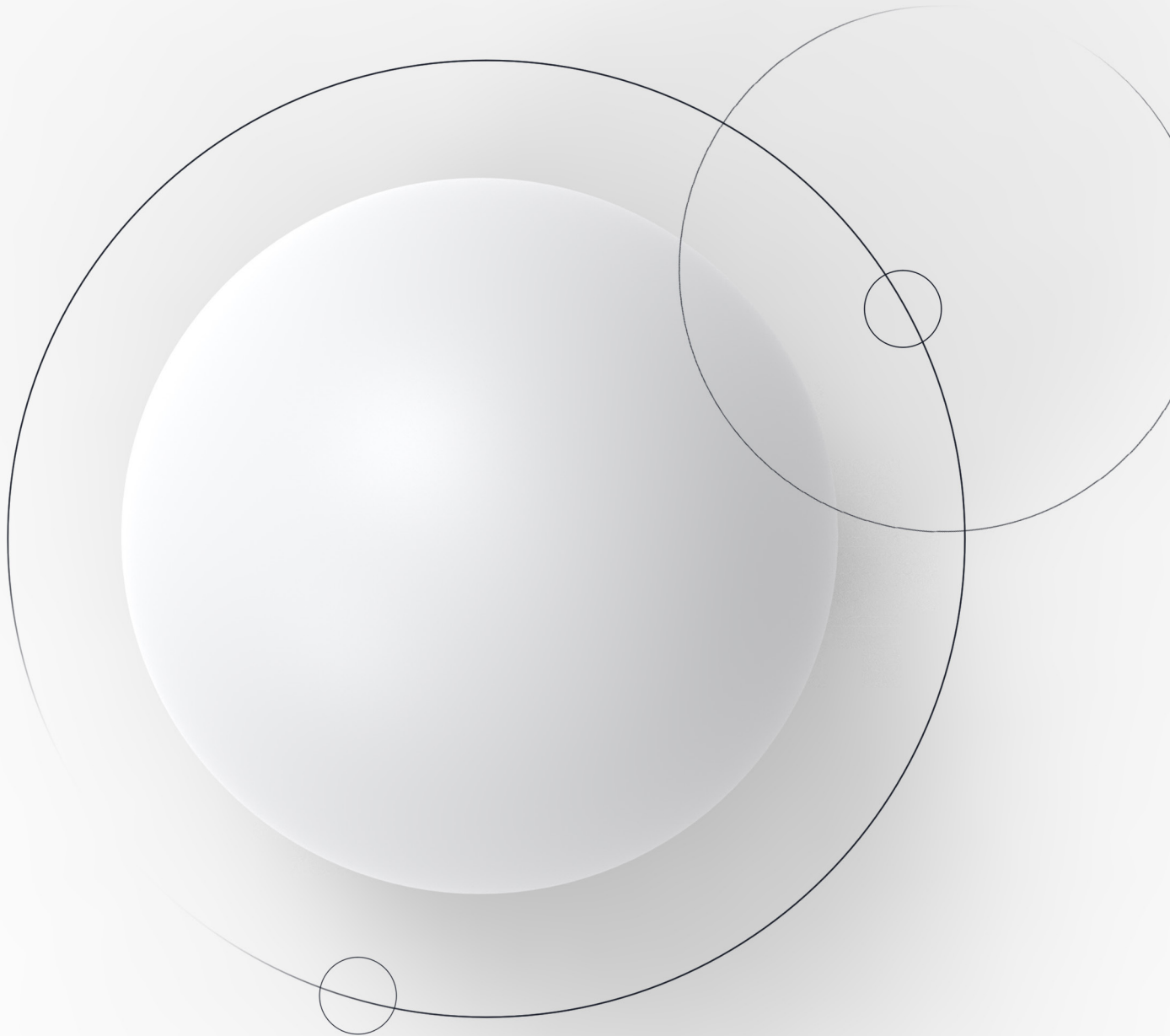


ESG (Environmental, Social, Governance) in Radiology Workflow to drive Strategic Business Value of University Hospitals in the Netherlands



Hyelin Lee

30 June 2023

ESG (Environmental, Social, Governance) in Radiology Workflow to drive Strategic Business Value of University Hospitals in the Netherlands

Author

Hyelin Lee
MSc Strategic Product Design
Faculty of Industrial Design Engineering
Delft University of Technology

Thesis committee

Chair

Prof. Dr. Ir. J.C. Diehl
Department of Industrial Design Engineering

Supervisor

Prof. Dr. S. (Saba) Hinrichs-Krapels
Department of Technology, Policy and Management

Mentor

E. Pupazan
Circular Economy Strategic Innovation Lead

Thesis

submitted in fulfilment of the requirements for the degree of Master of
Science in Strategic Product Design
at the Delft University of Technology,
to be defended in public
on June 30, 2023
at 11:00 a.m. in the Wim Crowel IDE.

Acknowledgments

This project has been a privilege to explore a subject very close to my heart. I want to thank my supervisors, mentor, project stakeholders, friends, and family for their support. Without each and everyone's contribution, reaching this outcome would not have been possible.

Thanks to my TU Delft supervisors, JC and Saba, for their commitment to the topic, constructive feedback, and trust in my ability to lead. Moreover, I appreciate the freedom I have been given in shaping this research.

Thanks to my mentor, Elena, who has tremendously supported me to grow and conduct this study. Her guidance for my graduation project led me to immerse myself in multifaceted aspects of the ESG topic, such as business strategy, ecosystem innovation, and systems change management. Her practical and holistic views on ESG and the future of healthcare had a powerful effect on me, both in my studies and personally.

Thanks to all project stakeholders from Erasmus MC, LUMC, Amsterdam UMC, UMC Utrecht, Radboud UMC, Alzijne Hospital, and NVvR (Nederlandse Vereniging voor Radiologie) for their commitment to the cause, their belief in the urgency for change, and their willingness to contribute with precious time and energy, in-between clinical responsibilities, in all the steps of the research: interviews, field research, co-creation, and validation workshops. I appreciate them for being vocal about the current challenges, as well as their concrete actions and inspiring leadership in driving ESG as a priority in Radiology and Healthcare at Large.

Thanks to my parents for their endless support and for nurturing a positive mindset. The last two years of full-time education aside a full-time job were extremely challenging, only their love and encouragement carried me through and up to the completion of this study.

Thanks to my friends, Emma S., Emma Y., and Maren, for being with me in good and bad times.

Thanks to my love, Tom, for accompanying me on this journey. Thank you for always being positive and supportive.

To everyone reading this thesis, happy reading!

Hyelin Lee

Executive summary

Healthcare is an essential part of our lives, promoting and preserving the health of individuals and society. The industry has been evolving at a high pace over the last few decades, driven by technology and growing care demands. This progress is currently having an opposite effect on the overarching objective of serving healthy living due to the increasing environmental footprint and social toll of the industry. Today, healthcare accounts for nearly 4.4% of global CO2 net emissions worldwide, while in the Netherlands, the sector accounts for about 7% of the national footprint. In particular, Radiology represents a clinical area of great concern, being a major contributor to the healthcare carbon footprint due to its high energy consumption and hazardous waste generation. Furthermore, Radiology professionals face heavy workloads due to rising demands for imaging exams, driven by patient expectations on the one hand, and the convenience of leading doctors, as well as existing differences in protocols across hospitals, on the other hand. These complex Environmental, Social, and Governance (ESG) challenges must be approached in an integrated way, to effectively enable the embedding of sustainable practices at the core of healthcare, accelerating in this way the transition towards a circular economy across the industry. This research aims to provide broad and deep insights into the Radiology ecosystem in the Netherlands, ESG definition guidance, and an end-to-end ESG strategic design toolkit that aims to simplify, measure, and integrate ESG efforts across healthcare. An integrated department-, hospital-, national-, and global approach is being proposed to streamline efforts towards 2030 ESG goals and beyond.

A systemic design approach is proposed for this study, combining mixed methodologies of qualitative, quantitative, and co-creation efforts with cross-disciplinary experts from six university hospitals, as well as the national Radiology association in the Netherlands. The steps towards framing, prioritizing, and embedding ESG into the Radiology workflow are consistently captured as research findings, concluding contextual insights on the ESG impact across the different levels of the system. These are represented as an ESG pyramid in this study. Identifying key ESG healthcare challenges and influential entities in the system offers a foundation for strategic dialogues on ESG goals definition. Additionally, an ESG healthcare ecosystem map has been developed to further understand the dynamics among key system stakeholders, on three main dimensions: financial, clinical compliance, and ESG. The perspective of embedding ESG in Radiology, within the Netherlands, is taken as a representative industry case study. Consolidation of clinical workflow data, operational insights, and current ESG context resulted in a cross-hospital view of Radiology ESG hotspots, dependencies, and opportunities. Interventions on ESG hotspots are then addressed and positioned, at corresponding decision power levels, within the larger system. Furthermore, a solution for integrated ESG value-impact measurement and continuous monitoring is proposed. Such a simplified and transparent way of working has the potential to increase awareness, drive collaboration, significantly reduce ESG spending and identify new circular value opportunities.

The outcomes of this research indicate that embedding ESG hotspots into the Radiology workflow should be approached in a holistic and systemic way. The ESG strategic design toolkit can facilitate relevant dialogues on the value and impact of ESG interventions across levels in the healthcare ecosystem, enabling hospitals and departments to effectively define ESG goals and programs. This simplifies complexity and provides consistency across the broader system hierarchy.

