Nationwide Survey – What is important for a sustainable radiology?

Bundesweite Umfrage – Was ist wichtig für eine nachhaltigere Radiologie?

Authors

Viktoria Palm[1, 2, 3], Lena Wucherpfennig[1, 2, 3], Thuy Duong Do[1, 3], Matthias Alexander Fink[1, 2, 3], Oyunbileg von Stackelberg[1, 2, 3], Benedikt Jakob Schwaiger[4], Hans-Ulrich Kauczor[1, 2, 3]

Affiliations

1 Department of Diagnostic and Interventional Radiology, University Hospital Heidelberg, Heidelberg, Germany
2 Translational Lung Research Center (TLRC), German Center for Lung Research (DZL), Heidelberg University, Heidelberg, Germany
3 Diagnostic and Interventional Radiology with Nuclear Medicine, Thoraxklinik am Universitätsklinikum Heidelberg, Heidelberg, Germany
4 Department of Neuroradiology, School of Medicine and Health, Technical University of Munich, Munchen, Germany

Keywords

Sustainability, Radiology, Energy Consumption Diagnostic Imaging, Green Radiology, Green Hospital, climate-surveillant healthcare system

received 16.2.2024
accepted after revision 28.6.2024
published online 2024

Bibliography

Fortschr Röntgenstr
DOI 10.1055/a-2378-6366
ISSN 1438-9029

Georg Thieme Verlag KG, Rüdigerstraße 14, 70469 Stuttgart, Germany

Correspondence

Viktoria Palm
Department of Diagnostic and Interventional Radiology, University Hospital Heidelberg, Heidelberg, Germany
viktoria.palm@med.uni-heidelberg.de

Supplementary Material is available at https://doi.org/10.1055/a-2378-6366.

Deutsche Version unter: https://doi.org/10.1055/a-2378-6366.

ABSTRACT

Purpose Radiology departments with the large diagnostic devices CT and MRI contribute significantly to the overall energy consumption of health facilities. However, there is a lack of systematic knowledge about the opinions of radiological staff on the most relevant aspects of sustainability. For this reason, we conducted a comprehensive survey for radiology employees on sentiment and experiences regarding sustainability in radiology.

Materials and Methods In collaboration with the Sustainability Network of the German Roentgen Society (DRG), we developed a questionnaire on various dimensions of sustainability in radiology. We conducted a nationwide online survey of radiology employees between July 1st, 2023 and November 30th, 2023. The absolute and percentage distributions were then determined.

Results From 109 participants, mainly doctors (67/109; 62 %) from university hospitals (48/109; 44.0 %), 81 out of 109 rated sustainability in professional environment (74.3 %) as important or very important. However, only 38 out of 109 (38 %) of the respondents were able to name specific sustainable procedures in their institute. The most important topics for a sustainable radiology were waste management (26/109, 22.6 %), energy reduction (19/109, 16.5 %), conscious behaviour (15/109, 13 %) and reduction of obsolete examinations (14/109, 12.2 %). In addition, a lack of qualifications (16 %), finances (21 %) and compliance (21 %) were named as challenges for the implementation of sustainable actions in radiology. The perceived importance of specific, sustainable measures in radiology is generally higher than the amount of already established actions.

Conclusion Radiology has significant, yet untapped, potential for sustainable optimization. There is a need for qualified and sensitized health care workers in radiology who are committed to sustainability in everyday clinical practice. Among other things, in this study the respondents demand a more critical indication for diagnostic workup, including avoiding redundant examinations, and a technological progress towards energy-efficient devices, which requires a dynamic exchange between radiology, industry and health care facilities.

Key Points

- Of 109 respondents from radiology departments, 74.3 % consider sustainability to be important or very important in a professional context.
- Waste management (22.6 %), energy reduction (16.5 %), conscious behaviour (13 %) and reduction of obsolete or redundant examinations (12.2 %) are, according to those surveyed, most important for a more sustainable radiology.
- Sustainability initiatives have been institutionally established among 38 % of participants. However, key challenges to the implementation of sustainable practices in radiology include insufficient compliance from staff and patients (21 %), limited access to funding (21 %), and a lack of necessary qualifications (16 %).
- The perceived importance of specific measures for sustainability in radiology is generally higher than the previously established measures.
- Technology & energy efficiency (59.6 %), energy contracting (46.8 %) and waste management (34.9 %) are the areas of interest with the highest priority.

Citation Format

- Palm V, Wucherpfennig L, Do TD et al. Nationwide Survey – What is important for a sustainable radiology?. Fortschr Röntgenstr 2024; DOI 10.1055/a-2378-6366

ZUSAMMENFASSUNG

Ziel Die Radiologie trägt insbesondere mit ihren diagnostischen Großgeräten einen nicht unerheblichen Anteil am energetischen Gesamtverbrauch der Gesundheitseinrichtungen bei. Allerdings fehlt es an systematischen Erkenntnissen über die Meinung radiologischer Mitarbeiter:innen zu den relevantesten Aspekte der Nachhaltigkeit. Aus diesem Grund führten wir eine umfassende Befragung von radiologischem Personal zu den Einstellungen und Erfahrungen bezüglich Nachhaltigkeit in der Radiologie durch.

