and associated greenhouse gas emissions.[12]

Recommendations

The CAR board has endorsed multiple recommendations and actions regarding radiology environmental sustainability in Canada. To ensure an inclusive and integrated approach to building sustainable radiology departments, the CAR calls for an inclusive and integrated approach to sustainable radiology (Table 1). To achieve climate-resilient radiology departments, the CAR calls for medical imaging climate adaptation, resilience, and emergency preparedness (Table 2). To achieve net-zero, environmentally sustainable radiology departments, the

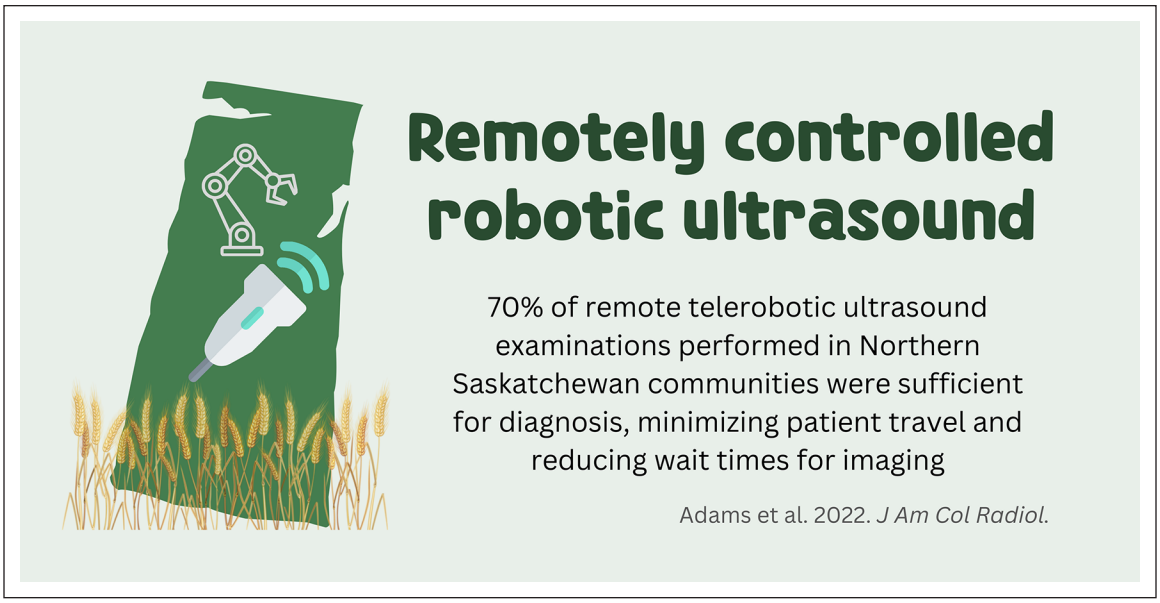


Figure 4. Remotely controlled robotic ultrasound can potentially reduce patient travel and greenhouse gas emissions while improving access to medical imaging.[13]