Keywords: ESG, Sustainability, Circular Economy, Radiology workflow, Healthcare Ecosystem



Table of Contents

Acknowledgments	5	Chapter 5: Positioning Radiology ESG Hotspots in the Healthcare Ecosystem	62
Executive summary	6	5.1 Introduction to ESG Pathways on System Levels	64
List of Abbreviations and Glossary	10	5.2 ESG Interventions Actionable by Radiology (Bottom-Up)	66
		5.3 ESG Transformation at Industry Level by Systemic Change (Top-Down)	66
		5.4 Bi-Directions of ESG Transformation	67
Chapter 1: Introduction	16	Chapter 6: Measurements of ESG in Hospital and Radiology	68
1.1 Background	14	6.1 How can ESG be Measured as a Business Driver?	70
1.2 Problem Description	15	6.2 ESG Value-Impact Score Card for Hospital	70
1.3 Project Stakeholders	16	6.3 ESG Value-Impact Score Card for Radiology	72
1.4 Project Assignment	17	Chapter 7: Consolidating ESG Strategy Toolkit	74
1.4.1 Ultimate Goals	17	7.1 Summary of ESG Strategic Design Process and Toolkit	76
1.4.2 Research Question	17	7.2 Building the System View	78
Chapter 2: Methodology	18	7.3 Identifying ESG Hotspots in Clinical Workflow	80
2.1 Introduction to Method	20	7.4 Mapping ESG Interventions on System Levels	80
2.2 Systemic Design Approach	20	7.5 Continuous Monitoring of ESG Value and Impact	81
2.3 Research Design Process	20	Chapter 8: Conclusions	82
2.3.1 Research Design Process Steps	21	8.1 Conclusion	84
2.3.2 Research Design Methods and Tools	23	8.2 Limitation	86
2.3.3 Data Collection and Interpretation	27	8.3 Recommendations to Future Research	86
2.4 ESG Definition for Healthcare	30	8.4 Personal Reflection	87
2.5 What is Radiology?	31		
Chapter 3: Analysing the ESG Pyramid	32	References	90
3.1 Introduction to Analysis	34		
3.2 ESG Pyramid	34	Appendices	96
3.3 Global ESG Driving Forces	36	Appendix A: EU and Dutch University Hospitals' ESG Goals and Roadmap	97
3.4 EU and Global ESG Healthcare Trends	38	Appendix B: ESG opportunities in Radiology Workflow	99
3.5 ESG Initiatives in University Hospitals in the Netherlands	39	Appendix C: Survey Results	104
3.6 Impacts of ESG on Radiology Clinical Workflow	42	Appendix D: Co-creation Blueprint	106
Chapter 4: Framing ESG Value and Impact in Radiology Workflow	44	Appendix E: ESG Transformation Strategy through the Integration Funnel	108
4.1 Introduction to Results	46	Appendix F: Project Brief	109
4.2 ESG Definition for Radiology	46		
4.3 Healthcare Ecosystem Map in the Netherlands	47		
4.4 Addressing ESG Challenges in Radiology Workflow	51		
4.5 Identifying ESG Hotspots in Radiology Workflow	52		
4.6 Opportunities to address ESG Hotspots in Radiology Workflow	58		

List of Abbreviations and Glossary

Abbreviations

APH	Amsterdam Public Health research institute
CE	Circular Economy
CO2	Carbon dioxide
CSR	Corporate Social Responsibility
CT	Computed Tomography
ESG	Environmental, Social, and Governance
EU	European Union
IPCC	Intergovernmental Panel on Climate Change
MRI	Magnetic resonance imaging
NFU	Nederlandse Federatie van Universitair Medische Centra
NVvR	Nederlandse Vereniging voor Radiologie
SDG	Sustainable Development Goals
UNEP	United Nations Environment Programme
UNDP	United Nations Development Programme
WHO	World Health Organization

Glossary

ESG (Environmental, Social, and Governance)

ESG is a framework designed to be embedded into an organization's strategy to generate value for all stakeholders in relation to environmental, social, and governance criteria. Following its formal proposal in 2004, the sustainable development of the global economy and society, called ESG principles, has been developed for 17 years (Li et al., 2021).

Ecosystem map

An ecosystem map is a visual representation of the various stakeholders, entities, and factors that interact with a particular system, illustrating the relationships and dependencies among them. It can be used to identify opportunities for collaboration, anticipate potential challenges, and create a shared understanding of the complex system.

CE (Circular Economy)

Circular economy is an economic model aimed at creating a closed-loop system where resources are used and reused efficiently, waste is minimized, and the environment is protected. Instead of the traditional linear model of take-make-waste, the circular economy focuses on a regenerative approach, where waste is considered a valuable resource and reused or recycled (Korhonen et al., 2018).

Radiology Workflow

Radiology workflow refers to the sequence of steps and processes involved in the delivery of radiological services, including the ordering of studies, the scheduling of appointments, the acquisition and interpretation of images, and the communication of results to referring physicians and patients.

Sustainability

In 1972, sustainability was first used in a similar context to today, regarding the future of humanity. The Brundtland Report from 1987 introduced the first "official" definition of sustainable development. Sustainability is the ability to meet the needs of the present generation without compromising the ability of future generations to meet their own needs. This includes social, environmental, and economic dimensions and requires an integrated approach to decision-making that balances the three pillars of sustainability: the social, environmental, and economic pillars (Brundtland, 1987).

Chapter 1

Introduction

This chapter provides the background and significance of the thesis, followed by the problem description and research question addressed in this thesis, project stakeholders and assignments.



1.1 Background

The buzz surrounding sustainability in healthcare is ultimately driven by the goal of improving human and planetary health. This is welcomed and important, in the context that today the healthcare sector contributes significantly to the climate crisis, accounting for nearly 4.4% of global CO2 net emissions, twice as much as the aviation industry (Health Care Without Harm, 2019). According to Kumar et al. (2021), hospitals are among the top consumers of energy and water, as well as greenhouse gas emissions and waste producers, including significant amounts of hazardous waste.

The UN 2030 Agenda for Sustainable Development (Transforming Our World: The 2030 Agenda for Sustainable Development, n.d.) and the IPCC reports (Reports — IPCC, n.d.) acknowledge the urgent global context and the unprecedented challenge of preventing the temperature from rising to 1.5°C. The European Commission aims to cut greenhouse gas emissions by at least 55% by 2030, putting Europe on a responsible path to becoming climate neutral by 2050 (2030 Climate Target Plan, n.d.).

In 2017, the EU introduced the overarching sustainable finance program to lead more long-term investments in sustainable economic projects and activities (Overview of Sustainable Finance, 2021). In order to mobilize capital flows toward a more sustainable economy, the EU Commission adopted the action plan on sustainable finance in 2018, which is constantly updated (Renewed Sustainable Finance Strategy and Implementation of the Action Plan on Financing Sustainable Growth, n.d.).

According to the UN Global Compact Strategy 2021–2023, the world is not on track to achieve the 2030 Agenda for Sustainable Development Goals (SDGs). Studies emphasize that today we are in the grips of a climate crisis, as well as a public health and economic crisis. The UN Global Compact, which was founded in July 2000, articulated its operations and strategies based on ten universal principles in the areas of human rights, labour, the environment, and anticorruption in their 2021–2023 strategy. The UN Global Compact Strategy aims to accelerate and scale the global collective impact of business by implementing core ESG principles, and the adoption of the SDGs by responsible companies and ecosystems (UN Global Compact Strategy 2021–2023 | UN Global Compact, 2021).

People's health and well-being are increasingly impacted by climate change (Health Care Without Harm, 2019). The World Health Organization (WHO) has also recognized the importance of sustainability in healthcare and has developed a WHO Global Strategy on Health, Environment, and Climate Change (WHO Global Strategy on Health, Environment, and Climate Change, 2020). This highlights six strategic green transformation objectives, shared across various healthcare sectors.

In the Netherlands, healthcare accounts for 7% of the national footprint in terms of CO2 emission equivalent. In addition, 4% of the waste and 13% of the used raw materials (metals and minerals) can be attributed to healthcare in the Netherlands (Steenmeijer et al., 2022). Since 2018, more than 200 stakeholders in the healthcare sector have signed pledges and agreements with the Dutch government on a Green Deal towards a Sustainable Care in the Netherlands. On November 4, 2022, the most recent Sustainable Care Green Deal 3.0 agreement was signed, consolidating five shared themes and objectives for the horizon 2023–2026 (Green Deal Samen Werken Aan Duurzame Zorg (Green Deal 3.0) | Greendeals, 2022):

- More focus on preventive health
- Increasing awareness and knowledge across healthcare professionals and patients
- 55% less direct CO2 emissions in 2030 and climate neutral in 2050
- 50% less primary use of raw materials in 2030 compared to 2016 and maximum circular care in 2050
- Reducing the environmental impact of and in medication

Primarily, ESG (Environmental, Social, Governance) aims to accelerate fostering sustainability in healthcare, by promoting, transforming, and governing responsible practices. This allows healthcare organizations to prioritize and formalize specific objectives and shared efforts. Adopting ESG across healthcare poses major challenges due to the complexity of operations, stakeholder structures, financial limitations, and conservative industry culture (2030 Climate Target Plan, n.d.).

This graduation project aims to clarify and connect the global and national contexts, proposing a study and framing of ESG as a value driver at the hospital level. As an industry representative case study, the researcher dives into one specific clinical area, Radiology, for an end-to-end assessment. Due to its high energy-consuming equipment and waste from interventional treatments (Woolen et al., 2023), as well as increasing demand and an overworked workforce (Health Workforce, 2023), Radiology is one of the clinical areas with the largest health carbon footprints.

MRI, for example, has a significant resource and carbon impact; rare earth substances like Helium; high energy consumption; heavy shipment, and many non-recyclable materials are being used. The need for storage in radiologic data centres has increased dramatically over the past five years, with an annual average of 23%, raising the ecological cost of big data (Buckley & MacMahon, 2021). Radiology workforce worldwide reports experiencing moderate or severe levels of job stress due to a high workload. This extensive effort is contrasted by an increasing behavioural trend of patient of 'no-show', impacting care delivery outcomes and effective human and financial resource management (Mieloszyk et al., 2019). Therefore, understanding in depth the ESG challenges and hotspots in Radiology, how to prioritize, position, and monitor corresponding ESG interventions, will provide a reliable blueprint and valuable case study for other clinical areas across healthcare.

1.2 Problem Description

Given the urgency of the global climate crisis (Reports — IPCC, n.d.), the projected continued growth of the world's population (World Economic Forum, 2022), the turning point in the quality of life, the rise of chronic health issues (Whiteford et al., 2013), and the increased use of technology (Erdal, 2018), we need to cross-connect emerging issues and find integrated solutions in order to be timely with solutions and effective in resource management (Health Care Without Harm). The complexity of the healthcare system and its growing impact on the three pillars of sustainability (Environment, Social, and Economic) calls for a radical new holistic approach to drive effective decision-making on investments, changes to protocols and regulations, or larger healthcare system redesign. In these tight internal and external contexts, hospitals tend to relate to ESG as an add-on limiting factor, rather than a structural system intervention for driving world health and business value.

