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Review article

Approaches to reduce medical imaging departments' environmental impact: A scoping review

S.S. Ghotra [a, b, *], M. Champendal [a], L. Flaction [a], R.T. Ribeiro [a], C. Sá dos Reis [a]

[a] School of Health Sciences (HESAV), University of Applied Sciences and Arts Western Switzerland (HES-SO), Lausanne, 1011, Switzerland
[b] Department of Radiology, Hospital of Yverdon-les-Bains (eHnv), 1400, Yverdon-les-Bains, Switzerland

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ABSTRACT

Introduction: Global warming stands as a paramount public health issue of our time, and it is fundamental to explore approaches to green medical imaging departments/(MID). This study aims to map the existing actions in the literature that promote sustainable development in MID towards the promotion of environmental impact reduction.
Methods: Following the JBI methodology and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR), this literature search was conducted on MEDLINE, Embase and CINAHL to encompass studies published after 2013. Combinations of keywords and relevant terms related to environmental sustainability, recycling, medical waste, and greening radiology were applied for this review. Three independent reviewers screened abstracts, titles, and eligible full-text. Disagreement was solved through consensus.
Results: 38 out of 4630 articles met all inclusion criteria, and four additional articles were identified and added through reference search. A third of the studies included were published after 2022, and most were conducted in developed countries (36/41). Articles focused on computed tomography (9/41), magnetic resonance imaging (6/41), interventional radiology (4/41), conventional radiography (4/41), ultrasound (2/41), mixed modalities (10/41), or not applicable to an imaging modality (6/41). Four principal categories were identified to decrease ecological footprint: energy consumption, waste management, justification and environmental pollution.
Conclusion: To minimise the environmental impact of MIDs raising awareness and promoting education is fundamental. Examinations must be justified adequately, energy consumption must be reduced, and waste management practices need to be implemented. Further studies are required to prioritise the most effective strategies, supporting decision-making among stakeholders.
Implications for practice: Several strategies are already possible to implement to reduce the environmental impact of MIDs and improve the healthcare outcomes for patients.

Introduction

The increasing demand for medical imaging services not only increases workload but also escalates the environmental impact of medical imaging departments (MID). It is crucial to explore approaches that can reduce the environmental impact of medical imaging departments (MIDs) to promote sustainable development without compromising patient care.[1–3]

The sustainable development concept was defined as " … development that meets the needs of the present without compromising the ability of future generations to meet their own needs", following the Brundtland report derived from the World Commission on Environment and Development (WCED) in 1987.[4] The report stated that global environmental problems are essentially derived from the great poverty that prevails in the South (poor countries or countries with no development) and the consumption and production patterns practiced in the North (developed countries). Twenty percent of the population in developed countries is historically responsible for 80% of the accumulation of

* Corresponding author. School of Health Sciences (HESAV), University of Applied Sciences and Arts Western Switzerland (HES-SO), Lausanne, 1011, Switzerland.
E-mail addresses: switindersingh.ghotra@hesav.ch (S.S. Ghotra), melanie.champendal@hesav.ch (M. Champendal), laurence.flaction@hesav.ch (L. Flaction), ricardo.ribeiro@hesav.ch (R.T. Ribeiro), claudia.sadosreis@hesav.ch (C. Sá dos Reis).

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CO2 and other gases.[4] Sustainable development highlights the need for a strategy that combines development and environment[4] and is structured in three pillars, namely economic, social and environmental sustainability which are strongly interconnected.[5]

Economic sustainability

Medical imaging is grounded on the interconnection of principles related to radiation protection, such as the principle of justification, the practice of "value-based radiology" and sustainability; thereby the economic pillar is based on the evaluation of the appropriateness of all radiological procedures.[6]

Guidelines to minimise unnecessary examinations, including specific directives for radiological diagnostics, were developed by the "Choosing Wisely" initiative, by collecting 600 recommendations from diverse medical societies.[7] Recommendations such as the American College of Radiology (ACR) appropriateness criteria are potentially linked to a positive impact between imaging exam cost and radiation protection, both for the patients and for the healthcare system.[8]