Material und Methoden In Zusammenarbeit mit dem Netzwerk Nachhaltigkeit der Deutschen Röntgengesellschaft (DRG) entwickelten wir einen kompakten Fragebogen zu verschiedenen Dimensionen der Nachhaltigkeit in der Radiologie. Zwischen dem 1. Juli 2023 und dem 30. November 2023 führten wir eine nationale Online-Befragung unter radiologischem Personal durch. Die absoluten und prozentualen Verteilungen wurden anschließend ermittelt.

Ergebnisse Von den 109 Teilnehmenden, mehrheitlich Ärzte:innen (67/109; 62 %) aus Universitätskliniken (48/109; 44,0 %), bewerteten 81 von 109 Nachhaltigkeit im beruflichen Umfeld (74,3 %) als wichtig oder sehr wichtig. Allerdings konnten nur 38 von 109 (38 %) der Befragten konkrete Nachhaltigkeitsmaßnahmen in ihrem Institut benennen. Die wichtigsten Bereiche für eine nachhaltigere Radiologie wurden von den Befragten als Abfallmanagement (26/109, 22,6 %), Energiereduktion (19/109, 16,5 %), bewusstes Handeln (15/109, 13 %) und Reduktion obsoleter Untersuchungen (14/109, 12,2 %) identifiziert. Zudem wurden mangelnde Qualifikation (16 %), Finanzierungsmöglichkeiten (21 %) und Compliance (21 %) von Mitarbeitenden und Patient:innen als Herausforderung für die Implementierung nachhaltiger Maßnahmen in der Radiologie genannt. Die empfundene Bedeutung spezifischer, nachhaltiger Maßnahmen in der Radiologie ist übergreifend höher als die bisher etablierten Maßnahmen.

Schlussfolgerung Die Radiologie besitzt großes, bisher unausgeschöpftes, Potenzial für nachhaltige Optimierung. Es besteht ein Bedarf an qualifiziertem und sensibilisiertem radiologischem Personal, das sich für Nachhaltigkeit im klinischen Alltag engagiert. Unter anderem werden ein technologischer Fortschritt hin zu energieeffizienteren Geräten und eine kritischere Indikationsstellung sowie Vermeidung redundanter Untersuchungen von den Befragten gefordert, was eine Kooperation von Radiologie, Industrie, Ärzteschaft und Praxis-/Krankenhausträgern erfordert.

Kernaussagen

- Von 109 Befragten aus radiologischen Abteilungen empfinden 74,3 % Nachhaltigkeit im beruflichen Kontext als wichtig oder sehr wichtig.
- Abfallmanagement (22,6 %), Energiereduktion (16,5 %), bewusstes Handeln (13 %) und Reduktion obsoleter bzw. redundanter Untersuchungen (12,2 %) sind nach Einschätzungen der Befragten am wichtigsten für eine nachhaltigere Radiologie.
- Bei 38 % der Teilnehmenden sind Nachhaltigkeitsmaßnahmen institutionell etabliert, wobei mangelnde Compliance (21 %) von Mitarbeiter:innen und Patient:innen sowie Finanzierungsmöglichkeiten (21 %) und Qualifikationen (16 %) eine Herausforderung für die Umsetzung nachhaltiger Maßnahmen in der Radiologie darstellen.
- Die empfundene Bedeutung spezifischer Maßnahmen zur Nachhaltigkeit in der Radiologie ist übergreifend höher als die bisher etablierten Maßnahmen.
- Technik & Energieeffizienz (59,6 %), Energie-Contracting (46,8 %) und Abfallmanagement (34,9 %) sind die Interessensgebiete mit dem höchsten Stellenwert.

Introduction

Sustainability is often used as a synonym for environmentally-friendly and energy-efficient lifestyles, measures, and processes. In radiology, the various elements of sustainability – ecology, economy, and social components – are closely interlinked. Environmental aspects, such as sustainable large imaging devices or avoiding business travel, reduce the CO_2-equivalent footprint and are therefore climate-friendly. In addition, economic and social aspects are of great importance for sustainability in radiology and can thus contribute to positively influencing climate change [1, 2]. Economical process optimizations can be energy-efficient. However, economically driven process optimizations are not necessarily employee-friendly. Nevertheless, a sustained high level of

employee satisfaction among doctors, MTRs and scientists is essential, as this not only reduces healthcare costs due to possible employee absenteeism but also reduces the frequency of costly and energy-consuming employee recruitment and relocation [1, 2]. The interlinked relationships between the different sub-areas of sustainability in radiology are complex, but they are in close – although difficult to grasp – context with climate, environment, and nature.

Sustainability and climate protection are now being increasingly written into laws, and the healthcare sector is no exception to this trend. At the 125th German Medical Congress, the German Medical Association also called for climate-neutrality in the healthcare sector by 2030 [3]. Radiology, in particular, is in the spotlight with its energy-consuming large imaging devices, and the field accounts for a significant proportion of the energy consumption by radiological service providers [4]. An MRI requires approximately 171 MWh per year, equivalent to the household consumption of 34 single-family households [5, 6]. This includes power used apart from image acquisition, i. e. in an unproductive state, which accounts for 72–91 % of total electricity consumption. From an ecological and economic perspective, there is a high potential for savings here and it is not currently being addressed adequately. However, because sustainability consists of the three pillars of economy, ecology, and a social component, there are potentially many more possible aspects to take into consideration [7, 8].