Research on sustainable healthcare and Radiology is becoming more prevalent in the healthcare fields, although much of it focuses solely on the three pillars of ESG:

- **"Environmental"**: Buckley & MacMahon (2021) emphasize the importance of research on sustainability for Radiology, because technology consumes high energy and has a substantial role in this specialty.
- **"Social"**: Over the last few decades, the workload of Radiology professionals has grown significantly, from medical imaging equipment solutions to the complexity of cross-sectional examinations performed per session and data handling activities (Catalina Imaging, 2020).
- **"Governance"**: Since its beginnings, the field of Radiology has had tremendous success, evolving from a support system for clinical decision-making to an essential element of multidisciplinary patient care. Modern radiologists have today a complicated and multifaceted job, due to the evolving interdependencies of Radiology and other clinical fields. Technological and social trends will determine how Radiology as a field and servicing will develop in the future (Brady et al., 2022).

Government and healthcare authorities play an important role and have the power to enact rules and set standards. The Dutch government is set to implement the "Green Deal Sustainable Healthcare" with more than 200 public and private industry members; however, there is little clarity on the roadmap, specific deliverables, and governance model to manage the engagement and commitments of the participating organizations (Reeder et al., 2023). Therefore, the government must take ownership and adopt a more proactive and structured approach to drive change beyond ESG initiatives as voluntary and personal initiatives (Brassil & Torreggiani, 2019).

Collaboration with other hospitals and medical associations is also essential for sharing knowledge, strategies, and an overarching future vision. Collaboration across the healthcare value chains and "open innovation" can drive significant improvements in sustainability (Lopes et al., 2017). The complexity of ESG in Radiology asks for holistic approaches to effectively reduce the impact of the healthcare industry and shift towards a circular economy (Hinrichs-Krapels et al., 2022). The integrated approach for addressing environmental, social, and governance changes is relatively new and will be an evolving subject.

1.3 Project Stakeholders

The graduation project is organized in collaboration with Erasmus MC (Erasmus Medical Center) as a primary stakeholder, and five other university hospitals in the Netherlands, in order to investigate cross-ESG challenges and opportunities for a shared vision and collaborative transformation. To achieve these goals, the researcher has engaged with key stakeholders from the LUMC (Leiden University Medical Center), Amsterdam UMC (Amsterdam University Medical Center), UMC Utrecht (University Medical Center Utrecht), Radboud UMC (Radboud University Medical Center), and Alrijne Hospital Leiden, as well as the national healthcare association for Radiology NVvR (Nederlandse Vereniging voor Radiologie).

The primary stakeholders for this study are categorized into two groups of professions: [1] ESG leads who prioritize sustainability programs in their hospital, publish annual hospital sustainability reports, or drive sustainability in procurement, and [2] Radiology experts (Radiologists, Technologists, or Radiology group leaders), who provide diagnosis and treatment for patients, are actively involved in sustainable initiatives, as part of a sustainability working group within a hospital, or act broader across the industry, as members of the green programs under the national association for Radiology (NVvR).

1.4 Project Assignment

1.4.1 Ultimate Goals

The graduation project aims to provide guidance and an end-to-end toolkit for hospitals, Green Teams, and particularly Radiology departments, to effectively contribute and help in achieving the national and global ESG goals. Taking a systemic approach and through collaboration with key ecosystem partners, the research strives to identify ESG strategic business value for hospitals, address key ESG hotspots in Radiology workflow, and provide an integrated measurement mechanism of ESG impact and value at department and hospital levels, connected to the external context of global and EU ESG initiatives.

1.4.2 Research Question

The study is motivated by the open questions and practical challenges of how ESG interventions can create strategic value, in the short and long term, effectively contributing to global and EU set goals. EU has set a target of reducing greenhouse gas emissions by at least 55% by 2030 and reaching net-zero emissions by 2050 (2030 Climate Target Plan, n.d.). The research additionally delves into how Radiology departments and hospitals prioritize, assess, and scale their initiatives to achieve these objectives. The main research question is defined as follows:

“How can ESG principles/policies be embedded in Radiology workflows?”

The answers are addressed through a systemic design approach, following the research methodology described in the next chapter.



Chapter 2

Methodology

This chapter describes the research methodology and design process, including the tools applied and data collection and interpretation. Later in this chapter, the theoretical foundation of ESG definition is presented later in this chapter, along with how it relates to healthcare. This chapter concludes with an introduction to the clinical and operational context of Radiology.

2.1 Introduction to Method

ESG encompasses a wide range of factors that go beyond the scope of a single problem-solving. The objective of the method presented in this chapter is to illustrate how systemic design approach facilitates end-to-end design process to strategically govern complexity. It also describes the process of interpreting data from qualitative (interviews), quantitative (surveys) and co-creations. The next section of the chapter provides background information on ESG definition for healthcare. In order to better understand the clinical workflow, stakeholders, and systems involved, this chapter ends with a definition of Radiology.

2.2 Systemic Design Approach

Complex societal problems such as sustainability have a significant impact across multiple interconnected institutions, organizations, phenomena, and stakeholders (DeTombe, 2001) and how they will continue to function over time. Instead of tackling problems from a single point of view, systemic design approaches them holistically, recognizing that the nature of problems is interrelated and cannot be solved alone (Bijl-Brouwer & Malcolm, 2020). Creating a “designerly practice” of framing problems from multiple perspectives can lead to new avenues for solutions (Dorst, 2011).

What does “systemic approach” mean in healthcare industry? Hinrichs-Krapels et al. (2022) highlights the importance of a quadruple-helix approach, which involves cross-disciplinary and cross-sectoral research and implementation across industry, government, academia, and the society/public. This approach encourages multidisciplinary and participatory approaches that consider the perspectives and needs of all stakeholders.

Systems thinkers have contributed to tackling challenging societal problems, particularly sustainability challenges, by adopting various approaches and methods and by providing valuable strategies, tools, and procedures (Espinosa et al., 2008). Classification of systems approaches has developed by Diehl J.C. et al. (2019) to identify appropriate criteria for incorporating systems thinking into the design process and provide a conceptual framework for systems thinker to tackle the complex societal problems.

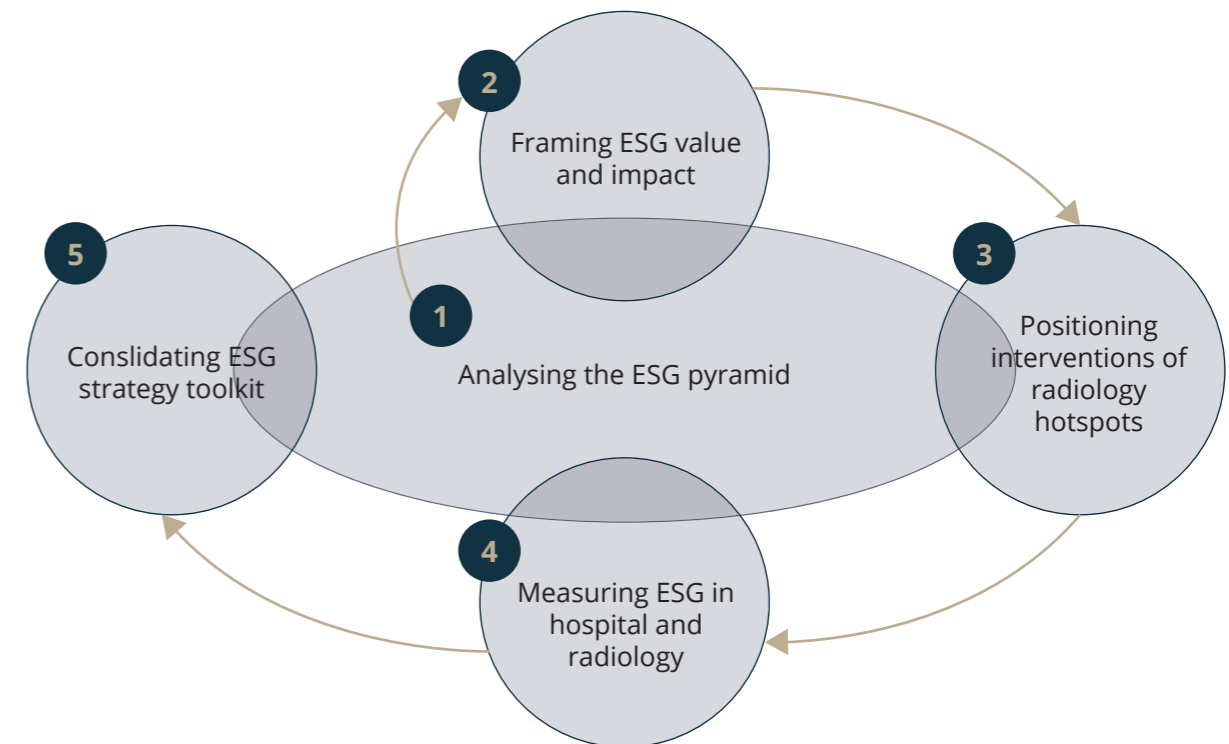
The researcher has chosen the systemic design approach to view the problems as part of a larger system and solve them by considering the relationships between different components of the system. Building a systemic design competence which referred by Diehl J.C. et al. (2019), the researcher also aspires to co-create with stakeholders to reach a shared understanding of complex challenges and co-design an end-to-end process, including supporting tools, that can enable them to effectively define, prioritize, measure and monitor the impact and value of potential interventions and solutions (as presented in Figure 1). Co-creation, participation, and interactive learning are considered fundamental principles for this research.

2.3 Research Design Process

The research takes on ambitious macro- and micro- objectives, addressing complex and interrelated challenges concerning the planet, the people and the systemic transformation processes in healthcare. Therefore, the research design process requires a number of steps of insights gathering, context setting and forward looking, in co-creation with multiple stakeholders. The proposed research design process is illustrated in Figure 1 and has five steps: [1] analysing the ESG pyramid as the fundamental

base, [2] framing ESG value and impact, [3] positioning interventions of Radiology ESG hotspots, [4] measuring ESG in Radiology and at Hospital level, and [5] consolidating ESG strategy toolkit with the research conclusions.

