MODERN RADIOLOGY eBook

Sustainable Imaging

EUROPEAN SOCIETY OF RADIOLOGY

Preface

Modern Radiology is a free educational resource for radiology published online by the European Society of Radiology (ESR). The title of this second, rebranded version reflects the novel didactic concept of the *ESR eBook* with its unique blend of text, images, and schematics in the form of succinct pages, supplemented by clinical imaging cases, Q&A sections and hyperlinks allowing to switch quickly between the different sections of organ-based and more technical chapters, summaries and references.

Its chapters are based on the contributions of over 100 recognised European experts, referring to both general technical and organ-based clinical imaging topics. The new graphical look showing Asklepios with fashionable glasses, symbolises the combination of classical medical teaching with contemporary style education.

Although the initial version of the *ESR eBook* was created to provide basic knowledge for medical students and teachers of undergraduate courses, it has gradually expanded its scope to include more advanced knowledge for readers who wish to 'dig deeper'. As a result, *Modern Radiology* covers also topics of the postgraduate levels of the *European Training Curriculum for Radiology*, thus addressing postgraduate educational needs of residents. In addition, it reflects feedback from medical professionals worldwide who wish to update their knowledge in specific areas of medical imaging and who have already appreciated the depth and clarity of the *ESR eBook* across the basic and more advanced educational levels.

I would like to express my heartfelt thanks to all authors who contributed their time and expertise to this voluntary, non-profit endeavour as well as Carlo Catalano, Andrea Laghi and András Palkó, who had the initial idea to create an *ESR eBook*, and - finally - to the ESR Office for their technical and administrative support.

Modern Radiology embodies a collaborative spirit and unwavering commitment to this fascinating medical discipline which is indispensable for modern patient care. I hope that this *educational* tool may encourage curiosity and critical thinking, contributing to the appreciation of the art and science of radiology across Europe and beyond.

Minerva Becker, Editor
Professor of Radiology, University of Geneva, Switzerland

Sustainable Imaging

CHAPTER OUTLINE:

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CHAPTER OUTLINE:

MODERN RADIOLOGY eBook

Based on the ESR Curriculum for Radiological Education

Sustainable Imaging

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/ Introduction

CHAPTER OUTLINE:

/ Introduction

The Climate Emergency is one of the largest threats to human health and wellbeing, a global health crisis of greater severity than the Covid-19 pandemic.

Healthcare in general, and medical imaging in particular, is an energy intensive activity with a substantial environmental impact. In recent years it has become increasingly clear than this environmental impact can lead to loss of human lives and livelihoods.

This chapter will examine the carbon cost of imaging together with additional associated environmental pollutants, looking at several specific imaging modalities, consumables and other related energy use such as transport.

We will consider modifications to current practice which can help reduce the impact of imaging but will also contemplate broader questions related to how healthcare is delivered. Is the current model of energy intensive downstream treatment one that can continue when some diseases are potentially preventable?

Although focusing on imaging, the content and themes of this chapter are applicable to most other areas of medicine. As healthcare providers we have an ethical responsibility to ensure that the care we deliver is not only safe and appropriate for the patient in front of us, but also sustainable and justifiable.

/ Background

CHAPTER OUTLINE:

/ Background

The Climate Emergency is one of the largest threats to human health and wellbeing.

Climate change is directly contributing to humanitarian emergencies from heatwaves, wildfires, floods, tropical storms and hurricanes and they are increasing in scale, frequency and intensity.