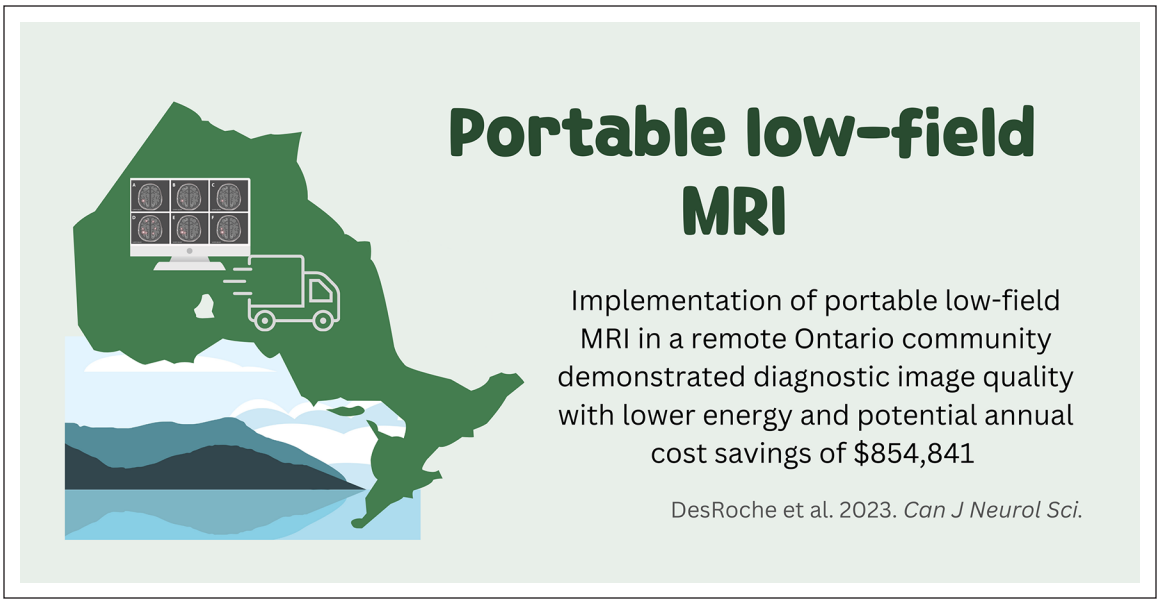


Figure 5. Portable low-field MRI can potentially avoid greenhouse gas emissions associated with patient and radiologist travel and reduce cost.[14]

CAR calls for energy and greenhouse gas emission targets, environmentally sustainable medical imaging equipment, environmentally sustainable medical imaging policies and procedures, environmentally sustainable purchasing in medical imaging, waste reduction in medical imaging, sustainable transportation in medical imaging, reduction of low-value and unnecessary medical imaging, sustainable resources and environmental contamination, and environmentally sustainable development and use of technology in radiology (Table 3).

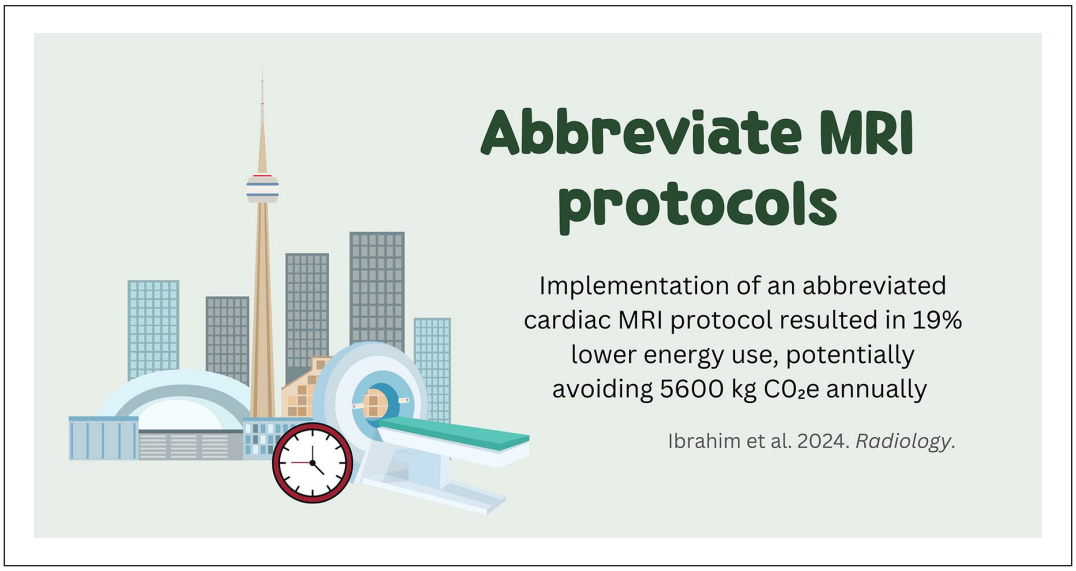


Figure 6. Implementation of an abbreviated cardiac MRI protocol reduces time, energy use, and greenhouse gas emissions.[15]

Table 1. Actions to Ensure an Inclusive and Integrated Approach to Building Sustainable Radiology Departments.

Type of action	Calls to action
An inclusive and integrated approach to sustainable radiology *Refers to the lens we must apply when building sustainable radiology departments, inclusive of diverse perspectives and mindful of the linkages between social and environmental determinants of health*	• Governments to coordinate investments in health promotion, disease prevention, and early detection, including implementing and supporting imaging-based screening programs for breast cancer, coronary artery calcium, and CT colonography[6] • Residency and fellowship training programs to incorporate training that addresses the symptoms and causes of climate-related health threats, as well as the health equity impacts on those who are disproportionately affected by climate change[16]

Table 2. Actions to Achieve Climate-Resilient Radiology Departments.