Figure 1. ESG Research Design Process



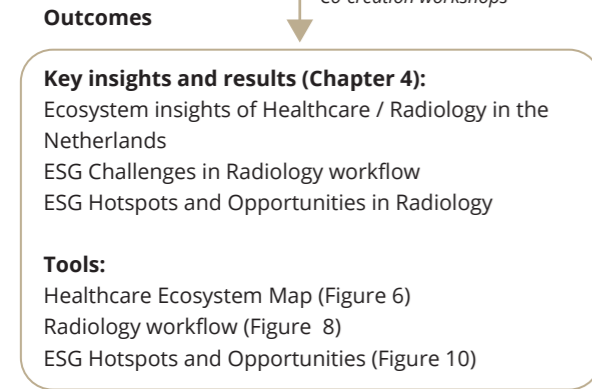
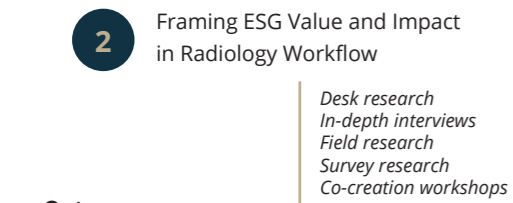
2.3.1 Research Design Process Steps

Step 1: Analysing the ESG Pyramid

The research starts by examining widely and deeply the developments of ESG policy programs, frameworks, trends, and initiatives at global, EU and national level, in the Netherlands. It also considers what mechanisms and resources are already available to use across university hospitals in the Netherlands, as well as where there are still significant gaps and challenges in the Radiology workflow today. This phase is concluded with a perceptual framing of the ESG Pyramid and the challenges for each of the identified pyramid levels in acting, collaborating, and scaling ESG for systemic impact in healthcare. Step 1 of the research design process will be addressed in depth in Chapter 3.



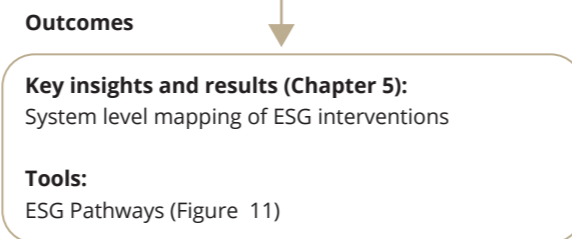
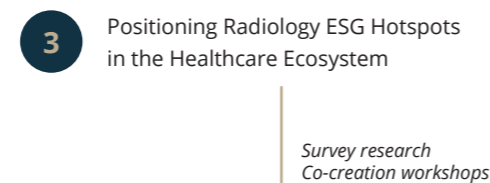
Step 2: Framing ESG Value and Impact in Radiology Workflow



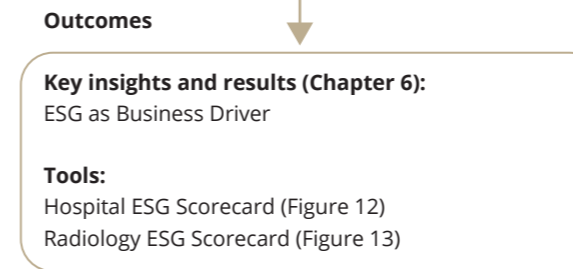
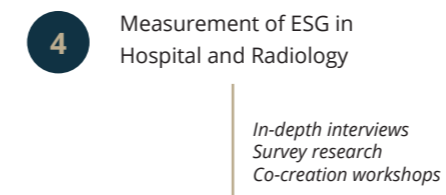
Further context of understanding is gathered with a group of ESG leads and Radiology experts across hospitals and decision-making entities in the Netherlands, to collect different types of knowledge or perspectives on ESG priorities, engagements, and challenges. In this phase, in-depth interviews and field research are conducted, and the protocols are described in Chapter 2.4.2 Research Design Methods and Tools. Furthermore, the researcher framed a Healthcare Ecosystem Map in the Netherlands to comprehend the decision power and dynamics between entities, with a mapped ESG Hotspots and Opportunities in the Radiology workflow. The research introduces the notion of ESG hotspots to highlight high value-impact intervention areas in Radiology, as described in Chapter 4.5. Chapter 4 presents all other Step 2 outcomes.

Step 3: Positioning Radiology ESG Hotspots in the Healthcare Ecosystem

In order to leverage ESG hotspots to drive action, it is necessary to identify which entities or actors can drive hotspots in healthcare ecosystem and work towards long-term solutions that benefit both healthcare and the larger society. ESG Intervention pathways across the ecosystem are then investigated for the identified ESG hotspots. Three directions of pathways are concluded: **bottom-up** (initiated and driven across the system by the Radiology department level itself), **top-down** (initiatives that must be driven by higher system levels for standardization and uniform transformation across the industry), and **bi-directional** (where parallel and collaborative top-down and bottom-up strategies are required to reach viable solutions). In this step, the researcher facilitated a series of Co-creation workshops with stakeholders who had previously been interviewed, to validate the assumptions as well as to create a sense of ownership and shared responsibility for driving change. In preparation for co-creation, a survey using Microsoft Forms was conducted to introduce stakeholders to the goals and setup of the workshops, collecting preliminary data. In Chapter 2.4.2 Research Design Methods and Tools, each protocol is presented. Step 3 outcomes will be presented in Chapter 5.



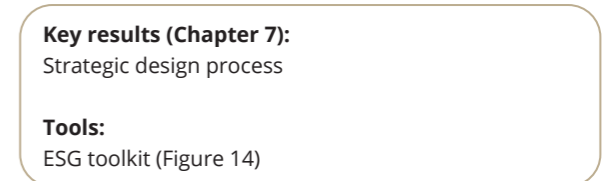
Step 4: Measurement of ESG in Hospital and Radiology



A standard for measuring the sustainable development initiatives of various businesses in the industry is necessary for an efficient and reliable evaluation system (Li et al., 2021). Measuring is crucial for identifying undesirable ESG trends, illustrating the impact of potential interventions, and demonstrating the short- and long-term value of ESG investments. The researcher creates a prototype measurement instrument called the ESG Value-Impact Scorecard that incorporates the important measuring criteria at the hospital and department levels (in this research, Radiology). This tool was validated with stakeholders through the surveys and during the Co-creation workshops, addressed in Step 3. Step 4 outcomes will be discussed in Chapter 6.

Step 5: Consolidating ESG Strategy Toolkit

The research ends with consolidating the ESG Strategy Toolkit and the end-to-end ESG strategic design process blueprint as the last step. This concludes a holistic view of all tools, methods, and resources that have been developed throughout the research process. The researcher aims that this toolkit can serve as a comprehensive guide for hospital professionals to adopt and transform ESG in the clinical workflows. Chapter 7 will present the consolidated ESG strategic design methodology and toolkit developed.



In the final chapter of this paper, Chapter 8, the researcher reflects on the lessons learned, valuable insights, experiences, and knowledge gained throughout the research process.

2.3.2 Research Design Methods and Tools

Five main methods are used to setup and execute upon this research (see Table 1).

1. Desk Research Protocol (Qualitative and Quantitative Research) - Step 1 of the Research Design Process.

The researcher outlined the search strategy that focused on the specific data in order to broadly and deeply identify the current ESG goals, frameworks, trends, and efforts in global, EU, national, and academic hospitals. Desk research included not only comprehensive scientific literature reviews but also reports from both public and private industries, news articles, blogs, and social media, given the topic's constant evolution and the interconnectedness of different sources. The researcher mostly used Scopus, ResearchGate, Google Scholar, organization websites and reports, hospital annual reports, and LinkedIn as search engines. The collective insights were continuously collected on a digital whiteboard called Miro, which helps systematically gather, analyze, and synthesize the relevance across multiple levels. The ESG goals and roadmap from the EU and university hospitals in the Netherlands are summarized in Appendix A.

Table 1. Research methods with main goals and data needs

Research Method	Research Type	Research Step	Main Goal	Data Needs
1 Desk Research	Qualitative + Quantitative	Step 1: Analysing the ESG Pyramid	Identifying current Global, EU, National and Academic Hospital ESG goals, frameworks, programs, initiatives	- Existing ESG goals for each system level and system entity - Existing ESG global frameworks - Existing ESG reports in academic hospitals and other Netherlands entities - Radiology clinical workflow and stakeholders involved
2 In-depth Interview	Qualitative + Quantitative	Step 2: Framing ESG Value and Impact in Radiology Workflow	Measuring the awareness, engagement and activation level of different stakeholders. Radiology workflow ESG insights and initiatives per hospital	- Department ESG priorities - Department ESG programs - Hospital ESG governance models - Cross-hospital collaborations - ESG challenges in Radiology - ESG opportunities in Radiology
3 Field Research	Qualitative		Assessing ESG challenges and impact across Radiology workflow (hospital visit)	- Radiology clinical workflow and stakeholders identification - Ongoing ESG initiatives
4 Survey Research	Qualitative + Quantitative	Step 3: Positioning Radiology ESG Hotspots in the Healthcare Ecosystem	Validation of Radiology ESG hotspots and initiatives at hospital, ESG metrics applicable and healthcare national ESG Ecosystem map	- ESG report existence at the hospital level - ESG report existence at the department level - Individual prioritisation of ESG hotspots
5 Co-creation Workshop	Qualitative + Quantitative	Step 4: Measurement of ESG in Hospital and Radiology	Consolidation insights on ESG Ecosystem map dynamics, Radiology ESG Hotspot prioritization and ESG interventions mapping on system levels; Co-definition of ESG Metrics for Radiology and Hospital	- Ecosystem validations - ESG hotspots driving forces mapped on system levels - ESG value and impact in scorecard at the hospital level - ESG value and impact in scorecard at the department level

2. Interviews Protocol (Qualitative Research) – Step 2 of the Research Design Process.

While desk research provides a foundation of exiting knowledge, interviews allow to capture different types of knowledge or perspectives on ESG and explore nuance or other phenomena that may not be readily available in existing sources.

- **Who are interviewed:** Stakeholders selected for the interview are categorized into two groups: [1] Sustainability/ESG leads who prioritize sustainability programs in their hospital, publish annual hospital sustainability reports, or drive sustainability in procurement, as well as [2] Radiology experts (Radiologists, Technologists, or Radiology group leaders) who provide accurate and timely diagnosis and treatment for patients, are actively involved in sustainable initiatives, or are part of a sustainability working group in a hospital or national healthcare association. The researcher conducted interviews with representatives across university hospitals and healthcare organizations to investigate cross-ESG challenges and opportunities. A snowball sampling method (Welch & Patton, 1992) was used to identify other relevant experts. The list of stakeholders who were interviewed is shown in Table 4.