Social sustainability

Social sustainability in MID focuses on the well-being of patients and healthcare professionals by promoting equity, diversity, inclusiveness, and work conditions within the field.[9] Aligning MID with the needs and expectations of patients and referring physicians is a fundamental aspect of social sustainability. Equally important is fostering employee loyalty through support for motivation, well-being, and job satisfaction. Sustainable principles must be also be extended to teaching and research, since it is important to retain future healthcare professionals in MID.[10,11]

Environmental sustainability

Ecology and global warming are critical public health concerns of our time,[12] posing potentially irreversible and catastrophic threats to life on Earth.[12] The evidence of the association between human activity, climate change, and health is increasing and the need for the healthcare sector to reduce emissions is clear.[13]

The healthcare sector is a high-resource consumer and waste producer, requiring a significant amount of energy and water and, at the same time, a producer of a multitude and different types of waste. Energy consumptions are mainly related to heating, air conditioning, ventilation, laundry, food services, and informatics systems.[14–16] Reducing the healthcare carbon footprint is a collective responsibility shared by both the leadership structure of healthcare institutions and every individual employee.

MID contributes heavily to the eco-footprint of healthcare systems.[13,17] Actions can be taken in different areas, such as decreasing energy, water consumption and waste production, while increasing recycling, the use of biodegradable materials[13,14] and promoting healthy behaviours, such as remote participation in medical imaging conferences.[13] There should also exist an encouragement for a sustainable approach to technology adoption and maintenance since new environmental friendly technologies can help minimise the ecological impact.[18] On the maintenance side the strategy should be of considering the potential for future equipment updates rather than resorting to complete replacements, which can be more resource-intensive and a larger environmental footprint.[18]

With the increase of radiological diagnostic and treatment procedures,[19] there is a significant responsibility for reducing the carbon footprint of MID by actively engaging the stakeholders, including radiographers, radiologists, medical physicists, managers and any other relevant professional figure[20] Increasing awareness is fundamental to stimulate healthcare professionals to reflect on their practice and include environmental sustainability as a quality measure for the evaluation of their work and future equipment and protocol choices.[2,21] Multiple studies highlight how the MIDs need to increase efforts to improve practices.[3,18,22,23] To create awareness and promote critical thinking in the future workforce, it is important to integrate sustainability practices in the education system and complement theoretical learning with hands-on clinical practice,[3] grounded in evidence-based knowledge.

The aim of this scoping review is to map the existing actions in the literature that promote sustainable development in medical imaging departments towards the promotion of environmental impact reduction.

Methodology

This scoping review was conducted in accordance with the Joanna Briggs Institute methodology for scoping reviews[24] and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR).[25] Scoping reviews synthesise findings from various studies in a structured way to answer research questions, map literature and identify emerging themes in actual literature, so no quality assessment is expected according to this method.[26] No ethical approval was required for this review.

Inclusion criteria

This scoping review aimed to summarise the evidence of sustainable development practices in medical imaging to provide a better overview of the current situation and possible actions to take into consideration to reduce the impact of MIDs on the environment. Studies concerning environmental sustainability, recycling of material, reuse of equipment, reduction of medical waste and greening in MIDs were included. Medical imaging modalities such as conventional radiography (CR), interventional radiology (IR), computed tomography (CT), magnetic resonance imaging (MRI), mammography, and ultrasound (US) were included. Primary studies published in English or French and focusing environmental sustainability of MIDs were also included. To ensure the relevance of findings to current clinical practice and provide actionable insights, only studies conducted after 2013 were included in this review. Studies related to nuclear medicine imaging modalities systematic and scoping reviews were not considered. Texts, web pages, editorials, opinion articles, unpublished articles and grey literature were excluded from this scoping review to avoid bias related to lower methodological quality and the absence of peer-review of unpublished literature.[27]

Search strategy

The search strategy (appendix I) was conducted on MEDLINE, Embase and CINAHL the 27th of August 2023. Multiple keyword combinations and relevant thesaurus terms related to environmental sustainability, recycling, medical waste, and greening radiology were used. The authors followed the JBI methodology and a three-step search strategy was utilised in this review. First, an initial limited search of MEDLINE was undertaken to identify articles regarding environmental sustainability in medical imaging departments. The text words contained in the titles and abstracts of relevant articles, and the index terms used to describe the articles were used to develop a full search strategy for MEDLINE. The search strategy, including all identified keywords and index terms, was adapted for each included database, namely CINAHL and EMBASE (appendix 1). The search strategy was peer-reviewed and

optimised by the university librarian. References of the included articles were assessed for inclusion in this scoping review.