37% of heat-related deaths are attributed to human-induced climate change. Heat-related deaths among those over 65 have risen by 70% in two decades. In 2020, 98 million more experienced food insecurity compared to the 1981–2010 average. The WHO conservatively projects 250 000 additional yearly deaths by the 2030s due to climate change impacts on diseases like malaria, undernutrition, diarrhoea and coastal flooding. [ref 1]

In 2017, the World Bank, in collaboration with Health Care Without Harm, published an estimated calculation which found that the health care sector generated 2.6 billion out of the 52 billion metric tons of CO2 globally emitted in 2011 — or 5% of global C02 emissions.[ref 2]

The health sectors of the United States, Australia, England, and Canada emit a combined 748 million metric tons of carbon dioxide annually. If the health sectors of these countries were a single independent nation, they would rank seventh in the world for greenhouse gas emissions. [ref 3]

While healthcare can undoubtedly deliver great benefits, it is increasingly clear that the environmental impact of healthcare-related emissions is also contributary to loss of human lives and livelihoods. Healthcare professionals and the public alike are ever more aware of the need to address sustainability in all healthcare activities and decisions.

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Ref 1: https://www.who.int/health-topics/climate-change#tab=tab_1
Ref 2:: Climate-Smart Healthcare: Low-carbon and Resilience Strategies for the Health Sector. World Bank 2017
Ref 3: Sustainability in Health Care. Howard Hu, Gary Cohen, Bhavna Sharma, Hao Yin, Rob McConnell. Annual Review of Environment and Resources 2022 47:1, 173-196. https://www.annualreviews.org/content/journals/10.1146/annurev-environ-112320-095157

CHAPTER OUTLINE:

The Climate Crisis is a Health Crisis.

The diagram on the right demonstrates how the multifactorial impacts of global heating can combine to impact health:

Impact of climate change on human health

(Source: U.S. Centers for Disease Control and Prevention)

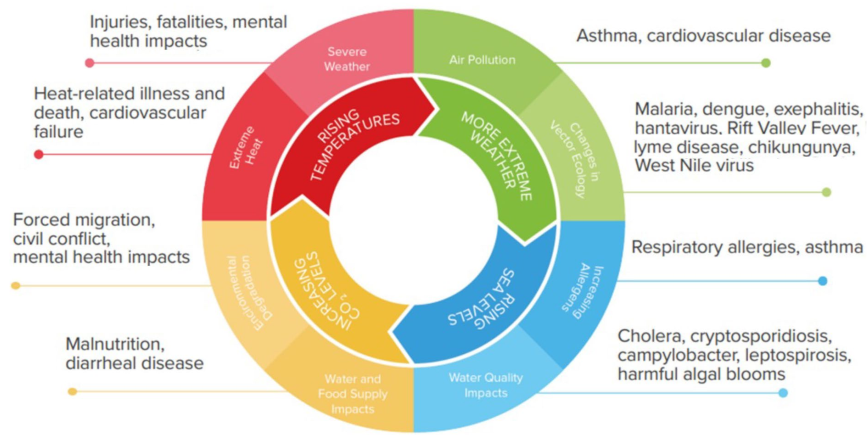

Diagram from: Duindam, D. Transitioning to Sustainable Healthcare: Decarbonising Healthcare Clinics, a Literature Review. Challenges 2022, 13, 68.

https://doi.org/10.3390/challe13020068

Within healthcare, medical imaging represents a significant proportion of carbon-based emissions, and also produces additional environmental pollution.

Estimates vary, but imaging is thought to account for approximately 10% of health-care related emissions [ref 1], which would equate to around 0.5% of global emissions.

In 2016, CO2 emissions from magnetic resonance imaging and computed tomography, calculated in 120 countries, accounted for 0.77% of total global emissions [ref 1].

Another estimate puts this proportion higher still at 1% [ref 2].

Whilst there is some variation amongst these figures, it is clear that medical imaging makes a significant contribution to greenhouse gas emissions. Recent research estimates that fossil fuel emissions causes 8.34 million premature deaths related to air pollution per year [ref 3]. Using the lower estimate of 0.5%, medical imaging would be responsible for 41,700 premature deaths every year on this basis or using the higher estimate of 1% some 83,400 deaths per annum.

Although some countries which have a high imaging-related energy use will utilise sustainably generated electricity, when we remember that these estimated air pollution related premature deaths do not factor in the additional premature deaths WHO anticipates as the result of global heating, the figures remain highly concerning.