Type of action	Calls to action
Medical imaging climate adaptation, resilience, and emergency preparedness *Refers to minimizing radiology departments' vulnerability to climate-related impacts and climate-related emergencies by strengthening capacity and resiliency in the human and built environment*	• Radiology departments to develop disaster management protocols to prepare for extreme weather events including potential work-force shortages and surges in imaging volumes[6] • Residency and fellowship training programs to incorporate climate adaptation into the curriculum to ensure future radiologists are prepared to appropriately diagnose climate-related illnesses[17,18] • Professional societies and journals to provide education for practicing radiologists on climate change and changing disease patterns including expansion of vector borne illnesses and increased cardiovascular complications that may be identified on medical imaging[2,19] • Hospitals and medical imaging departments to upgrade infrastructure to minimize damage to imaging departments and equipment in the event of flooding, storms, extreme temperatures, and power outages[6,20] • Hospitals and medical imaging departments to ensure that information technology systems and data storage have redundancy and back-up power sources[6]

Table 3. Actions to Achieve Net-Zero, Environmentally Sustainable Radiology Departments.

Type of action	Calls to action
Energy and greenhouse gas emission targets *Refers to setting and developing a plan to achieve specific energy-use and GHG emission targets in radiology departments*	• Government, regulators, and professional societies to develop sustainability related metrics and provide targets to reduce emissions for each imaging modality[21] • Vendors and industry partners to adhere to sustainability guidelines for reporting and GHG emissions reduction targets[22,23] • Hospital and medical imaging administrators to develop organizational and departmental sustainability plans, define key performance indicators, set emissions reduction targets, and take actions to make their organizations more sustainable[6] • Radiologists, technologists, and leadership teams to advocate for net-zero targets[24]
Environmentally sustainable medical imaging equipment *Refers to the reduction of energy intensity, associated GHG emissions and environmental impact of medical imaging equipment*	• Governments and regulators to define and mandate environmental performance and resilience standards for new and refurbished medical imaging equipment[25] • Vendors and industry partners to develop medical imaging equipment with lower energy requirements and automated low power modes in idle and off states[6] • Radiology departments to consider low-field MRI and other emerging medical imaging technology with lower energy and associated GHG emissions when appropriate[20] • Funding organizations and professional societies to incentivize and fund development and implementation of medical imaging equipment with lower energy and GHG emissions[2]
Environmentally sustainable medical imaging policies and procedures *Refers to development of policies and procedures to reduce use-phase GHG emissions in radiology departments*	• Radiology departments to implement policies to reduce wasted energy including protocols to turn equipment off overnight and on the weekend when not in use[26] • Radiology and hospital information technology teams to evaluate software to automatically power down computer workstations and other electronics when not in use in non-operational hours including overnight and weekends[27] • Radiology departments and leadership teams to optimize scheduling of imaging to reduce idle time between examinations and increase overall utilization per imaging unit[28] • Radiologists to abbreviate imaging protocols to reduce use-phase emissions per imaging examination[15] • Radiology administrators to reduce energy use through changing energy use practices and investing in equipment such as motion sensor lighting and climate control systems[29] • Radiology departments to optimize data storage and define policies for data retention and storage[30]
Environmentally sustainable purchasing in medical imaging *Refers to reduction of upstream and downstream adverse environmental impacts of purchasing and procurement of in radiology infrastructure, equipment, and supplies*	• Radiology departments and procurement teams to develop and implement sustainable procurement goals and strategies that increase the proportion of sustainable purchase orders and contracts[31] • Radiology departments and procurement teams to set targets to switch to reusable supplies from disposable supplies where feasible, to align with circular economy principles[2] • Radiology departments and leadership team to include environmental sustainability in procurement evaluation criteria and requests for proposals (Scope 3)[2] • Radiology leadership to engage hospital administration teams to invest in clean energy infrastructure rather than fossil fuel boilers (Scope 1) and advocate for purchase of electricity created by renewables rather than fossil fuels (Scope 2)[32]

(continued)

Table 3. (continued)