Study selection

All identified studies were uploaded into Zotero[28] and duplicates were removed by using Bramer's et al.'s method.[29] Subsequently, the references were imported into a free web-based tool, Rayyan,[30] for study selection. Firstly, the title and abstract were evaluated by three independent reviewers to select studies aligned with the inclusion criteria. Eligible full-text articles were retrieved and reassessed by the same reviewers. Studies not meeting the inclusion criteria were excluded and the reason is provided in Fig. 1. Disagreements at each stage of the selection phase between reviewers were resolved through discussion and consensus.

Data extraction and analysis

Data were extracted based on the extraction table (appendix II) developed by two independent reviewers and included the following characteristics: document references (authors, year, title), purpose, methodology (study design, country of study, sample/characteristics, other), primary outcomes (imaging modalities, category, context, action, research strategies) and key findings. The table was specific for this review. Data was extracted individually by the reviewers; results were discussed, and a consensus was reached for the final data extraction table. A descriptive analysis and a narrative summary of the included literature were used to present the results.

Results

Search and study selection

A total of 4630 articles were identified through the three databases, and after removing duplicates, 3018 articles were selected by the search strategy. 37 articles met all criteria and were included after the title, abstracts and full-text screening. Fig. 1, aligned to the PRISMA 2020 statement for reporting reviews,[31] highlight the search and study selection results. In the eligibility step, the reasons for exclusion were the wrong concept (n = 130) and wrong publication type (n = 35), the wrong population (n = 2) and wrong context (n = 7) (Fig. 1). Further literature was included after checking the references of the included studies and, finally, 41 articles were included for this scoping review.

Included studies

Studies were mainly published across developed countries (36/41), followed by developing countries (5/41) and only one from a least developed country. Countries' classification was defined based on the United Nations report "World Economic and Situation Prospects".[32] The majority (17/41) were from the United States of