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Ref 3 Lelieveld J, Haines A, Burnett R, Tonne C, KlingmÃ¼ller K, MÃ¼nzel T et al. Air pollution deaths attributable to fossil fuels: observational and modelling study BMJ 2023; 383 :e077784 doi:10.1136/bmj-2023-077784

Four Principles of Sustainable Health Care

CHAPTER OUTLINE:

/ Four Principles of Sustainable Healthcare

Within healthcare, medical imaging represents a significant proportion of carbon-based emissions, and also produces additional environmental pollution. In considering how to deliver less harmful imaging services it is useful to recall the four principles of sustainable healthcare [Mortimer F, 2010]:

1. **Prevention**

/ Promoting health and preventing disease by tackling the causes of illnesses and inequalities.

2. **Patient Self-Care**

/ Empowering patients to take a greater role in managing their own health and healthcare.

3. **Lean Service**

/ Streamlining care systems to minimise wasteful activities.

4. **Low Carbon**

/ Prioritising treatments and technologies with a lower environmental impact.

<∞> REFERENCE

Mortimer F. The sustainable physician. Clin Med (Lond). 2010 Apr;10(2):110-1. doi: 10.7861/clinmedicine.10-2-110. PMID: 20437974; PMCID: PMC4952075

Imaging Modalities

/ Imaging Modalities

Medical Imaging or radiology utilises several different examination techniques or modalities, covered in detail elsewhere in the eBook for Undergraduate Education in Radiology.

Each modality has particular advantages and disadvantages in relation to demonstrating different body regions and pathologies, but there is also variation in the carbon footprint of each modality.

While radiology departments endeavour to use resources judiciously regardless of sustainability issues, examination of the relative carbon cost of different imaging techniques may be helpful in planning imaging departments of the future, and working out how imaging can best serve patients more broadly.

CHAPTER OUTLINE:

/ Ultrasound

The use of sulphur hexafluoride microbubbles as contrast agent for ultrasound examinations increases the environmental impact (see Consumables: Ultrasound Microbubbles).

Ultrasound does have some technical limitations, with visibility of the chest and abdomen partly limited by the ribs and bowel gas respectively and is known to be operator dependent, meaning reliability of findings is more variable compared to CT or MRI. However, image quality continues to improve with developing technology and in view of the relatively low carbon footprint ultrasound may become increasingly useful in settings where cross-sectional imaging resources are limited.

<!> ATTENTION

In most situations ultrasound has the lowest greenhouse gas emissions, particularly compared to cross-sectional imaging. An abdominal ultrasound is estimated to produce 0.5 Kg CO_2e, compared to 9.2 kg for an abdominal CT scan and 17.5kg for and abdominal MRI.

/ Computed Tomography (CT)

While an abdominal scan is estimated to produce 9.2 Kg CO_2e, whole body scans or multi-phase acquisitions can result in some examinations exceeding 30Kg CO_2e.

Schöckel L et al {2020] estimated 350million CT examinations are performed globally each year. Assuming a CO_2e of 9.2Kg per examination, CT scans would contribute some 3.2 million tonnes of CO_2 globally each year.

<∞> REFERENCE

Schöckel L, Jost G, Seidensticker P, Lengsfeld P, Palkowitsch P, Pietsch H. Developments in X-Ray Contrast Media and the Potential Impact on Computed Tomography. Invest Radiol. 2020 Sep;55(9):592-597. doi: 10.1097/RLI.0000000000000696. PMID: 32701620

CHAPTER OUTLINE:

/ Magnetic Resonance Imaging (MRI)

MRI requires a very strong magnetic field to operate (most clinical scanners using field strength of 1.5 or 3 Tesla) > **see eBook chapter on MRI.**

The carbon cost of installing and maintaining superconducting magnets is substantial (see also MRI: Helium).

MRI often delivers information that is not readily provided by other imaging modalities, but this high energy consumption is prompting radiology departments to examine how to perform examinations in a more sustainable fashion.