- **How are interviewed:** Each interview lasted 45 to 65 minutes and was semi-structured and open-ended. Open questions are more inviting and give interviewers more agency (Eppich et al., 2019). Most interviews were conducted via Zoom or Teams meetings for convenience of location and time; some took place in person at the hospital, and one was answered via email. The conversations were recorded under individual agreements for transcription purposes. The original audio is only available and accessible to the researcher, as per university regulations. The report discloses a brief explanation of their roles and responsibilities within the organization, but their names are withheld out of respect for their privacy.
- **What are asked:** Semi-structured interviews are combined with pre-planned questions and emergent questions or probes depending on the dialogue between the interviewer and participants (DiCicco-Bloom & Crabtree, 2006). The researcher intended a different set of questions for Sustainability/ESG leads and Radiology experts, as each has specific interests and priorities. The flow of questions was consistent in terms of [1] awareness of ESG and the mechanisms to be familiar with; [2] the governance structure of ESG prioritization to meet their long-term goals; [3] internal and external collaboration efforts; and [4] their vision of a future sustainable hospital or Radiology. The interview stopped when saturation was reached and the researcher began to see the same patterns of responses repeatedly. The questionnaires for interviews for both groups are presented in Table 2. In-depth interviews served various purposes in this research, as shown in Table 5.

Table 2. Interview questionnaires for ESG leads and Radiology experts

Informant	Interview questionnaires
Sustainability / ESG lead	<p>Awareness: How are you aware and relate to the long-term goals of the EU (and global)?</p> <p>Priorities: Is sustainability a key priority in your hospital and how is it addressed across departments?</p> <p>Priorities: How do you report on this internally and externally?</p> <p>Collaboration: To what extent do you collaborate with other hospitals in order to maximize synergy and share efforts?</p> <p>Vision: How do you envision the future of healthcare, and how are you hoping to influence it in your position?</p>
Radiology expert	<p>Awareness: How familiar are you with the sustainability?</p> <p>Priorities: Do you see initiatives in Radiology that address sustainable practices?</p> <p>Collaboration: How are these connected to broader sustainable programs in your hospital and cross-healthcare?</p> <p>Vision: What is your vision, and what practical interventions could you implement to foster sustainable practices in Radiology?</p>

3. Field Research in the Radiology Department – Step 2 of the Research Design Process.

Radiology is a complex web of several workflows with many different stakeholders involved. The researcher had the opportunity to visit the Radiology department at Erasmus MC and was welcomed by the technologists who had previously been interviewed. It was allowed to observe and interact with healthcare professionals in a natural environment. Focused on gathering insights into ongoing ESG initiatives, the researcher was also involved in discussions with Radiology staff to identify bottlenecks and potential opportunities for enabling conditions to embed these initiatives in the workflow. The session lasted for a half-day, and the researcher also conducted in-depth interviews on-site. The findings from the field research are mapped in the Radiology workflow in Chapter 4.

4. Surveys Protocol (Quantitative Research) – Step 3 and 4 of the Research Design Process. Surveys are efficient to collect data from a large number of participants in a relatively short amount of time. The purpose of the surveys is to use the data to provide insight into the Co-creation workshop, in which participants can become familiar with the subject and activities that will be carried out during the workshop.

- **Who are surveyed:** The survey was distributed to every stakeholder who had been previously interviewed in step 2. All survey questions are relevant for both Sustainability/ESG leads and Radiology experts, therefore a single link has been set up to make it easy to quantify the results.
- **How are surveyed:** The survey was filled out using Microsoft Forms, which is easy and intuitive to use. It was sent together with the invitation to the co-creation workshop and the researcher indicated that it should only take a few minutes for efficiency. The surveys were conducted anonymously in order to encourage more honest and unbiased responses.
- **What are asked:** The survey includes five questions for effectiveness while also resulting actual outcomes. Lists of questions, supporting assets, and question types are shown in Table 3. The survey results are presented in Appendix C.

Table 3. Survey questions and types

Survey questions	Supporting assets	Type of questions
1 Do you report on ESG at hospital level?		Yes / No / I don't know
2 Do you report on ESG at Radiology department level?		Yes / No / I don't know
3 What are the top 3 hotspots would you give the highest priority based on the highest impact on the ESG and the possibility for action and influence by Radiology in the hospital?	ESG Hotspots in Radiology workflow (outcome of Step 2)	Multiple choice (limited 3 options)
4 What other hotspots do you take into account besides those listed on the slide from question 3?		Open text
5 Does the Ecosystem Map represent all actors and the complexity in the Healthcare system in the Netherlands (to address identified hotspots)? If not, which other actors would you include or exclude, and why?	Healthcare Ecosystem Map (outcome of Step 2)	Open text

5. Co-creation Workshop Protocol (Co-creation) – Step 3 and 4 of the Research Design Process. Co-creation refers to a collaborative process where multiple stakeholders come together to jointly create and shape a solution, product, or outcome. This is a generative design research approach that engages stakeholders as partners who are "experts of their experience, promotes out-of-the-box thinking, and makes stakeholders' tactic values explicit" (Sanders & Stappers, 2014). The researcher aims to bring together the stakeholders who were previously involved in the interviews, actively share common or different perspectives, and ensure to work towards a common purpose. The co-creation workshop also has the aim of validating the various tools that have been created for steps 3 and 4. The protocol for the co-creation workshop is as follows:

- **Who are Co-created:** The main participants in the Co-creation workshop are the stakeholders who were previously interviewed in step 2. The researcher applied the method of snowball sampling through the participants to broaden and deepen validations, despite the fact that a small number of stakeholders were unable to participate due to hospital priorities. As a result, a chairman from NVvR as well as a radiologist from Radboud also joined the Co-creation. Table 4 lists the stakeholders that participated.

- **What are asked:** Prior to the workshop, the researcher created four supporting assets on Miro, a digital whiteboard: [1] Healthcare Ecosystem Map in the Netherlands (outcome of Step 2) [2] ESG Hotspots in the Radiology Workflow (outcome of Step 2) [3] ESG Hotspots PathwaysI (outcome of Step 3) [4] Measurements of ESG (outcome of Step 4). Each visual had prepared key questions to validate the assumptions and fill any gaps. The blueprints for co-creation are shown in Appendix D.
- **How are Co-created:** In contrast to step 2, where 1:1 in-depth interviews were conducted, this phase's co-creation was meant to bring together stakeholders from various hospitals or healthcare organizations as well as different fields of expertise. Since it was challenging to have everyone there at once, the researcher spread out the series of sessions over the course of one week to accommodate their schedule. The sessions were taped under individual agreements for data interpretation in order to capture the interactive feedback and activities on Miro. Only the researcher had access to the original recordings, which were removed after transcription. Table 5 presents the role that Co-creation workshops played in serving several of the research goals and the corresponding outcomes documented in this paper.

Table 4. Overview of stakeholders who were interviewed and co-created

	Organization	Stakeholder group	Roles / Positions	Years of experience	Interview	Co-creation
1			Program manager	+12 years	In-depth interview	Yes
2		Sustainability / ESG lead	Program manager	+21 years	E-mail	-
3	Erasmus MC	Radiology expert	Procurement and sustainability lead	+11 years	In-depth interview	Yes
4			Manager of department Radiology	+21 years	In-depth interview	Yes
5			Manager of department CT	+14 years	In-depth interview	Yes
6	Erasmus MC & NVvR	Radiology expert	- Technologist - Green Team at Erasmus MC - Sustainability Working Group of NVvR	+8 years	In-depth interview	Yes
7	LUMC	Radiology expert	Manager of department Radiology	+22 years	In-depth interview	Yes
8	Amsterdam UMC	Radiology expert	Manager of department MRI	+29 years	In-depth interview	-
9			Technologist	+10 years	In-depth interview	-
10	Alrijne Hospital & NVvR	Radiology expert	- Radiologist - Sustainability Working Group of NVvR	+40 years	In-depth interview	Yes
11	Radboud UMC & NVvR	Radiology expert	- Radiologist - Sustainability Working Group of NVvR	+23 years	-	Yes

2.3.3 Data Collection and Interpretation

The key results from the initial processing steps are revisited and linked to the overarching re-search goals. Table 5 presents the data modelling criteria and data interpretation considerations then applied to reach final conclusions with respect to [1] the structure and gaps in the global and national landscape of the healthcare ecosystem; [2] key ESG challenges and priorities of ESG Hotspots across the Radiology workflow; [3] system-level positioning of ESG Hotspots interventions; and [4] ESG value-impact metrics to measure ESG adoption in Radiology workflows. Chapter 8 presents the researcher's final conclusions on the defined research question and overarching study goals.