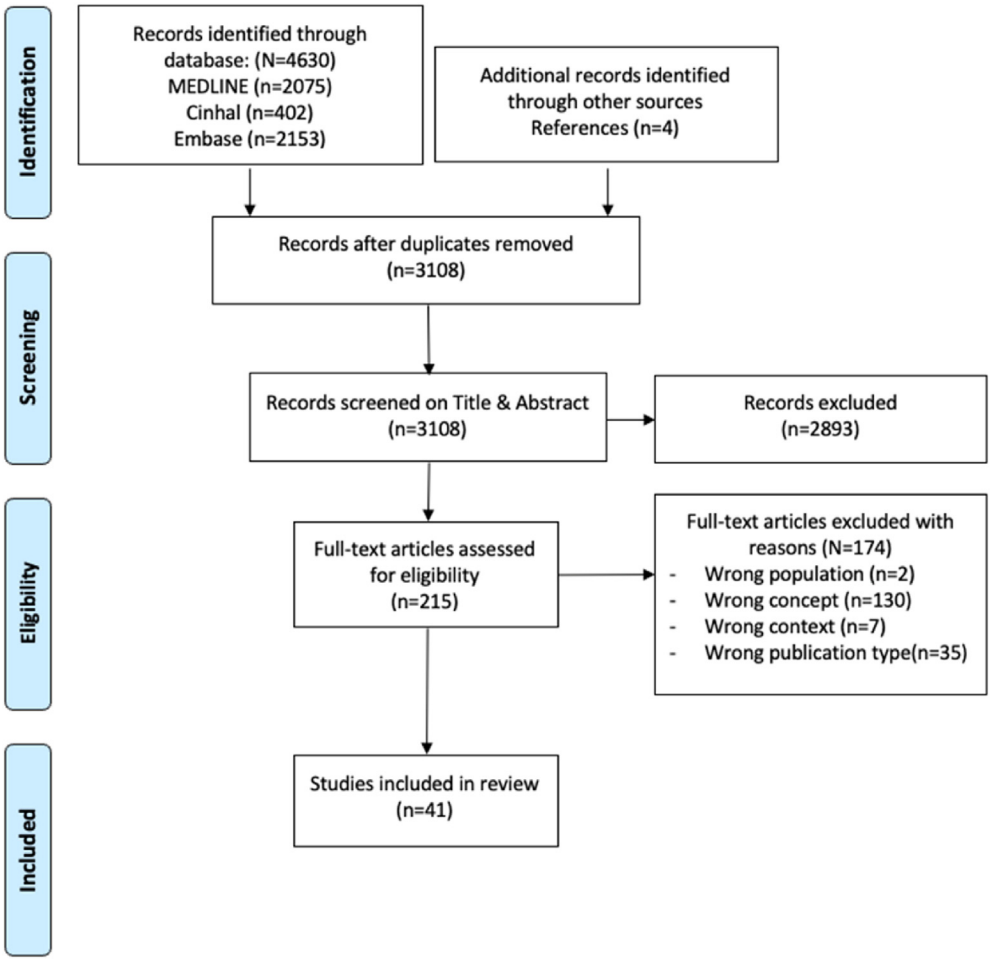

Figure 1. Search results, study selection and inclusion.[31]

America, a third (14/41) from European countries and one from the continent of Africa (Fig. 2).

A third of the studies included were published after 2022 and focused on CT (9/41), MRI (6/41), IR (4/41), CR (4/41), US (2/41), mixed modalities (10/41), or not applicable to a modality (NA) (6/41) (Fig. 3).

Categories for action

Four primary categories were delineated for the sustenance and enhancement of environmental sustainability practices: i) energy consumption, ii) waste management, iii) examination justification and iv) environmental pollution. Multiple strategies related to the four categories have been collected through the different studies and summarised in "Table 1". Furthermore, some general strategies have been extracted indicating paths and actions required to better implement environmental sustainability practices.

Energy consumption

Energy consumption was the main topic for 16 articles. Three articles were related to MRI,[33–35] two to CT,[36,37] two to IR,[38,39] three to mixed imaging modalities,[40,41,70] four to electronic devices in the MIDs,[42,44,45] one to staff mobility[46] and one opinion on climate emergency.[20] Four studies followed the Life Cycle Assessment (LCA) approach to estimate energy consumption,[33,36,38,70] five were prospective[38,40,41,44,45] and eight used other methods.[20,34,35,37–39,42,46] Energy consumption was evaluated across different states of activity, such as modality off, on, and standby. The energy consumption of different imaging modalities was also compared to evaluate which has the highest burden on energy consumption. The energy consumption for staff travel, impacting radiologists and trainees, was also highlighted as an issue. A summary of the findings can be found in the "Table 1".

Waste management

Fourteen articles explored the management of waste within various medical imaging modalities. Five included studies on CT,[36,47–50] four on IR,[38,39,51,52] two on MRI,[36,53] and one on CR,[54] as well as two investigations encompassing all imaging modalities within a MID.[20,40] Among these studies, there were five prospective observational studies[49–51,53,54] with a cross-sectional design, that specifically examine the number of consumables (materials, plastics, contrast agents, paper, etc.) used. Another category comprised four prospective studies[33,36,38,40] employing life cycle assessment methodologies with a focus on enhancing quality. Additionally,

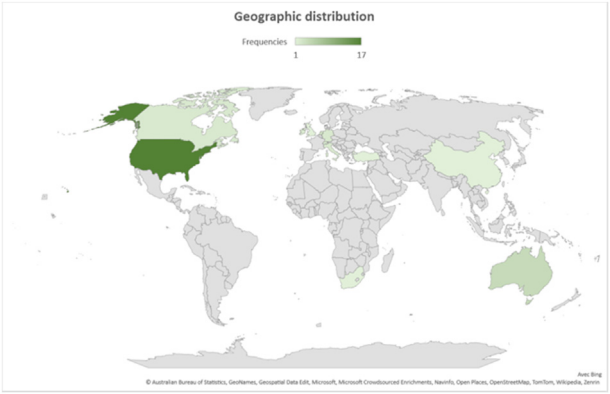

Figure 2. Geographic distributions of included studies.