For example, implementation of power-save mode for 12 hours overnight instead of off mode on all outpatient MRI units in the United States could save U.S. health care 58 863.2–76 288.2 MW-hours, $8.2–$10.7 million, and 41 606.4–54 088.3 metric tons of CO_2e [Wollen SA et al 2023].

<!> ATTENTION

An estimate of carbon footprint suggests an abdominal MRI scan produces 17.5Kg CO_2e, approximately double that of an abdominal CT scan and some 35 times the carbon cost of an abdominal ultrasound scan. [McAlister S, et al 2022]

/ Nuclear Medicine

Energy costs related to nuclear medicine imaging techniques including gamma cameras, SPECT and PET scanners are also likely to be substantial, although relatively little published literature exists currently.

REFERENCE

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Woolen SA, Becker AE, Martin AJ, Knoerl R, Lam V, Folsom J, Eusemann C, Hess CP, Deshpande V. Ecodesign and Operational Strategies to Reduce the Carbon Footprint of MRI for Energy Cost Savings. Radiology. 2023 May;307(4):e230441. doi: 10.1148/radiol.230441. Epub 2023 Apr 25. Erratum in: Radiology. 2023 Jul;308(1):e239020. PMID: 37097133

Additional Energy Costs

Transport

In the UK, patient and staff transport is thought to account for approximately 10% of the National Health Service (NHS) carbon footprint.

In England alone there are over 9.5bn NHS related road miles per year, accounting for around 3.5% of all road travel.[ref 1]

While transport logistics are largely beyond the control of radiology departments, there is scope to modify working practice to reduce unnecessary travel:

- "hub and spoke" service delivery where subspecialist radiologists attend district general hospitals to deliver examination lists closer to the local community, reducing travel to the tertiary centre
- Portable CT scanners and mammography units located at convenient sites within the community
- Modify working practice to utilise teleradiology or off-site systems to reduce unnecessary staff commuting

Image created by M. Jackson using Image Creator via Copilot App

REFERENCE

Ref 1: The NHS: Carbon Footprint
Faculty of Public Health Special Interest Group document 2020
https://www.fph.org.uk/media/3126/k9-fph-sig-nhs-carbon-footprint-final.pdf

Educational meetings have traditionally been in-person events and most people find such events more engaging and stimulating than on-line learning, particularly for events that last a few hours or even days. The social opportunities that such events provide between formal sessions are also known to be vital in forging professional relationships and friendships that often lead to productive collaborations and innovative new practice.

However, the carbon cost of national and particularly international conferences and meetings is substantial, requiring scrutiny in the context of the climate emergency.

Yakar and Kwee calculated the carbon footprint of the RSNA 2017 annual meeting (the largest radiology conference hosted in Chicago every year). Airplane travel from 24,000 attendees (around half from USA, half from other countries) equated to 40,000 tonnes of CO2e. When good quality electronic learning resources are available can we justify intercontinental travel for the purposes of Continuing Professional Development (CPD)?

<∞> REFERENCE

Yakar D, Kwee TC. Carbon footprint of air travel to international radiology conferences: FOMO? Eur Radiol. 2020 Nov;30(11):6293-6294. doi: 10.1007/s00330-020-06988-2. Epub 2020 Jun 10. PMID: 32518990; PMCID: PMC7283036

CHAPTER OUTLINE:

/ Artificial Intelligence

It is hoped that AI algorithms and machine learning will offer improved diagnostic accuracy and efficiency in relation to medical imaging going forwards. Advanced computing may offer new solutions which ultimately lead to a reduction in energy cost and greenhouse gas emissions. However, for the time being artificial intelligence is a high energy undertaking.

Recent research suggests that NVIDIA, a market leader in AI computing, will see its servers consume more than 85.4 terawatt-hours annually by 2027, exceeding the energy usage of countries such as Sweden and Argentina [de Vries, 2023]. In 2020, information-and-communication-technology infrastructure and devices consumed around 5 % of global electricity use [UK Parliament 2022]. In 2022, Google reported that machine learning had accounted for 15 per cent of its energy usage over the previous three years [Patterson, 2022].