Currently, there is a lack of scientifically based studies that collect data regarding the need and importance of sustainability in radiology. Which specific measures are considered important? What has been established already institutionally? What is the sentiment towards sustainability in radiology? This comprehensive national survey of radiological staff is intended to provide a scientific overview of sentiments nationally based on attitudes and experiences related to sustainability in radiology.

Materials & Methods

Together with the Sustainability Network of the German Radiological Society (DRG), an online survey with 14 questions on sustainability in radiology was created, and it was made available publicly via the SurveyMonkey portal (SurveyMonkey Europe UC, Dublin, Ireland) from July 1, 2023 to November 30, 2023. The survey was distributed during this period via the DRG website, the website of the network "Sustainability@DRG," advertised in various editions of the DRG newsletter, in the DRG social networks and, in particular, on the Forum for Young Radiology, as well as through the authors' radiologist networks. Graphical preparation and data evaluation to assess the percentage and absolute distribution was carried out in MS Excel (Microsoft, Redmond, USA, vers. 16.0).

The survey covered the four following topics:

- Demographics (number of questions, F = 4): Gender, age, place of work, job title
- Importance of sustainability (F = 3): Sustainability professionally, personally, engagement
- Sustainability in radiology (F = 4): Established measures, challenges, most important areas
- DRG's Sustainability Network (F = 3): Sustainable areas of interest, DRG sustainability measures, active participation

The full survey can be found in **Supplement 1 (Suppl. 1)**. To evaluate the free-text responses, summarizing groups were created, whose detailed explanations can be found in the supplement as follows:

The topics mentioned on sustainable personal engagement (**Suppl. 2**) result in a natural overlap with related grey areas of the classification. The table list shows the main thematic focus of the responses. General responses were assigned to "conscious behavior," while specific feedback, such as implementing defined "turn-off" times, was assigned to "energy reduction". "Conservation of resources" implies, in particular, mention of CO_2-equivalents and mobility/travel. If more specific examples were given, e. g. in connection with energy or waste, these responses were assigned instead to the dedicated categories.

Suppl. 2 also includes free-text responses regarding sustainable, already established measures in radiology (**Suppl. 3**) and challenges in establishing these processes (**Suppl. 4**). The free-text responses in **Suppls. 2 and 3** regarding the most important points for sustainable radiology can be found in **Suppl. 5**.

Interests in the topic of sustainability were surveyed using a multiple choice option based on eight thematic areas, with the free-text category "Other" grouped together with "digitalization of patient processes," "upcycling," "heat coupling," and "interfaces".

The sustainability measures requested by the DRG were queried based on potential multiple selection using ten topics, which were then summarized in five topic blocks for the graphical representation (**Suppl. 6**).

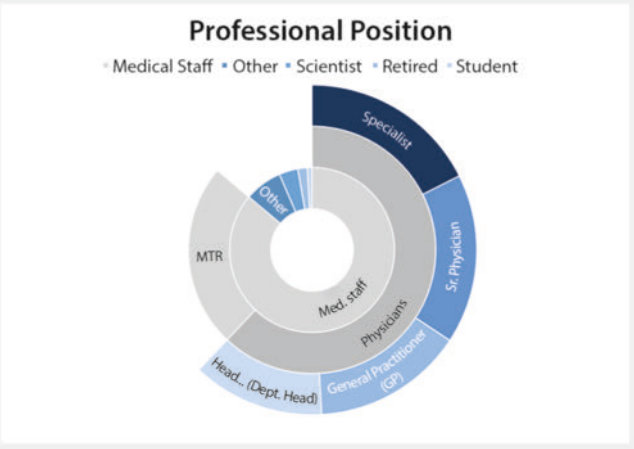
Results

Demography

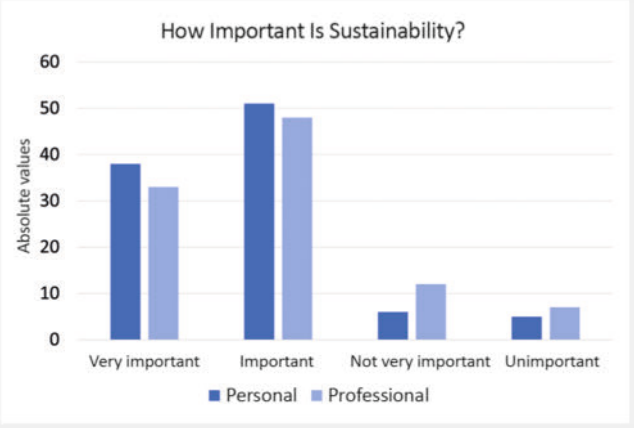
A total of 109 people (male N = 56; 51.9 %; female N = 52; 48.1 %) participated in the survey, most of whom were in their fourth decade of life (38.5 %, N = 42) (▶ **Table 1**). Among respondents, the professional groups, doctors and MTRs, referred to as medical

▶ **Table 1** Age distribution of respondents.

Age group	N	%
< 30 years	16	14.7
30–39 years	42	38.5
40–49 years	23	21.1
50–59 years	19	17.4
60–69 years	6	5.5
70-plus years	3	2.8



▶ **Fig. 1** Professional positions of the radiological staff surveyed. Medical personnel comprised 85.3 % (N = 93) of respondents, including doctors who made up the largest number of respondents at 62 % (N = 67).