Table 5. Data Collection and Interpretation Models

Research Design Step	Research Goal	Data Needs	Data Collection Method	Data Modelling Criteria	Data Analysis Considerations	Outcomes
Step 1: Analysing the ESG Pyramid	Identifying Global, EU, National and Academic Hospital ESG goals, frameworks, programs, initiatives	Current ESG Goals and Programs: <ul style="list-style-type: none"> • Global • EU • National • Hospital • Radiology Department 	<ul style="list-style-type: none"> • Desk research • In-depth interviews 	<ul style="list-style-type: none"> • Cross-validation from official sources , hospital representatives 	<ul style="list-style-type: none"> • Comparison of goals and timelines of global and local entities • ESG priorities, roadmaps and governance models • ESG programs scope and active steering • ROI measurements 	<p>Key insights and results (Chapter 3): ESG Global Forces and Frameworks Global Healthcare trends ESG initiatives in University Hospitals in the Netherlands</p> <p>Tools: ESG Pyramid (Figure 4)</p>
Step 2: Framing ESG Value and Impact in Radiology Workflow	Understanding the ecosystem context of Radiology and measuring: <ul style="list-style-type: none"> • stakeholder ESG awareness level; • ESG initiatives at department in the context of hospital ESG goals / roadmap • ESG current impact and bottlenecks across Radiology workflow 	<p>Netherlands Healthcare Ecosystem</p> <ul style="list-style-type: none"> • Entities • Roles & Responsibilities • Business models • Dependencies <hr/> <p>ESG awareness level & initiatives</p> <ul style="list-style-type: none"> • Department level • Hospital Green Teams • Hospital management <hr/> <p>Radiology workflow</p> <ul style="list-style-type: none"> • Clinical workflow steps • ESG challenges across workflow • ESG hotspots and opportunities mapping • Current ESG measurements & reporting in Radiology 	<ul style="list-style-type: none"> • Desk research • In-depth interviews • Field research • Survey research • Co-creation workshops 	<ul style="list-style-type: none"> • Cross-validation of in-depth insights with official sources or representing experts <hr/> <ul style="list-style-type: none"> • Quantitative and qualitative analysis <hr/> <ul style="list-style-type: none"> • Expert cross-validation of workflow steps, clinical roles, ESG challenges and opportunities, current ESG measurements & reporting 	<ul style="list-style-type: none"> • Functional clusters in the ecosystem • Influence and power flow on: ESG, finance, and compliance • Important dependencies, partnerships, programs <hr/> <ul style="list-style-type: none"> • Cross- connection department initiatives, personal staff efforts and hospital ESG goals <hr/> <ul style="list-style-type: none"> • Similarity and differentiation aspects in radiology workflow across hospitals • Expert reasoning and context for selected ESG challenges, hotspots and opportunities • Existing ESG metrics and reporting mechanisms 	<p>Key insights and results (Chapter 4): Ecosystem insights of Healthcare / Radiology in the Netherlands ESG Challenges in Radiology workflow ESG Hotspots and Opportunities in Radiology</p> <p>Tools: Healthcare Ecosystem Map (Figure 6) Radiology workflow (Figure 8) ESG Hotspots and Opportunities (Figure 10)</p>
Step 3: Positioning Radiology ESG Hotspots in the Healthcare Ecosystem	ESG Hotspot prioritization in Radiology; Deeper insights level in the Ecosystem dynamics and system level mapping of expert-proposed Radiology ESG interventions	ESG Hotspots & Interventions <ul style="list-style-type: none"> • Expert hotspot ranking (top 3) • Hotspots interventions selection (expert group ideation) • System level mapping of ESG interventions and implementation pathway directions (expert group debate and decision) 	<ul style="list-style-type: none"> • Survey research • Co-creation workshops 	<ul style="list-style-type: none"> • Expertise led prioritization of ESG hotspots and interventions, based on consensus or majority • Cross-validation of ESG pathways considerations and constraints against gathered learnings from prior desk research 	<ul style="list-style-type: none"> • Analysis of expert criteria for ESG hotspot ranking • Perspectives and dimensions in experts dialogue on system level positioning of ESG interventions, gaps, risks and means for influence 	<p>Key insights and results (Chapter 5): System level mapping of ESG interventions</p> <p>Tools: ESG Pathways (Figure 11)</p>
Step 4: Measurement of ESG in Hospital and Radiology	Co-definition and expert validation of ESG Metrics and Measurements for Radiology and at Hospital level	ESG metrics <ul style="list-style-type: none"> • Clinical Workflow key performance indicators • ESG metrics in use • Expert feedback and validation of proposed ESG topics and metrics (ESG Scorecard Department, Hospital) 	<ul style="list-style-type: none"> • In-depth interviews • Survey research • Co-creation workshops 	<ul style="list-style-type: none"> • Cross-expert validation of clinical and ESG performance indicators • Expert validation of proposed metrics and reporting approach (ESG scorecard) 	<ul style="list-style-type: none"> • Common reporting mechanisms on clinical workflow performance • Formal and informal ESG indicators used in Radiology departments and at top-level, in different hospitals 	<p>Key insights and results (Chapter 6): ESG as Business Driver</p> <p>Tools: Hospital ESG Scorecard (Figure 12) Radiology ESG Scorecard (Figure 13)</p>
Step 5: Consolidating ESG Strategy Toolkit	Developing an end-to-end strategic design process & tools for defining ESG goals, prioritize interventions and measure their added value and impact	Validation of <ul style="list-style-type: none"> • Process steps • Governance model • Tools 	<ul style="list-style-type: none"> • In-depth interviews • Co-creation workshops 	<ul style="list-style-type: none"> • Qualitative and quantitative 	<ul style="list-style-type: none"> • Expert feedback in majority leading 	<p>Key results (Chapter 7) Strategic design process</p> <p>Tools: ESG toolkit (Figure 14)</p>

2.4 ESG Definition for Healthcare

Healthcare organizations have historically embraced environmental, social, and governance (ESG) efforts through caring for patients and developing treatments, vaccines, and systems to improve human health and save lives (PWC 2019). ESG, which stems from responsible investment, is defined as a corporate commitment to improving social well-being and ensuring long-term sustainability for stakeholders (Agarwal et al., 2023). Organizations with a strong ESG strategy tend to perform better in terms of future financial performance through long-term executive strategies (Velte, 2017).

The ESG principle is a framework consisting of environmental (E), social (S), and governance (G) factors (see Figure 2) that help in measuring the environmental footprint and social impact of business operations (EBA Report, 2021). Adopting these ESG principles in healthcare can lead to more sustainable, resilient, and socially responsible practices, such as reducing waste, energy, and carbon emissions, improving patient outcomes, and improving community health by promoting ethical governance and accountability (Serafeim, 2013).

Figure 2. ESG framework (international frameworks) by EBA Report, 2021

Dimension	Factors	Definition
Environmental (E)	<ul style="list-style-type: none"> GHG emissions Energy consumption and efficiency Air pollutants Water usage and recycling Waste production and management (water, solid, hazardous) Impact and dependence on biodiversity Impact and dependence on ecosystems Innovation in environmentally friendly products and services 	Environmental matters that may have a positive or negative impact on the financial performance or solvency of an entity, sovereign, or individual.
Social (S)	<ul style="list-style-type: none"> Workforce freedom of association Child labor Forced and compulsory labor Workplace health and safety Customer health and safety Discrimination, diversity, and equal opportunity Poverty and community impact Supply chain management Training and education Customer privacy Community impacts 	Social matters that may have a positive or negative impact on the financial performance or solvency of an entity, sovereign, or individual.
Governance (G)	<ul style="list-style-type: none"> Codes of conduct and business principles Accountability Transparency and disclosure Executive pay Board diversity and structure Bribery and corruption Stakeholder engagement Shareholder rights 	Governance matters that may have a positive or negative impact on the financial performance or solvency of an entity, sovereign, or individual.

Source: EBA Report on ESG risks management and supervision. Available online: <https://www.eba.europa.eu/eba-publishes-its-report-management-and-supervision-esg-risks-credit-institutions-and-investment> (accessed on 31 July 2021).

The ESG definition for Radiology will be introduced in Chapter 4.2, building on previous recommendations, and expanded with new insights and ESG factors concluded with experts during this research. This definition will be the reference for defining a measurement and monitoring mechanism for the ESG strategic value for the Radiology departments and wider across hospitals, which will be presented in Chapter 6.

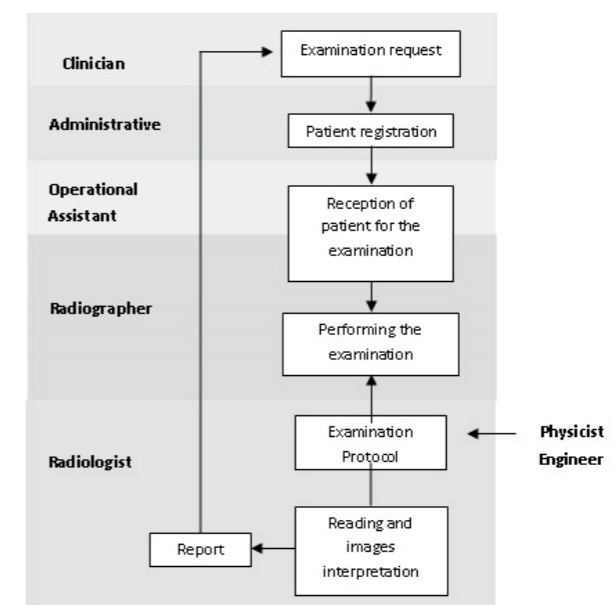
2.5 What is Radiology?

Radiology is the branch of medical discipline that uses x-ray, radioactive substances, and other kinds of radiant energy to diagnose diseases and guide their treatment, within the bodies of humans and other animals (Radiology - Wikipedia, 2020). It consists of two main areas: Diagnostic Radiology and Interventional Radiology, both of which use radiant energy to diagnose and treat diseases. The images can be provided by various imaging techniques, including X-ray, MRI, Ultrasound, CT scans, and PET scans. Each examination in Radiology must go through many sequential steps, including scheduling the patient, beginning and completing image acquisition, sending the completed images from the scanner into the digital image archive, dictating the preliminary and final interpretation, delivering reports, and submitting charges (Pianyk et al., 2017).

A radiology imaging service cannot operate efficiently without a well-organized group of healthcare professionals. In the Radiology department, the stakeholders listed in Figure 3 are generally involved in the decision-making process for delivering imaging services. Maia (2021) identified five: [1] the Clinician, who requests the examination; [2] the Administrator, who schedules patients and records payments; [3] the Operational Assistant, who guides the patient from the waiting room to the exam room; and [4] the Radiographer or technologist, who welcomes the patient and performs the examination. The Radiographer or Technologist completes the image acquisition under the supervision of the Radiologist or with the assistance of [5] the Physician Engineer. The exam will then be interpreted and reported by a Radiologist before being sent to the Clinician, or it may go there directly (Maia, 2021).

In resource-constrained settings, fewer and less specialized professionals often fulfil multiple roles in Radiology due to limited technical, staffing, or economic resources. For instance, technologists may handle additional administrative and IT responsibilities, while some radiologists may perform nursing procedures themselves. However, it is crucial to ensure that these roles are adequately represented, either by specialized individuals or multitasking professionals, as they all play a vital role in servicing effective and safe imaging (Pianyk et al., 2017).

Figure 3. Radiology workflow and stakeholders in decision-making (flowchart from Maia, 2021)



Source: Maia, M. Health Technology Assessment And Decision-Making Processes: The Purchase Of Magnetic Resonance Imaging Technology. Available online: <https://doi.org/10.1017/s0266462321000970> (December 2021).



Chapter 3

Analysing ESG Pyramid

This chapter's goal is to give an overview of the relevant underlying knowledge, literature, and published reports. The chapter highlights all the important terms, trends, and initiatives defining the ESG pyramid, as well as the ESG impact, concluded with experts, across the Radiology workflow.