<∞> REFERENCES

de Vries, The growing energy footprint of artificial intelligence, Joule (2023), https://doi.org/10.1016/ j.joule.2023.09.004

Energy consumption of ICT. UK Parliament Research Briefing (2022) POSTNOTE Number 677, September 2022

David Patterson Google Research February 15 ,2022 Good News About the Carbon Footprint of Machine Learning Training (research.google)

Image created by M. Jackson using Image Creator via Copilot App

<!> ATTENTION

Energy costs related to AI are predicted to decrease as technology improves, but at present the use of AI algorithms in imaging analysis adds yet more carbon footprint to an already energy-hungry endeavour.

/ Consumables

CHAPTER OUTLINE:

Personal Protective Equipment (PPE)

Vast quantities of single use personal protective equipment were utilised during the Covid-19 pandemic, prompting questions about the environmental impact of items such as disposable face masks, gloves and aprons.[refs 1,2] The World Health Organization estimated that some 89 million medical masks, 76 million examination gloves, and 1.6 million pairs of goggles were required worldwide in each month of the pandemic [ref 3].

While the use of such items has reduced post-pandemic, and the imaging department typically uses less PPE compared to other specialties, the collective impact on a global basis remains concerning.

Infection control measures are vital to protect both patients and staff but must be judicious and follow evidence-based practice to reduce unnecessary waste.

Image created by M. Jackson using Image Creator via Copilot App

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Ref 1: Rizan C, Reed M, Bhutta MF. Environmental impact of personal protective equipment distributed for use by health and social care services in England in the first six months of the COVID-19 pandemic. J R Soc Med. 2021 May;114(5):250-263. doi: 10.1177/01410768211001583. Epub 2021 Mar 16. PMID: 33726611; PMCID: PMC8150566

Ref. 2: Bennett R, Maraka J. Healthcare should not cost us the Earth BMJ 2020; 371 :m4289 doi:10.1136/bmj.m4289

Ref 3: WHO News Release, 3 March 2020 https://www.who.int/news/item/03-03-2020-shortage-of-personal-protective-equipment-endangering-health-workers-worldwide

/ Contrast Agents

Iodinated contrast media (ICM) are used in a number of x-ray based imaging techniques, but most commonly in the setting of CT.

Millions of litres of ICM are used globally each year, with a recent estimate of over 10 million litres per annum [ref 1].

Following IV use, these agents are excreted in urine and enter the water supply system. Iodinated contrast media have been found in sewage water, surface water and drinking water at multiple sites across the world. A study conducted at the river Rhine (crossing the border between Germany and the Netherlands) calculated some 71 tonnes of ICM flowed from Germany into the Netherlands in 2020.

Whilst the ICM themselves are considered safe, they can react with commonly used disinfectants, such as chlorine in the presence of organic matter and the resulting breakdown products are more toxic than standard disinfection products [ref. 2]. Existing treatment technologies are not yet capable of removing ICM and their transformation products from wastewater.

Image created by M. Jackson using Image Creator via Copilot App

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Ref. 1: Dekker HM, Stroomberg GJ, Prokop M. Tackling the increasing contamination of the water supply by iodinated contrast media. Insights Imaging. 2022 Feb 24;13(1):30. doi: 10.1186/s13244-022-01175-x. PMID: 35201493; PMCID: PMC8873335

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/ Sustainable Imaging

CHAPTER OUTLINE:

/ Iodinated Contrast Agents

<!> ATTENTION

Strategies to address ICM entering the water supply include:

- Specific processing of hospital wastewater prior to discharge into the sewage system.
- Collection of urine in disposable bags for outpatient scans.
- Eliminate use of contrast when not required.
- Collect and recycle opened contrast that has not been administered.
- Rationalise the volumes of contrast bottles utilised during a radiology examination list to reduce waste.

Reducing unnecessary use and wastage of ICM is also beneficial in reducing non-water-related environmental impact as substantial energy costs etc are incurred in the manufacture of these agents.