▶ **Fig. 2** Comparison of the importance of sustainability in respondents' professional and personal lives. The results show that most respondents ranked sustainability equally important in both areas – from important to very important.

personnel, were represented most heavily at 85.3 % (N = 93). In this group, physicians dominated with 62 % (N = 67), with specialists (17.4 %; N = 19) and senior physicians (16.5 %; N = 18) forming the largest subgroups (▶ **Fig. 1**). The majority of respondents (70.6 %; N = 77) works in hospitals, with employees of university hospitals dominating at 44 % (N = 48). 20.2 % of respondents (N = 22) work in an affiliate or a medical care center. A minority work for medical companies, including teleradiology and temporary staffing agencies.

Sustainability – Engagement and Sentiment

The majority of respondents (58.7 %; N = 64) stated that they were not actively involved in the area of sustainability; 82.7 % (N = 89) rated sustainability in a personal context and 74.3 % (N = 81) in a professional context as important or very important (▶ **Fig. 2**). Nine persons did not respond to the question. The perceived importance of sustainability in the workplace shows no gender-specific correlation, with 73.1 % (38/52) of female and 75 % (42/56) of male participants rating sustainability from important to very important.

Personal engagement in correlation with importance of sustainability

The Sankey diagram (▶ **Fig. 3**) illustrates the relationship between active engagement and the perceived importance of sustainability, as well as the downgrading of its importance in a professional context compared to a personal context. All actively engaged individuals (N = 36) rate sustainability as important or very important. Overall, the majority of all participants (77 %; 77/100) rate the importance of sustainability equally in their professional and personal lives. Of those respondents who have a different opinion on the importance of sustainability, 78.3 % (18/23) rate sustainability in a professional context as less important.

Sustainability in Radiology

Established measures

Overall, 38 of 109 respondents (38 %; 38/100 plus 9 non-respondents) were able to name measures already established in radiology. Apart from energy reduction and digitalization, more people are personally engaged in the other topic areas compared to institutional measures already implemented (▶ **Fig. 4**). Energy reduction and digitalization were mentioned more frequently by participants as established measures rather than engaged measures. Yet considering their importance to a more sustainable radiology, it seems that not enough is being done overall (▶ **Table 2**, ▶ **Fig. 5**).

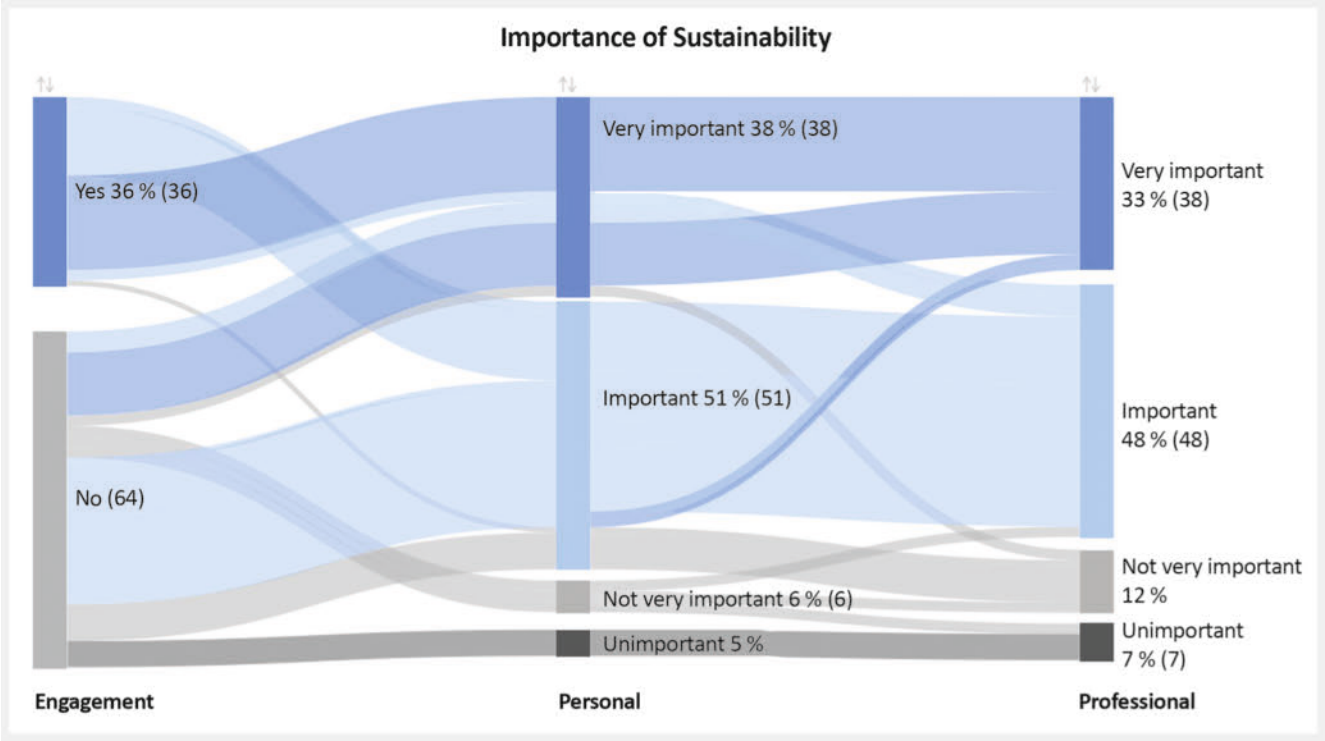
Importance of sustainable measures

In total, there were 56 responses to the most important measures to promote more sustainable radiology, specifying 115 different points in a total of nine subject areas plus "Other" (▶ **Table 2**). While compared to established measures and personal engagement, diet does not seem to be a significant factor for sustainable radiology, there are three areas that have not yet been addressed but appear to be significant: finances/funding opportunities, process optimization, and reducing the number of examinations or behaving more consciously when determining the indication.