Type of action	Calls to action
Waste reduction in medical imaging *Refers to reduction or sustainable management of medical and non-medical waste in radiology*	• Radiology departments to collaborate with suppliers and health care providers to reduce waste by transitioning from single-use disposable products to reusable products, redesigning common interventional radiology procedure kits and improving disposal, reprocessing, and recycling methods for imaging products and supplies[33] • Vendor partners and radiology departments to collaborate on development and implementation of programs for recycling unused contrast material including iodinated contrast and gadolinium-based contrast[34] • Radiology departments and hospitals to ensure that infrastructure is in place for recycling and composting of non-medical waste[35]
Sustainable transportation in medical imaging *Refers to reduction of air pollution and GHG emissions of transportation associated with medical imaging including patients and the workforce*	• Governments to collaborate with health authorities to reduce patient travel and improve health equity by providing local access to imaging services when feasible, particularly in northern, remote, rural, and Indigenous communities[13,36] • Radiology departments to coordinate imaging with other healthcare appointments to minimize patient travel for multiple visits[37] • Government, health systems, and radiology departments to promote, provide infrastructure for, and incentivize active and low-carbon transportation for patients, caregivers, and radiology team members[38] • Governments to collaborate with health authorities to reduce regulatory barriers to remote radiologist interpretation of imaging studies, when appropriate • Relevant radiologists and departments to implement remote reporting when feasible, to reduce pollution and emissions related to radiologist transportation[39] • Governments to finance zero-emission vehicle replacements for healthcare fleets, including vehicles used in the delivery of mobile imaging infrastructure to remote communities
Reduction of low-value and unnecessary medical imaging *Refers to reducing the adverse environmental impact of medical imaging services via resource stewardship while ensuring capacity to meet current and future medical imaging needs*	• Professional radiology societies, in collaboration with medical specialty societies and associations, to develop guidelines to Image Wisely and reduce unnecessary and excessive medical imaging[40] • Governments to collaborate with health authorities to reduce unnecessary repeat imaging by developing information technology solutions to facilitate access to prior medical imaging examinations from outside centers[12] • Governments to collaborate with health authorities to reduce unnecessary repeat imaging by providing incentives and reimbursement for radiologist second opinion interpretations of prior relevant imaging • Radiologists and referring clinicians to adhere to appropriate use guidelines for initial and repeat imaging including follow-up of incidental findings[41] • Radiology departments and hospital information technology to automate clinical decision support tools in electronic health records to reduce unnecessary low-value imaging and align with appropriate use guidelines while ensuring capacity to meet current and future medical imaging needs[42] • Medical, residency, and fellowship training programs to incorporate education on low-value imaging and appropriate use criteria

(continued)

Table 3. (continued)

Type of action	Calls to action
Sustainable resources and environmental contamination *Refers to reducing the reliance on finite resources and reduction of GHG emissions and environmental contamination related to radiology equipment and supplies*	• Governments to anticipate challenges to medical device, helium, contrast media, and other supply chains as a result of national and international climate disruption, and to ensure institutional purchasing is coordinated with decarbonization efforts to increase use of reusable items where appropriate, recycle and reuse supplies when feasible, maximize value through bulk purchasing when feasible[43] • Radiologists and radiology departments to reduce waste and environmental waterbody contamination of CT and MRI contrast media by switching from single use to multi-patient dose contrast delivery systems[44] • Radiologists and radiology departments to reduce unnecessary utilization of CT and MRI contrast media through implementation of low- or no-contrast protocols and virtual contrast enhanced imaging when appropriate[23] • Radiologists and radiology departments to implement policies to guide appropriate use of ultrasound-enhancing agents and provide education on their direct environmental impact as fluorinated gases with high global warming potentials[45] • Radiologists and radiology departments to implement policies to reduce the environmental impact of administered radiopharmaceuticals and minimize radioactive waste in nuclear medical imaging[46] • Vendors, radiologists, and procurement teams to develop and prioritize low- or no-helium MRI systems and processes to recycle and recapture helium used for cooling[20] • Radiology departments to promote sustainable anaesthetic practices such as eliminating desflurane use and installing anaesthetic gas capture and reuse systems when anaesthesia is required in medical imaging[47]
Environmentally sustainable development and use of technology in radiology *Refers to innovation, development, and implementation of environmentally sustainable medical imaging technology including mobile and robotic imaging*	• Radiology departments, industry, and health authorities to collaborate on the implementation and evaluation of mobile imaging solutions to reduce patient travel and increase imaging access to imaging in rural and remote communities, such as robotic ultrasound and mobile MRI[14,48] • Radiology departments to evaluate potential trade-offs with mobile imaging with respect to reduced emissions related to patient travel but potentially higher emissions related to operation and transport of mobile imaging equipment and teams[13] • Governments, health authorities, and radiology departments to develop standards for remote scanning by technologists to reduce the need for patient and technologist travel to and from remote areas, including capacity for real time remote supervision by radiologists when appropriate • Vendors, radiologists, and scientists to collaborate on development, evaluation, and implementation of artificial intelligence (AI)-tools to improve sustainability in radiology and evaluate trade-offs with respect to the energy and GHG emissions required to develop AI models[23]

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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: KH: Co-Chair CAR Environmental Sustainability Working Group; Deputy Lead Sustainability, JDMI; Chair, ISMRM Environmental Sustainability Working Group; Member, RSNA Sustainability Task Force; Member, AUR Sustainability Committee; Associate Editor, Canadian Association of Radiologists Journal. AH: Regional Department Head, Medical Imaging VCH and PHC; Vice-President, Canadian Association of Radiologists.

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.

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