CHAPTER OUTLINE:

/ Gadolinium-based Contrast Agents

Gadolinium is a heavy metal used as an intravenous contrast agent in MRI examinations. Some types of tumours and infective processes are only readily visualised by administering gadolinium-based contrast agents (GBCAs). However, there is growing concern over gadolinium entering the water supply. World consumption of gadolinium oxide is estimated at approximately 1000 tons per year, with no effective means of removal or recycling at present. GBCAs are almost completely excreted in the urine within 30hrs of injection. GBCAs have been found in drinking water of several European cities. [ref 1]

GBCAs appear to be stable molecules which limits the toxicity of gadolinium. However, research on the embryos and larvae of the sea urchin *Paracentrotus lividus* suggests that gadolinium pollution poses a risk to marine life [ref 2]. Given that GBCAs have only been in use since 1988, the long-term effects of thousands of tons accumulating within the ocean remains to be seen.

In addition to concerns related to water pollution, extraction of gadolinium also has a significant environmental impact.

Image created by M. Jackson using Image Creator via Copilot App

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Ref. 2: Martino C, Byrne M, Roccheri MC, Chiarelli R. Interactive effects of increased temperature and gadolinium pollution in Paracentrotus lividus sea urchin embryos: a climate change perspective. Aquat Toxicol. 2021 Jan 21;232:105750. doi: 10.1016/j.aquatox.2021.105750. Epub ahead of print. PMID: 33529976

CHAPTER OUTLINE:

/ Helium

Helium is used in various industries, from space research to weather forecasting, but hospitals are the largest users, accounting for 32% of the global market in 2021.

A typical MRI unit requires approximately 2,000 litres of liquid helium to keep the superconducting magnets cool enough to operate. Additional top-ups may be required over the lifetime of the unit to replace helium that boils off and escapes into the atmosphere.

Helium is not a greenhouse gas, but it is one of the earth's rarest elements, produced by the natural radioactive decay of uranium or thorium present in the earth's crust. This process is very slow, meaning the earth's helium supply is finite and irreplaceable [ref 1].

Some scanners are equipped with a unit to help capture and re-use lost helium, but this is not universal.

Manufacturers are developing low helium use scanners (the first UK machine of this type was installed at King's College, London in 2022, using less than one litre of helium).

There is also promising research in low field MRI systems (operating with a magnetic field strength of 0.25 – 1.0 T, compared to typical scanners at 1.5 T and 3.0 T). These systems do not require helium, use substantially less energy and are much easier to install compared to conventional scanners. Currently images are of lower quality, but it is hoped such machines may provide cross-sectional solutions in more remote communities [ref 2]. If image quality continues to improve, the reduced environmental impact may accelerate the adoption of such systems.

Image created by M. Jackson using Image Creator via Copilot App

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Ref 1: Mary Henderson Keeping an eye on the potential shortage of helium for MRIs. RSNA News January 25,2023 https://www.rsna.org/news/2023/january/helium-shortage-for-MRI

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/ Sustainable Imaging

CHAPTER OUTLINE:

/ Ultrasound Microbubbles

Sulphur hexafluoride (SF6) is used as a contrast agent in ultrasound examinations in a variety of settings including liver lesion characterisation, trauma imaging and assessment of VUR in children.

This agent has a good patient safety profile and may help provide valuable clinical information.

Ultrasound examinations typically use very small quantities.

However, SF6 is one of the most potent greenhouse gases, estimated to be 23,500 times more effective at trapping infrared radiation than CO2.

Cumulative effect from global use in this context is a growing concern. In industry the main (and growing) use of SF6 is as an electrical insulating agent, reminding us that even if electricity used to power healthcare comes from renewable sources, the environmental impact of electrical infrastructure may still be substantial.

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CHAPTER OUTLINE:

/ Miscellaneous

Many hospitals continue to produce "hard-copy" radiology reports on paper. Estimates of the carbon cost of an A4 sheet of paper vary between 4.5g – 60g. [ref 1, ref 2]. If all radiology examinations performed in England (43.3 million) were accompanied by a one sheet report this would equate to between 195,000 Kg and 2,598,000 Kg CO_2e.