3.1 Introduction to Analysis

This chapter introduces the concept of the ESG pyramid, a framework that aims to connect the macro, mezzo, and micro within the global healthcare system. Key challenges for the different levels of the pyramid will be concluded and discussed based on a broad literature study. The chapter's next section presents ESG goals and initiatives in different university hospitals in the Netherlands. Finally, how ESG considerations in Radiology clinical workflow can have a significant positive impact is presented.

3.2 ESG Pyramid

Having a solid ESG strategy has evolved from a 'nice to have' to an 'essential part' of any organization's capabilities and business. ESG reporting is becoming mandatory for an increasing number of organizations and industries worldwide. However, for healthcare and its clinical workflows, the speed of change is slow, and systemic interventions are extremely challenging. Figure 4 illustrates the proposed concept of the ESG pyramid (the research focus area) that aims to address the entities involved, their roles, and the key challenges at each level.

The researcher identified three important levels to be considered in the ecosystem: [1] Global and regional EU level; [2] National healthcare and Hospital level; and [3] Department and Clinical workflow level.

- **Level 1** introduces global ESG driving forces as well as their current defined ESG goals, programs, and governance frameworks, as presented in Chapter 3.3 Global ESG Driving Forces. The EU presents the most advanced programs, goals, and policy frameworks for environmental protection, social justice, and responsible governance. Nevertheless, there is a gap between the EU and the national government of the Netherlands with regard to policy alignment, involvement in the decision-making process, and advocacy for particular needs and priorities to ensure that the ESG initiatives are effectively implemented at the national level (The United Nations, 2017).

Figure 4. ESG pyramid and key challenges



- **Level 2** investigates the setup and entities involved in the Netherlands healthcare system, highlighting the specific ESG setup and initiatives in academic hospitals as presented in Chapter 3.5. The decentralized healthcare system in the Netherlands aims to improve accessibility, local decision-making, and patient-centered care (Decentralisation of Government Tasks, n.d.). On the other hand, the problem is further compounded by confusion about decentralization principles and practices because of the lack of clearly defined new roles for all levels, including those who get the benefits of decentralization (World Health Organization, 2001). The policy is limited by inconsistent technical competence at the local level, resistance from the center to share responsibility, and a lack of cooperation across entities.
- **Level 3** investigates ESG impact in the Radiology workflow for this research, as presented in Chapter 3.6. Radiology is at the forefront of providing patients with diagnosis and treatment guidance. However, embedding ESG principles into the Radiology workflow poses several operational challenges due to the complexity of the workflow and multiple stakeholders involved (Maia, 2021), limited financial and human resources (Catalina Imaging, 2020), and low levels of urgency and awareness of the impacts Radiology makes (Buckley & MacMahon, 2021).

This research aims to further assess identified gaps at Levels 2 and 3, ongoing initiatives within and across hospitals, as well as opportunities to accelerate and bridge efforts across the healthcare system in the Netherlands. The system structure and its dynamics are captured as an ESG Healthcare Ecosystem Map, which is described in Chapter 4.

3.3 Global ESG Driving Forces

According to desk and literature research, institutions rely on several international frameworks and standards to define ESG factors, while some use their own definitions (EBA Report, 2021). The following established entities are defining and scoping ESG, formalizing reporting frameworks, and driving transformation across international systems and are frequently used by organizations.

1. Intergovernmental Panel on Climate Change (IPCC) and United Nations Environment Programme (UNEP)

In October 2018, the Intergovernmental Panel on Climate Change (IPCC) released an alarming report that concluded that limiting global warming to 1.5°C would help prevent the worst effects of climate change (Reports — IPCC, n.d.). Established by the World Meteorological Organization (WMO) in 1988, IPCC provides UNEP with an objective source of scientific basis for climate change policies and a framework to underlay negotiations. The IPCC's mission and formal role is to provide global decision-makers with a reliable, rigorous, and up-to-date assessment of the science underlying climate change. IPCC has published a total of sixth assessment reports since 1990. The most current report is the Sixth Assessment Reports (AR6), which was released in March 2023 after three first instalments in 2021 and 2022 (AR6 Synthesis Report: Climate Change 2023 — IPCC, n.d.). Additionally, the IPCC plays a significant role in the annual Conference of the Parties (COP) meeting, which bring together public and private entities to decide upon shared global priorities and programs under the United Nations Framework Convention on Climate Change (UNFCCC) treaty (List of Parties to the United Nations Framework Convention on Climate Change - Wikipedia, 2005).

Reference Links

UN: <https://www.un.org/en/> | UNEP: <https://www.unep.org/> | IPCC: <https://www.ipcc.ch/>
 COP: <https://unfccc.int/process/bodies/supreme-bodies/conference-of-the-parties-cop> | UNFCC: <https://unfccc.int/>

2. Sustainable Development Goals (SDGs) and United Nations Development Programme (UNDP)

On January 1, 2016, the world embarked on a 15-year mission to complete the UN's 2030 Agenda for Sustainable Development. The 17 Sustainable Development Goals (SDGs) and the 169 goals have drawn significant attention from the public and academia (Biermann et al., 2022). These goals are designed to be the blueprint to achieve a better and more sustainable future for all, calling for ending poverty, protecting our planet, and ensuring peace and prosperity for all people. To assist governments in integrating the SDGs into their national plans, policies, and institutional frameworks, UNDP deploys integrated policy support missions, such as the Global UNDP Strategic Plan 2022-2025 (Strategic Plan 2022-2025 | UNDP, n.d.).

Reference Links

SDGs: <https://sdgs.un.org/goals> | UNDP: <https://www.undp.org/>
 UNDP Strategic Plan 2022-2025: [Strategic Plan 2022-2025 | UNDP](#)

3. Corporate Social Responsibility (CSR)

Since the 1960s CSR has been evolving as an accountability concept for businesses with respect to the impact of their decisions and actions on society, environment, ethical practices within the growth of the economy (ISO 2010; Hąbek and Wolniak 2016; Hąbek 2017; Financial Time 2018). From its introduction, CSR that social responsibility must take environmental factors into account and demand incorporation of inclusive and sustainable interventions in business operations (Żelazna et al., 2020). Companies that prioritize CSR work are appreciated that stand for more than simply financial gain, promoting sustainable development (European Commission, 2002).

Reference Link

[European Commission, 2002](#)

4. Environmental, Social, and Governance (ESG)

In June 2004, the United Nations Global Compact put forward the concept of ESG for the first time, advocating enterprises to consider environmental, social, and governance performance while focusing on their core business objectives (UN Global Compact, 2004). ESG evolved as a new concept, built upon prior corporate social responsibility (CSR) principles, expands across areas of ethical financial investments, increased accounting transparency and innovation of sustainable value propositions. ESG is not only evaluating the overall performance of businesses but drives structural changes towards green financing and policy frameworks to secure long-term economic growth (Wan et al., 2023).

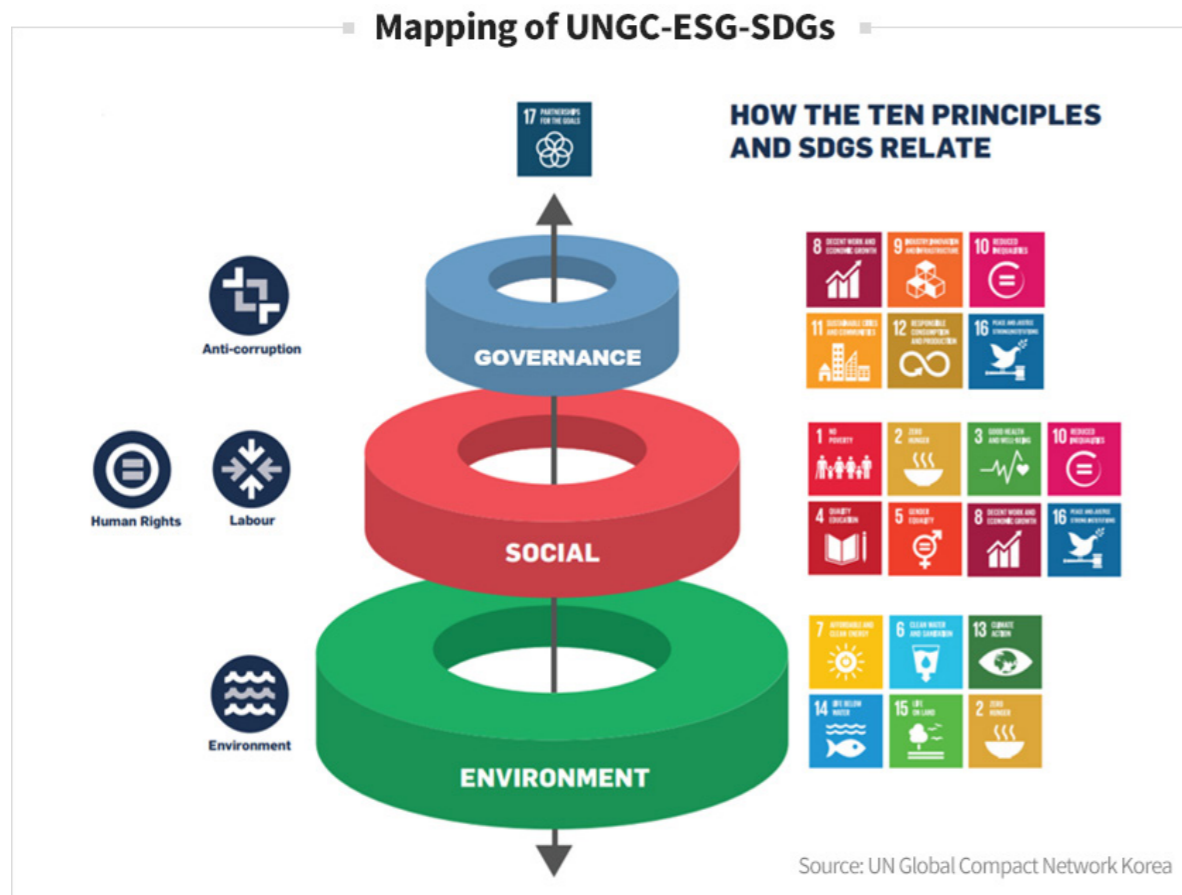
Reference Link

UN Global Compact, 2004: <https://unglobalcompact.org/library/255>

5. Connecting SDGs and ESG Frameworks

In 2020, the UN Global Compact Network Korea disclosed the framework (see Figure 5) connecting for the first time the SDGs and the ESG dimensions, providing an actional solution and interconnected measurement mechanism of the SDGs goals within ESG frameworks. This framework is often used by organizations to couple their sustainability goals and programs to SDGs and integrate these in a preferred ESG reporting framework. This approach provides a higher level of transparency on priorities, enables dialogue with internal and external stakeholders, and enables formal reporting, towards stakeholders and investors on the business goals, sustainable pathways and achieved progress (Khaled et al., 2021).