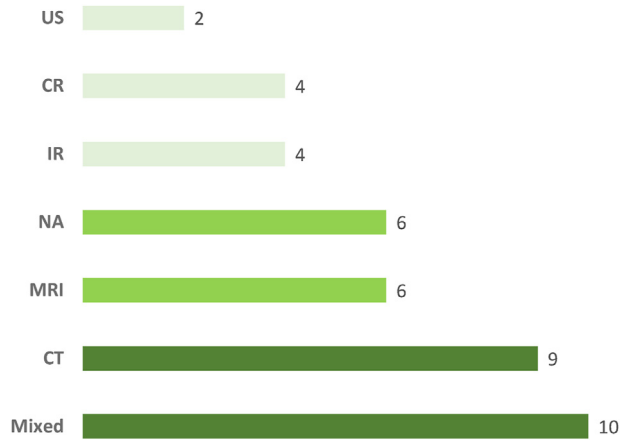

Figure 3. Medical imaging modalities.

there were two retrospective observations,[47,48] two studies[20,39] involving staff surveys to assess attitudes toward waste, and one audit[52] that included observations. One article[46] related to recycling opportunities was identified, which aimed to evaluate the total volume of waste originating from IR product packaging. The study also sought to determine the proportion of this waste that has the potential for recycling. A summary of the findings can be found in the "Table 1".

Examination justification

Thirteen articles focused research on the analysis of the correct justification and decision-making appropriateness of the prescribed medical imaging procedures in MID. These included six mixed modalities (MRI, CT, X-rays) studies,[55,56,58–61] three CR,[62,63,71] two CT[64,65] and one for US.[72] Among these, four were prospective studies,[59,62,64,72] three were retrospective,[55,56,58] and five other types of primary studies.[60,61,71,63,65] This category describes the assessment of the appropriateness of medical imaging examination through different strategies such as: 1) the involvement of pre-authorisation systems or incorporation of radiologists in pre-ordering processes; 2) data exchange agreements between hospitals to reduce duplicate images; 3) adopting ACR criteria of appropriateness as guidelines or local algorithms development and implementation to aid clinical decision-making processes. One article[57] described an algorithm to automatically perform repeat-reject analysis in CT. A summary of the findings can be found in the "Table 1".

Environmental pollution

This category comprised seven studies,[20,38,39,66–68,73] with four[20,38,39,68] addressing the measurement of carbon footprint on waste production. One study[67] examined samples collected from tap water to investigate the potential pathway of anthropogenic Gadolinium. Two articles[73,66] explored the opportunity to use local resources to support medical imaging procedures in lower-income countries. One article[73] focused on the on-site construction of a low-field MRI system in Africa, while the other[66] explored an alternative local production of US gel. A summary of the findings can be found in the "Table 1".

General strategies

The efforts to map local attitudes and awareness in the MID concerning climate change will yield valuable insights into the

Table 1
Eco-friendly practices to reduce the environmental impact of medical imaging departments.