While electronic reporting eliminates this cost, data storage of reports and images remains a substantial energy cost.

Single-use interventional equipment is costly both in relation to manufacture and disposal.

Reporting equipment including reporting stations, laptops, dictaphones, monitors, meeting room projectors etc may not require replacement on a daily basis, but do not last forever and also incur both manufacturing and disposal carbon costs.

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Ethical Consider-ations

CHAPTER OUTLINE:

/ Ethical Considerations

The Four Principles (or Pillars) of Medical Ethics are:

1. Beneficence	2. Non-maleficence	3. Autonomy	4. Justice
doing good	to do no harm	giving the patient the freedom to choose freely, where they are able	ensuring fairness

While historically these have largely been applied to consider specific case-by-case ethical conundrums, in the era of the climate crisis, we must utilise these principles more broadly to guide our practice and work towards limiting the impact of medical imaging on climate change.

Regarding issues of sustainability and climate justice, principles 2. (Non-maleficence) and 4. (Justice) are of relevance. As pointed out by some authors, climate change is not only an ethical and justice issue, but it can also be considered a human rights challenge because it affects disproportionally poor and vulnerable individuals both in low- and high-income countries [ref 1, ref 2]. Promoting climate change literacy, helping medical institutions to reduce their environmental impact and ensuring that campaigns promoting a healthy lifestyle to prevent diseases reach all members of a society are challenging tasks awaiting all of us.

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/ **Sustainable** Imaging

CHAPTER OUTLINE:

/ Preventable Disease

According to the World Health Organisation 80% of premature heart attacks and strokes are preventable.

Healthy diet, regular physical activity and not using tobacco products are key to prevention.

WHO estimates 30-50% of all cancer cases are preventable, key risk factors being:

- Tobacco
- Alcohol
- Poor diet
- Physical inactivity
- Infections such as hepatitis and human papilloma virus
- Environmental pollution
- Occupational carcinogens
- Radiation (most commonly solar ultra-violet radiation)

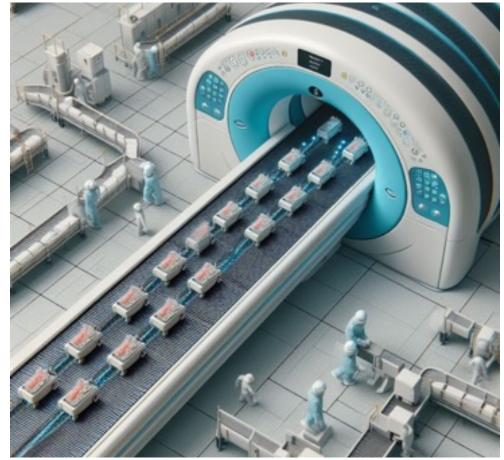
When we know what is causing such a large proportion of the disease burden, it is more important than ever to focus on large scale prevention campaigns to reach all individuals in a society.

In addition, decarbonising medical practice without compromising patient care is a major challenge for the decades ahead and will require some "big picture" thinking alongside the more modest carbon-cutting changes to imaging practice currently underway.

CHAPTER OUTLINE:

Imaging Begets Imaging

Medical imaging examinations can create more imaging examinations. One examination may provide an inconclusive result with the recommendation for an alternative scan for further characterisation. An otherwise normal scan may reveal an incidental finding unrelated to the clinical presentation for which further imaging is suggested. Antenatal imaging has revealed multiple congenital lesions which previously may never have bothered the patient, but which now typically get multiple follow-up examinations.



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Imaging protocols have historically been based on defensive medicolegal considerations – it is considered "safer" to arrange a follow-up scan (or multiple scans) to ensure an equivocal lesion is not malignant.

In the context of imaging contributing to the climate emergency, is it time to eliminate the "reassurogram"?