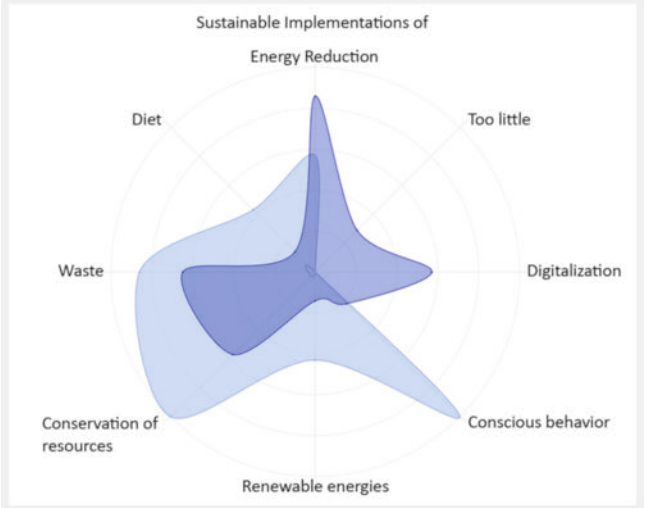
In addition, contrast medium recycling, contrast medium consumption, and contrast medium composition were frequently mentioned under the category of waste, in order to reduce the contrast medium in the environmental cycle or to improve biodegradability. Furthermore, under the topic of energy reduction, the focus was particularly on innovations in technology development to reduce the energy consumption of large imaging devices, to which 52.6 % (10/19) of the responses in this topic area referred. In contrast, the topic of renewable energies in radiology is underrepresented both in established measures and in perceived importance (▶ **Fig. 5**).

Challenges

Challenges in establishing these institutionally implemented sustainable measures are reported by 42.1 % (18/38) of the partici-



▶ **Fig. 3** Sankey diagram showing the correlation between active engagement and the perceived importance of sustainability, as well as the importance of sustainability in personal versus professional environments. All actively engaged individuals (N = 36) rate sustainability as important or very important. Overall, the majority of respondents (77 %; 77/100) consider sustainability equally important in both their professional and personal lives. For the other 23 %, the majority (78.3 %) feel that sustainability is less important professionally than personally.



▶ **Fig. 4** Overlaps between established measures in radiology (dark blue) and active personal engagement (light blue).

pants (▶ **Fig. 6**). The most important topics are financing, other issues, and compliance by employees and patients. However, qualifications with employee training and the need for possible process support also seem to be important.

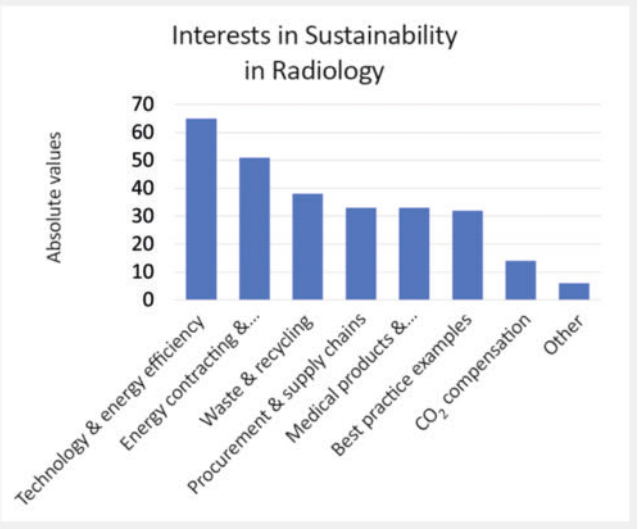
▶ **Table 2** Overview of perceived importance compared to established measures in radiology.

Measures	Perceived importance	Established measures
Waste	22.6 %	23.7 %
Energy reduction	16.5 %	31.6 %
Conscious behavior	13.0 %	7.9 %
No. of examinations	12.2 %	0 %
Digitalization	10.4 %	21.1 %
Workflow optimization	5.2 %	0 %
Finances	5.2 %	0 %
Renewable energies	3.5 %	5.3 %
Diet	0 %	5.3 %