Categories	Recommended strategies
Energy consumption[20,33–40,41–46]	• Improve energy efficiency in imaging modalities. • Assess the impact of patient distribution on energy efficiency enhancements. • Reduce idle energy. • Promote the integration of design features aimed at reducing total energy consumption in MRI equipment. • Engage in collaboration with medical imaging department groups to develop strategies for reducing energy usage. • Implement a methodology for conducting a comparative assessment of energy usage in MRI systems. • Provide third-party testing services for hospitals and healthcare firms. • Turn off imaging equipment, computers, and lighting. • Combine automated shutdown/restart of workstations. • Use simple motion sensors for room lighting. • Propose guidelines for the sustainable use of imaging equipment. • Consider the use of renewable energy sources, which could be provided locally, e.g., by solar panels at building roofs. • Increase awareness of energy saving strategies in clinical practice.
Waste management[20,33,36,38–40,47–54]	• Modify procedure packs to reduce the likelihood of discarding unused items. • Reduce the utilisation of single-use supplies in favour of safely reprocessable items, including surgical instruments and gowns. • Explore alternative packaging methods for products to diminish the overall waste burden. • Optimise consumables utilisation. • Conduct a comparative analysis of MRI equipment for hospital sustainability initiatives. • Apply evidence-based methods to gain insights from healthcare teams. • Engage specialists to implement innovative sustainability improvements and strategies. • Prioritise changes that are likely to be adopted for quality improvement. • Properly segregate non-infectious cardboard, paper, and plastic in the IR suite and channel them into the recycling stream. • Consider donating older or unused equipment and supplies to hospitals in developing countries strategically, with the aim of extending their usability.
Examination justification[55,56,57,58–62,63–65]	• Follow appropriateness criteria guidelines (i.e. ACR). • Develop local or implement algorithm to aid-decision making in medical imaging procedures ordering. • Include pre-authorisation system supervised by radiologists. • Implement interprofessional collaboration to help correct ordering of medical imaging procedures. • Include clinical audit for quality improvement system. • Develop algorithms to automatically perform repat-reject analysis to define required training area.
Environmental pollution[20,38,39,66–68]	• Turn off imaging equipment, computers, and lighting. • Reduce air exchanges and allowing climate control systems to vary temperatures widely during non-working hours. • Explore alternative transportation for work and congress. • Reduce the number of physical attendees and promote virtual events. • Use of alternative and locally produced resources (i.e. US gel). • Build and assembling of technology locally.
General strategies[20,33,36–39,45,52–54,59,61,63,65,57,69]	• Map local attitudes and awareness concerning climate change. • Strategies to improve awareness and provide continuous professional development. • Clinical audit and quality improvement project. • Foster interdisciplinary approach and engage specialists for innovative sustainability improvements. • Engage with suppliers to revise procedure packs and reduce packaging. • Implement regular QA and control programs, as well integrate sustainability as quality measure. • Maintain well-documented polices addressing repeat examination factors to define and target training requirements. • Encourage staff participation in educational programs for skill enhancement. • Multidisciplinary approach to reduce unnecessary imaging.

healthcare community's perceptions and knowledge gaps, informing targeted strategies for improvement and increasing adherence to eco-friendly practices. Through the implementation of continuous professional development (CPD) programs, MID stakeholders' awareness and competence increase in addressing climate change.[20,39,65,57,69] Moreover, by promoting interdisciplinary collaboration and engaging specialists, innovative sustainability improvements can be successfully implemented, enhancing both environmental and healthcare outcomes.[33,36,37,59,61,57] Collaboration should be carried out also with suppliers and vendors to revise procedure packs and reduce packaging leading to significant reductions in waste generation and resources required to recycle waste.[45,52] Clinical audit and quality should include sustainability as a quality measure metric in order to promote a culture of environmental responsibility while considering patient care improvement.[33,36–38,53,54,61,63] Moreover, maintaining well-documented policies and encouraging staff participation in educational programs will facilitate effective training and skill enhancement, ensuring the ongoing success of sustainability initiatives within the healthcare setting.[54] A summary of the findings can be found in the "Table 1".

Discussion

The aim of this scoping review is to map the existing actions in the literature that promote sustainable development in MIDs towards the promotion of environmental impact reduction.

This review identified multiple possible actions that can help MID stakeholders to adopt and promote eco-friendly practices. Four main categories of action emerged from this review, namely: i) energy consumption, ii) waste production, iii) examination justification and iv) environmental pollution. Furthermore, strategies to ease implementation were extrapolated, mainly focusing on mapping and raising climate change awareness of stakeholders, fostering interdisciplinary work between healthcare professionals as well as suppliers, encouraging CPD and education and finally integrating environmental sustainability as a quality measure.

There is a geographical imbalance in article distribution which was observed in a previous systematic review focusing on environmental sustainability in clinical radiology and radiotherapy practice.[3,22] It is important to consider the fact that higher-income countries have easier access to medical imaging devices, which

could contribute to this imbalance.[74–76] Further investigations are required to clearly state the reason for this geographical imbalance.

A third of the studies included were published after 2022, which may be related to the fact that climate change awareness is a worldwide hot topic,[77–79] as well as linked to policymakers' strategies.[16,80,81]

Four main categories for action emerged from this review and are discussed accordingly:

Energy consumption

In the pursuit of improving energy efficiency within MID, a multifaceted approach is essential. Similar to other studies,[3,22,39,82,83] this review suggests that actions should focus on 1) powering down medical imaging and other devices during idle periods, 2) prioritising the use of energy-efficient image equipment and engagement of collaboration with MID groups to develop strategies, and 3) the integration of design features to reduce energy consumption.