The unfortunate, if catchy, acronym VOMIT (Victim of Medical Imaging Technology) was coined in 2003 to describe individuals who are over investigated based on spurious or incidental findings on scans, particularly cross-sectional imaging such as CT and MRI. In the era of the climate crisis, we should also consider VOMITING (Victims of Medical Imaging Technology – International / Global), those suffering from air pollution or the effects of global heating, even if located in a distant country to where the imaging was performed.

Avoiding an Apocalyptic Death Spiral

The seemingly relentless growth in high resource medical imaging alongside artificial intelligence and high precision health data analysis is a concerning trend from the environmental and health costs perspectives. More and more imaging is performed but in some cases along a trajectory of diminishing returns.

It is time to consider whether healthcare resources need to be reallocated to promote heath and prevent disease rather than mainly rely on high-energy scanners to image disease processes in extraordinary detail.

As healthcare professionals at an early stage of your career, you will be instrumental in shaping how care is delivered in the years to come. Will you participate in shaping these discussions? Can we find solutions to ensure that remarkable imaging technology can deliver genuine patient benefit without contributing to environmental catastrophe?

Image created by M. Jackson using Image Creator via Copilot App

/ Take-Home Messages

- Medical imaging has an environmental impact due to substantial energy consumption and a considerable amount of waste, particularly through the disposal of contrast agents, consumables and equipment. Therefore, medical imaging also contributes to the climate crisis.

- As healthcare professionals we have an ethical duty to ensure that our practice is safe, that we responsibly use resources, and that we minimise the environmental impact of medical imaging while ensuring - at the same time - optimal patient outcomes.

- Radiology departments are in the process of reviewing and modifying practice to help reduce waste and eliminate unnecessary imaging. Furthermore, the introduction of new imaging techniques hold promise at improving sustainability while providing accurate diagnostic information.

- There also needs to be a broader discussion within medicine and society concerning the manner in which healthcare is delivered. Tackling the causes of preventable disease must take priority over downstream high resource interventions. The next generation of healthcare professionals will need to help drive this transition.

CHAPTER OUTLINE:

Test Your Knowledge

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<?> QUESTION

1

Approximately how many premature deaths can be attributed to pollution related to medical imaging on a worldwide basis each year?

- ☐ 60
- ☐ 6000
- ☐ 60,000
- ☐ 60,000,000

/ Test Your Knowledge

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<?> QUESTION

2 According to a recent study how much iodinated contrast flowed into the Netherlands from Germany along the river Rhine in 2020?

- ☐ 7.1 kg
- ☐ 710 kg
- ☐ 7.1 tonnes
- ☐ 71 tonnes

/ Test Your Knowledge

<?> ANSWER

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CHAPTER OUTLINE:

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3 Which of these imaging modalities typically has the highest carbon footprint per examination?

- ☐ Plain Radiograph
- ☐ Ultrasound
- ☐ CT
- ☐ MRI

/ Test Your Knowledge

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<?> QUESTION

4 Sulphur Hexafluoride is a powerful greenhouse gas used as a contrast agent in ultrasound. Compared to carbon dioxide how powerful is its greenhouse effect?

- ☐ 23 times
- ☐ 230 times
- ☐ 2300 times
- ☐ 23000 times

/ Test Your Knowledge

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CHAPTER OUTLINE:

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5 What are the four principles of sustainable healthcare

- ☐ Prevarication, Patient self-care, Lean Service, Low Carbon
- ☐ Prevention, Patient self-care, Lean Service, Low Carbon
- ☐ Prevention, Patient self-harm, Lean Service, Low Carbon
- ☐ Prevention, Patient self-care, Late Service, Low Car use

/ Test Your Knowledge

<?> ANSWER

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/ Test Your Knowledge

<?> QUESTION

6 Which principles of medical ethics are of particular relevance to the climate crisis?

- ☐ Philanthropy and benefaction
- ☐ Wisdom and austerity
- ☐ Justice and non-malificence
- ☐ Pride and prejudice

/ Test Your Knowledge

<?> ANSWER

6 Which principles of medical ethics are of particular relevance to the climate crisis?

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/ Additional Resources

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