Interests & Information Needs of Respondents

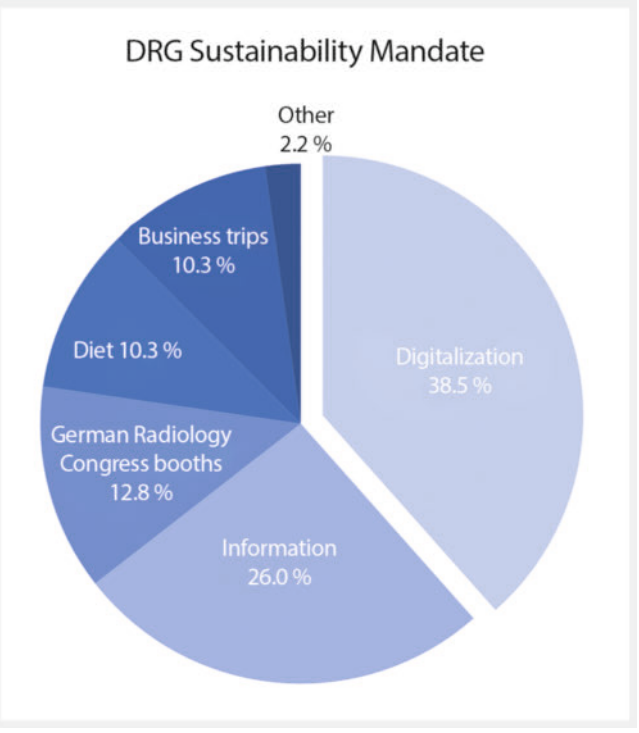
In order to better meet the information needs of radiological staff in the future, interests in eight topics related to sustainability were surveyed (▶ **Fig. 7**). In line with the perceived importance for more sustainable radiology, the majority of participants (59.6 %; N = 65) are interested in technology and energy efficiency

▶ **Fig. 5** Overlaps between established measures in radiology (dark blue) and the sustainability measures that respondents consider most important (light blue).



▶ **Fig. 7** Personal interests in the area of sustainability in radiology.

▶ **Fig. 6** Difficulties in designing sustainable radiology particularly concern employee and patient compliance as well as financing options.



▶ **Fig. 8** Sustainability mandate – what respondents would like to see from the German Roentgen Society (DRG).

as well as energy contracting (46.8 %; N = 51), while CO_2 compensation is of least interest (12.8 %; N = 14).

DRG Sustainability Mandate

▶ **Fig. 8** presents the participants' wishes regarding the DRG sustainability mandate. Topics of digitalization with increased online events and reduced paper use are in the foreground with 38.5 % (105 of 273 responses), followed by the provision of information and the creation of guidelines with a total of 26.0 % (N = 71) (▶ **Table 3**).

Discussion

For almost three-quarters of respondents, sustainability in radiology is important or very important. However, only 38 % of respondents were able to name sustainability measures in their institutes. Waste management, energy reduction, conscious behavior, and reducing the number of obsolete or redundant examinations are considered to be the most important measures for promoting a more sustainable radiology. However, a lack of qualifications, financing

▶ **Table 3** Detailed overview of the total of 273 responses in relation to the participants.

Topic	Responses	Percentage of 109 respondents
Electronic event and participation documents	40	36.7 %
Events or meetings (e. g. at the German Radiology Congress) on the topic of sustainability	40	36.7 %
Sustainable convention booth concepts for the industry	35	32.1 %
DRG guidelines for sustainable procurement to support your own procurement decisions	31	28.4 %
Preferably digital training event formats	29	26.6 %
Sustainable catering at DRG events and committee meetings	28	25.7 %
Necessary business trips only with environmentally-friendly means of transport (train, public transportation)	28	25.7 %
Publication of RÖFO in digital format only	21	19.3 %
Committee meetings as web conferences	15	13.8 %
Other	6	5.5 %

options, and compliance among employees and patients poses challenges for implementing sustainable measures in radiology.

Based on a life cycle analysis of goods and consumption in 33 hospitals, Keller et al. identified electricity, medications (12 %), building infrastructure (15 %), food/catering (17 %), and indoor climate management (26 %) as the most significant causes of CO_2-equivalent emissions in the healthcare sector [9]. In our study, energy reduction is not only considered one of the most important factors for sustainability, but is also the most important area of interest of the respondents at almost 60 %, which is significantly greater than the importance of more sustainable energy, building infrastructure, or diet. Both standby mode of many ultrasound devices and PACS workstations, as well as steady state of CT and MRI devices, are energy inefficient [4, 5, 10]. This means there is a high potential for energy optimization. For example, not only can energy-efficient, low-field MRI reduce energy consumption but it also does not require helium [11]. AI and deep-learning based reconstructions, as well as post-processed denoising, can also achieve higher image quality in shorter acquisition time with corresponding energy reduction per examination [12].

The resulting importance of "turn-off mode" in technical devices also implies compliance and awareness among employees of the importance of turning off devices, which is in line with our survey results: conscious behavior has been classified as the third most important sector for more sustainable radiology. In contrast, compliance appears to be one of the biggest challenges in establishing sustainable measures for 21 % of respondents.

In addition to the ecological sustainability aspect of energy savings, the associated reduction in costs is financially beneficial. This economic aspect is also reflected in the second largest area of interest, "energy saving contracting". In this model, it is not the hospital but an external service provider, the contractor, who bears the costs of investing a new system, e. g. a new heating system. The invested amount is gradually paid off with the saved energy costs, which in the best case creates a win-win situation [13]. A major benefit for the hospital is that the contractor contractually guarantees the energy cost savings. In addition, it provides the know-how for planning, implementation, and operation of the systems, which can reduce the knowledge gaps mentioned by the participants in our study. This can help overcome hurdles in implementing sustainability measures and improve the long-term economic viability of the facility.