Not constrained to MID, healthcare institutions should promote the use of renewable energy sources, like solar panels.

The development of a local strategy is fundamental, where MID stakeholders collaborate and evaluate which actions are feasible in their department without impacting key indicators such as patient care and clinical output and service quality.

Energy consumption eco-friendly practices reduce the burden on the environment, while reducing costs, thus creating a more economically sustainable hospital.[84] A Swiss energy efficiency of medical imaging equipment report indicated that there is a potential energy reduction of 30–40% for MRI, CT or CR equipment per year, leading to a potential cost reduction of 5850 Swiss francs (CHF) per year for one MRI scanner to a 540 CHF per year for one CR equipment.[85]

Waste management

To enhance environmental sustainability practices within MID, strategies around the key concept of the 3 ″Rs" - reduce, reuse and recycle - are paramount.[18,52] In accordance with other studies,[3,52,83] this scoping review identified that waste management approaches are key to sustainable development. Key action areas: 1) Prioritising multipackage material or re-processable equipment, 2) strength recycle practices within MIDs and 3) strategically re-allocate expansive and sophisticated equipment.

Prioritising multipackage material or re-processable equipment directly reduces the accumulation of unnecessary packaging and waste. Emphasising the importance of eco-conscious practices and exploring alternative packaging methods is fundamental to guarantee MID daily practices. Waste management is particularly fundamental in IR services, as this modality is the main source of normal waste production, as well as infectious material. Separation of infectious material is vital to enhance circular economy waste management in the hospital and the external discharge, directly impacting economic and environmental sustainability.[3,52,83]

Donating unused, expensive and sophisticated equipment strategically is fundamental not only to donate material to other healthcare institutions, but also to donate to lower-middle-income countries, especially in rural and semi-rural areas. It is fundamental to take into consideration the complex ecosystem of certain regions of which healthcare decision-makers are partially aware, prompting unsuccessful equipment donation and creating unnecessary waste. For these lower-income countries, other solutions seem to be more adequate rather than donating old-refurbished equipment.[75,86]

Examination justification

The appropriate justification of medical imaging investigation is directly associated with a reduction of the impact on the environment. Multiple strategies have been identified, such as strictly following appropriateness criteria and guidelines for medical imaging examination. However, this review highlights stakeholders' low adherence to medical imaging investigation appropriateness recommendations, which is in accordance with studies that evaluate adherence to American College of Radiology (ACR) appropriateness criteria. These practices leads to an increased number of unnecessary investigations[77,78]; to mitigate this issue, some key actions are suggested: 1) increase formal training in appropriate imaging order practices, in both undergraduate and graduate medical education or integrate appropriate criteria into decision support to reduce overuse[87–89]; 2) use a pre-ordering process, where the radiologist needs to validate the request for a medical imaging investigation or to establish local decision-making algorithms[18]; and 3) establish data exchange agreements between hospitals to reduce the probability of duplicate exams, thus reducing the environmental impact, cost and patient exposure to ionising radiation.[90]

Environmental pollution

To limit MID environmental pollution, findings from this review suggests these key points: 1) conserving energy and reducing emissions, 2) exploring alternative transportation methods, 3) exploring and prioritising local resources.

Implementing practices like turning off imaging equipment, computers, and lighting during idle period, optimising air exchanges and climate control systems during non-working hours, and promoting a dedicated commitment allow to reduce energy consumption and emissions. Similar results were found in the literature.[3,22,91] Exploring alternative transportation methods for work and congress attendance, or promoting virtual events, exemplifies a proactive stance towards diminishing carbon footprint and fostering a culture of sustainability. Staff mobility's impact on the environment has been shown in a study concerning the environmental footprint of the Radiological Society of North America (RSNA) annual meeting. This study stated that the aeroplane-travel impact on the environment and the associated disease burden is relevant and suggested exploring alternative participation methods, i.e. remote-virtual attendance.[68] Preferring the use of local resources has also a reduced carbon footprint and can be explored by MIDs stakeholders. Complementary local resources, like purchasing food and office equipment from local suppliers, need to be evaluated by local policymakers and healthcare institutions.[92] A result partially missing in this review is the water contamination, which is a topic to further explore, as the waste of contrast agents used in MID are poured directly and/or indirectly into the wastewater.[93–96] Strategies to limit contamination need to be developed through the collaboration of MID stakeholder manufacturers as well as patients. Current recommendations are related to reducing the use and waste of contrast agents, measures to collect residues and recycling systems.[93–96]

General strategies

Strategies to increase awareness, educate and foster the different stakeholders in and out of the MID department for interdisciplinary collaboration are fundamental for creating effective strategies to implement practices and cultures, and laying the foundations for integrating environmental sustainability in the quality assurance programme. This review suggests that: 1)

mapping attitudes and awareness for future practices implementation is fundamental, 2) there is a need for education of current and future MIDs stakeholders, 3) interdisciplinary approach of the stakeholders is paramount. Similar recommendations for MID clinical practices and academic stakeholders were also suggested in the literature.[3,95]

However, the results of this scoping review highlight a lack of studies focusing on sustainable development education which could be useful to increase awareness and the adoption of environmental sustainability practices in MID and academic settings. This area should be investigated in future to allow for better implementation of eco-friendly practices. In fact, the lack of leadership, knowledge and misconception, data, awareness, concern, time, perceived increased workload, staff attitudes and manufacturers and regulatory agencies have been identified as common barriers to overcome in the implementation of eco-friendly practices in IR departments.[52] Implementation strategies and studies are fundamental to ensure the successful and lasting application of sustainable practices.

Implication for clinical practice

This review proposes multiple areas of action for MID stakeholders to increase eco-friendly practices and reduce environmental impact. Focus should be given to the following key points: 1) reduce energy consumption 2) enhance waste management to reduce waste production and increase recycling 3) improve justification accuracy to reduce unnecessary imaging procedures, and 4) reduce activities that pollute the environment. Education is paramount to increase awareness in MID stakeholders, through a CPD integration, as well as in the upcoming health professionals, by implementing environmental sustainability in the radiography curriculum.

Limitations

This review has certain limitations; firstly the absence of an evaluation of the quality of the included studies following the typical JBI methodology of scoping reviews.[24] This scoping review included studies published after 2013 to concentrate on recent environmentally sustainable practices. Nonetheless, this might result in overlooking other actions that have been explored differently in earlier literature, namely the extensive use and advantage of digital radiography compared to x-ray films.[18,97] Despite the efforts made by the authors to include all relevant articles, it remains possible that certain studies were overlooked due to the selection of databases and search terms. Namely, there is a lack of studies exploring the improvement of education to reduce the environmental impact. The lack of education-related studies could be linked to a lack of primary studies, as well as a need to perform a more precise search strategy focused on education to increase awareness of MIDs stakeholders.

Future perspectives

Future research should focus on evaluating the efficiency of the multiple actions synthesised in this review. Additional investigation is needed in 1) mapping and increasing awareness before implementing new eco-friendly strategies in clinical practice, 2) evaluating the opportunity to foster interdisciplinary collaboration between MIDs stakeholders, hospital professionals and suppliers to reduce the MID environmental impact. The need for environmental sustainability education and education strategies to increase awareness should be investigated. Implementation strategies need to be developed to ensure effective and sustainable changes. Finally, an investigation to include environmental sustainability as a quality measure indicator should be conducted to offer stakeholders metrics to evaluate and improve their future practices in the framework of a continuous quality improvement practice.

Conclusions

MID stakeholders have multiple options to reduce their environmental impact and improve their daily eco-friendly practices, namely promoting the judicious justification of imaging investigations, minimizing energy consumption, instituting recycling practices, decreasing environmental pollution and striving for enhanced health outcomes. Furthermore, it is essential to enhance the awareness and education of current healthcare professionals in clinical practice and future healthcare professionals who are still in undergraduate programs. Further research is needed to identify and prioritise the most effective strategies, thereby fostering critical thinking and informed decision-making among stakeholders.

Ethics approval

Ethical approval was not required for this review.

Conflict of interest statement

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.radi.2024.08.002.

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