In addition to electricity, industrial manufacturing processes at 29 % are one of the world's two largest sectors responsible for CO_2-equivalent emissions [14]. For the participants in our study, however, the sustainability aspect in the manufacturing process is still of secondary importance, although companies are reducing the environmental footprint of radiology devices through optimized infrastructure, as well as renewable energies and refurbishing [15, 16].

In our study, the waste management sector, which was mentioned most frequently by participants in our survey on sustainable radiology, shows a major need to catch up in terms of measures implemented by institutions. However, medical products have a small impact of around 3 % on the emissions associated with the healthcare system, and 45 % of this amount stems from nitrile gloves. As a result, this one factor represents an important element with potential for optimization [9]. According to Keller et al., waste and water consumption accounted for a relatively small share at 5 % of CO_2-equivalent emissions. In addition to the general aspects mentioned, especially with regard to the use of plastic and disposable products, one aspect was raised by many participants in our study: the poorly biodegradable, iodine-containing contrast agent. This is largely excreted via urine and enters the wastewater circulation, extrapolated, for example, to about 200 kg per day into the Rhine [17]. However, sewage treatment plants are unable to adequately remove the contrast agent from the water circulation [18]. In order to ensure that less contrast agent enters the water circulation in the future, the amount of contrast agent can be reduced by optimizing the image contrast, for example, by spectral imaging and post-processing methods [19]. Recycling the contrast medium by collecting the residues in

special disposal containers with subsequent reprocessing is also offered by a range of large manufacturers [20].

In 2023, De Reeder et al. found that despite a high level of awareness for sustainability, interventional radiology staff had taken little or no action in this regard [21]. In our survey, only 38 % stated that sustainable measures had been established in the institute, despite the perceived importance of sustainability in radiology among 74.3 % (N = 81) of participants. In addition to compliance, qualifications (16 %) and financing (21 %) appear to be further challenges for establishing sustainable measures in radiology. The problem is that there is no universal solution for radiology. University hospitals have different requirements than medical care centers. Building technology, infrastructure, and financial possibilities differ. There is currently a lack of individual advice and dynamic support in the process of greening radiology, promoting specialist knowledge in the various sustainability sectors, providing the suitable financing options, and ensuring access to experts regarding concrete implementation.

Limitations

This nationwide survey represents the opinions and existing knowledge of the respondents. To the extent to which there is agreement, for example, with actually established measures and the challenges associated with them cannot be determined from this survey. The questions and responses were not standardized, and the survey was not conducted in a standardized manner, resulting in factors influencing the study results. A pre-selection bias cannot be ruled out due to a possibly disproportionate participation of people with a particular interest in the topic of sustainability. Due to the anonymity of survey participation, it is not possible to collect geographical data and thus validate the representativeness of the study population for the potential target population. Despite extensive recruitment efforts by the DRG and the authors, only 109 people were recruited to participate. Furthermore, some of the questions could only be answered by a few participants (e. g. institutional challenges N = 18). So the representativeness is limited and varies depending on the number of responses per question. Nevertheless, this study was the first to provide an overview of the opinions of radiology staff with regard to sustainability.

Conclusions

Our study shows a discrepancy between the importance of sustainability in radiology, which is perceived by the majority (74.3 %) as important to very important, and the current reality, as only 38 % of respondents were able to name established sustainability measures at their institute. Waste management, energy reduction, conscious behavior, and reducing the number of obsolete or redundant examinations are considered by the participants in our survey to be the most important measures for more sustainable radiology. At the same time, a lack of qualifications, financing options, and compliance among employees and patients pose challenges for implementing sustainability measures in radiology. Addressing these challenges in a targeted manner in the future can help increase the proportion of established measures in radiology. At the same time, technical innovations are required, particularly to reduce the energy consumption of large appliances. The results of the survey underscore the broad scope of the topics to be addressed for more sustainable radiology and highlight the need for a dynamic context of science, industry and practice/hospital operators as well as radiological staff in order to enable a climate-resilient, future-oriented healthcare system in the future.

Clinical Relevance of Study

- In the clinical-radiological context, the majority (N = 81; 74.3 %) consider sustainability to be important to very important.
- Measures established in radiology have some catching up to do compared to those considered important in almost all subareas, especially waste management, including contrast medium recycling, energy-efficient large imaging device innovation, and behaving more consciously when determining the indication, as well as workflow optimization while preventing duplicate examinations.
- Renewable energies (3.5 %) currently have little importance in radiology, where interests are dominated by the topics of technology/energy efficiency (59.6 %) and energy contracting (46.8 %).
- There is a desire for better information availability, concrete assistance, qualifications/training in sustainability management, and valid guidelines on the topic of sustainability in radiology.
- Sensitivity in everyday clinical practice is necessary to drive progress, enable a climate-resilient, future-oriented healthcare system, and compensate for health consequences.

Acknowledgement

Special thanks go to the DRG, in particular to Nina Franke and Dr. Martin Völker for their support of the study with regard to the publication and advertising of the questionnaire. The authors would also like to thank the “Nachhaltigkeit@DRG” network and the “Forum Junge Radiologie”, in particular the respective chairpersons Dr. Isabelle Redenius and Dr. Isabel Molwitz, for their general support and and promotion of the study.

Conflict of Interest

Benedikt J. Schwaiger is a partner and employee at Raya Diagnostics GmbH, Munich. Viktoria Palm is an employee at Raya Diagnostics GmbH, Munich

References

[1] Palm V, Heye T, Molwitz I et al. Sustainability and Climate Protection in Radiology – An Overview. Rofo 2023. doi:10.1055/a-2093-4177

[2] Palm V, Molwitz I, Rischen R et al. Sustainability and climate protection: Implications on patient-centered care in radiology. Radiologie (Heidelb) 2023; 63: 672–678. doi:10.1007/s00117-023-01199-4

[3] Ärztetag für Klimaneutralität des Gesundheitswesens bis 2030. Bundesärztekammer 2021. Accessed January 26, 2024 at: https://www.bundesaerztekammer.de/presse/aktuelles/detail/aerztetag-fuer-klimaneutralitaet-des-gesundheitswesens-bis-2030

[4] Heye T, Knoerl R, Wehrle T et al. The Energy Consumption of Radiology: Energy- and Cost-saving Opportunities for CT and MRI Operation. Radiology 2020; 295: 593–605. doi:10.1148/radiol.2020192084

[5] Woolen SA, Becker AE, Martin AJ et al. Ecodesign and Operational Strategies to Reduce the Carbon Footprint of MRI for Energy Cost Savings. Radiology 2023; 307: e230441. doi:10.1148/radiol.230441

[6] Energy consumption. Federal Statistical Office. Accessed February 06, 2024 at: https://www.destatis.de/EN/Themes/Society-Environment/Environment/Material-Energy-Flows/Tables/electricity-consumption-households.html

[7] Schreyer AG, Schneider K, Dendl LM et al. Patient Centered Radiology – An Introduction in Form of a Narrative Review. Rofo 2022; 194: 873–881. doi:10.1055/a-1735-3552

[8] Molwitz I, Kemper C, Stahlmann K et al. Work expectations, their fulfillment, and exhaustion among radiologists of all career levels: what can be learned from the example of Germany. Eur Radiol 2023. doi:10.1007/s00330-023-09510-6

[9] Keller RL, Muir K, Roth F et al. From bandages to buildings: Identifying the environmental hotspots of hospitals. Journal of Cleaner Production 2021; 319: 128479. doi:10.1016/j.jclepro.2021.128479

[10] Ninan TM, Vardhanabhuti V, Nensey R et al. Footprint of your images. ECR 2010 EPOS 2010. Accessed January 23, 2024 at: https://epos.myesr.org/poster/esr/ecr2010/C-2946

[11] Klein H-M. Low-Field Magnetic Resonance Imaging. Rofo 2020; 192: 537–548. doi:10.1055/a-1123-7944

[12] Feuerriegel GC, Weiss K, Kronthaler S et al. Evaluation of a deep learning-based reconstruction method for denoising and image enhancement of shoulder MRI in patients with shoulder pain. Eur Radiol 2023; 33: 4875–4884. doi:10.1007/s00330-023-09472-9

[13] Ärzteblatt DÄG Redaktion Deutsches. Nachhaltigkeit: Das grüne Krankenhaus. Deutsches Ärzteblatt 2013. Accessed January 30, 2024 at: https://www.aerzteblatt.de/archiv/147581/Nachhaltigkeit-Das-gruene-Krankenhaus

[14] Gates B. My message at COP: Invest in innovations that save and improve the most lives. gatesnotes.com. Accessed January 23, 2024 at: https://www.gatesnotes.com/COP28-World-Climate-Action-Summit

[15] Nachhaltigkeit in der Radiologie: Mehr als nur CT im Energiespar-Modus. Accessed January 26, 2024 at: https://healthcare-in-europe.com/de/news/nachhaltigkeit-radiologie-energiespar-modus-siemens.html

[16] Philips macht weiterhin deutliche Fortschritte in Richtung ESG-Ziele 2025. Philips. Accessed January 26, 2024 at: https://www.philips.de/a-w/about/news/archive/standard/news/2023/202302-philips-macht-weiterhin-deutliche-fortschritte-in-richtung-esg-ziele-2025.html

[17] Auswertungsbericht Röntgenkontrastmittel. 2011. Accessed January 30, 2024 at: https://www.iksr.org/de/oeffentliches/dokumente/archiv/fachberichte/fachberichte-einzeldarstellung/187-auswertungsbericht-roentgenkontrastmittel

[18] MERK'MAL. MERK'MAL 2018. Accessed January 26, 2024 at: https://merkmal-ruhr.de

[19] Shuman WP, Chan KT, Busey JM et al. Dual-energy CT Aortography with 50 % Reduced Iodine Dose Versus Single-energy CT Aortography with Standard Iodine Dose. Academic Radiology 2016; 23: 611–618. doi:10.1016/j.acra.2015.12.019

[20] Dekker HM, Stroomberg GJ, Prokop M. Tackling the increasing contamination of the water supply by iodinated contrast media. Insights Imaging 2022; 13: 30. doi:10.1186/s13244-022-01175-x

[21] de Reeder A, Hendriks P, Plug-van der Plas H et al. Sustainability within interventional radiology: opportunities and hurdles. CVIR Endovasc 2023; 6: 16. doi:10.1186/s42155-023-00362-1