Figure 5. Framework connecting ESG and SDGs by UN Global Company Network Korea (SDGs, the Compass for ESG Management, 2021)



Source: SDGs, the Compass for ESG Management. Available online: <https://mediask.co.kr/90001-246> (accessed on 22 June 2021).

In the context that the UN Sustainable Development Goals (SDGs) are a globally agreed and accepted framework of practices with clearly defined indicators and goal-oriented recommendations that enable criteria-unbiased sustainability assessment, this research adds the perspective of ESG as value driver and widely accepted change instrument across industries worldwide (Five Ways That ESG Creates Value, 2019).

3.4 EU and Global ESG Healthcare Trends

In order to frame and interpret the healthcare system data gathered in this study, the researcher initially conducted an extended literature study to understand the key global factors and ESG trends driving the transformation of the healthcare industry. Three main insights are relevant to be highlighted in the context of this research:

1. Increasing demand for healthcare

Growing global populations and quality of life depreciation cause extreme pressure on the healthcare system and increase costs. By 2030, it is predicted that there will be a shortage of 13 million nurses worldwide (World Economic Forum, 2022). As a result, across the globe, the healthcare industry is increasingly under pressure of 'doing more with less', in a sustainable and socially responsible way.

2. Top priorities of climate change, circular economy, and ESG by healthcare providers

Healthcare accounts for 4.4% of global CO2 emissions and consumes more than 10% of materials extracted and processed globally every year (Health Care Without Harm, 2019). Furthermore, in the US only, the number of healthcare facilities has increased by more than 22% since 2003, leading to a 21% rise in energy consumption by 2019 (Bawaneh et al., 2019). The trend analysis shows that reporting on ESG is becoming the norm across the industry, improving measurement transparency, and providing information to stakeholders on progress towards set targets and goals.

3. Prioritizing waste management in hospitals







According to Practice Greenhealth, hospitals produce 13 kg of waste per bed per day, with hazardous waste accounting for 15–25% of that total. In response to the dilemma, 94% of patients are considering the importance of hospital sustainability programs, and healthcare leaders are eager to partner to drive sustainable practices and future-proof healthcare innovation (Better Business Center, 2019), upstream as well as downstream. A powerful instrument that can accelerate ESG transformation across healthcare value chains is Procure-ment, recognized by both suppliers (Future Health Index | Philips 2021) and hospitals (Strategic Procurement in the European Healthcare Sector, 2019). This can have short-and long-term positive impacts on finances, compliance, and ESG.

As a result of workforce shortages, climate change, and economic pressures, healthcare providers worldwide are being forced to improve operational efficiencies and develop new care delivery models (Health Workforce, 2023). Socially conscious healthcare professionals are becoming more aware of the need to reduce the carbon footprint to protect the planet's and people's health.

3.5 ESG Initiatives in University Hospitals in the Netherlands

University hospitals and medical associations in the Netherlands are increasingly aware of the importance of ESG and are taking steps to address them and improve their sustainability practices. A comprehensive analysis of ESG activities at six university hospitals in the Netherlands—Erasmus MC, LUMC, Amsterdam UMC, UMC Utrecht, Radboud UMC, and Alrijne Hospital Leiden — as well as a national healthcare association — NVvR—were conducted as part of the study (see Table 6). These activities, which were cited in the annual reports, press articles, and social media posts of the hospitals, were classified into categories for cross-analysis.

Table 6. ESG activities at the six hospitals and a national healthcare association in the Netherlands

	Erasmus MC	LUMC	Amsterdam UMC	UMC Utrecht	Radboud UMC	Alrijne Hospital Leiden	NVvR
ESG Strategic Plans or Annual Reports	Yes – Annual sustainability report	Yes - Annual report	Yes - Strategic plan 2020-2023	Yes - Sustainability policy 2020-2025	Yes -Sustainability policy 2021-2025	Yes - Annual report	Yes -Guidelines for radiological reporting
Reference Links	Erasmus MC Sustainability Report 2021: https://www.erasmusmc.nl/-/media/erasmusmc/pdf/2-themaoverstijgend/erasmusmc_duurzaamheidsverslag_2021_def.pdf	LUMC Annual Report 2022: https://www.lumc.nl/siteassets/over-het-lumc/het-lumc/strategie-en-verantwoording/bestanden/jaarverslagen/lumc-jaarverslag-2022.pdf	Amsterdam UMC Strategic plan 2020-2023: https://www.amsterdamumc.org/download/strategic-plan-aph-2020-2023-htm	UMC Utrecht Sustainability policy 2020-2025: https://assets-eu-01.kc-usercontent.com/546dd520-97db-01b7-154d-79bb6d950a2d/18e2512d-856b-40df-a09d-ad200d97f29b/IPDF%20Duurzaamheidsbeleid%202020-2025_mrt2021_v2.pdf	Radboud UMC Sustainability policy 2021-2025: https://www.radboudumc.nl/getmedia/7cf7384b-e933-43fa-9e1f-fa5ea837051e/Duurzaamheidsbeleid-2021-2025-Definitieve-versie.aspx	Alrijne Sustainability and Environment Report 2021: https://www.alrijne.nl/media/6743/milieujaarverslag-2021.pdf	NVvR Sustainability Working Group: https://radiologen.nl/kwaliteit-nvvr/werkgroep-duurzaamheid
Sustainable Care Green Deal 3.0							- Established the NVvR '21-'30 strategic vision: Radiology, the navigator of healthcare
Reference Link	https://www.greendealduurzamezorg.nl/deelnemers/						
ESG Communities	- In 2020, Green Team was introduced - To raise awareness and provide the creative impetus for sustainability practices - 15 Green Teams presently	- Developed the Green Team (specifically, Operating Room) - To improve waste collection and the elimination of disposable gowns - 25 Green Teams presently	- In 2022, the Green Care (Groen Zorg) community was introduced - Developed Green Teams (specifically, Operating Room) - Focus on reducing pollution, protecting food supply, and assessing healthcare's environmental impact.	- In 2021, a Hub Circular Hospital was created - Focus on disposables and circular business models for cataract surgery	- Since 2021, 9 Green Teams (specifically, Operating Room) are dedicated - To advance the separate disposal of waste in operating rooms	- Green Teams - Focus on themes on CO2 reduction, waste counteract, green doctoring and healing environment	- Partly inspired by Sustainable Care Green Deal, a joint sustainability working group was set up at the end of 2021 - 10 sustainability working group members presently
ESG Internal Programs	- Standardised urine bags in the Radiology department - Material flow analysis in the intensive care unit - Sustainability strategy integrated into procurement - ICU environment hotspots: gloves, gowns, and CRRT (Continuous Renal Replacement Therapy) bags	- Dashboard Groen 2022 to monitor progress and raise awareness of improvements with the support of the Green & Healthy programs	- In 2021 the Amsterdam Public Health research institute (APH) has recalibrated its strategic plan, aiming to reduce its negative impact on climate and waste through its daily operations	- Five themes for the new sustainability policy: CO2 natural and sustainable real estate, sustainable transport, circular business operations, clean wastewater, and an environment that promotes health	- Contribute to a healthy environment, combat climate change, expand the circular economy, and create equal opportunities for all	- Standardised urine bags in the Radiology department - Sustainability as a selection criterion for purchasing (e.g., circular and energy-efficient medical equipment)	- Focused on activities related to waste separation, contrast agents, energy consumption and stock management systems
ESG Collaboration with ecosystem partners	- Sustainability coordinators at Erasmus MC collaborate with between UMCs to ensure interactions with the steering committee and management group as well as monitor the progress of the 4 Green Deal-related working groups - Close cooperation in the field of procurement, with national Green Teams supporting each other in the transition to sustainability	- LUMC and Erasmus MC are members of this consortium and have implemented various sustainability initiatives through technical solutions as part of its Medical Delta Sustainability Program	- The Academic Medical Center (AMC) and the VU University Medical Center (VUmc) joined forces to leverage their respective expertise, research, and facilities - Joins enable to ensure sustainable access to complex patient care	- The working groups align on CO2 reduction strategy and roadmap, and they work together to finance initiatives - There are various contracts with suppliers to support the committee achieve its sustainability goals - Close cooperation with universities to contribute various levels of care research, and education to be more sustainable	- Joint commitment across Radboud University and Radboud UMC to work together to accelerate the adoption of sustainable practices	- Internal and external inspirations by Green Teams - Partnership with TU Delft students from different disciplines	- The sustainability working group is affiliated with the green care alliance as a green care

3.6 Impacts of ESG on Radiology Clinical Workflow

To be able to navigate the developing global health trends and upcoming climate crisis, it is imperative to harness the adaptability of healthcare and Radiology (Buckley & MacMahon, 2021). Incorporating ESG considerations into the Radiology clinical workflow can lead to optimized operations, high-quality value-based care, and drive sustainable and responsible healthcare practices.

- **Environmental impact**

Significant energy is wasted across the Radiology workflow and practice at large. Two-thirds of CT energy use occurs during the inactive idle system state, and one-third of MRI energy usage occurs during the system off state, requiring constant cooling (Heye et al., 2020). However, the vast majority of the energy used in Radiology, about 86%, is indirectly consumed by data centers through data storage servers and cooling systems (Buckley & MacMahon, 2021). In addition, waste generation is an equal concern. Both diagnosis and interventional procedures lead to large amounts of contrast leftovers and single-use medical consumables and devices. Disposable surgical supplies are the hospital's second-top source of carbon emissions in the Radiology department (Hawkins & Tremblay, 2023), while contrast substances are not recyclable in the Netherlands. More research is needed to promote energy-efficient imaging equipment, advocate for reducing and removing unnecessary data scans, raise awareness about sustainability, and suggest alternative approaches to reducing medical waste.

- **Social impact**

Diagnosis and Interventional Radiology involves a variety of stakeholders, including physicians, radiologists, technologists, and support staff, to deliver patient-centered care by prioritizing the needs and comfort of patients. However, because of the demanding nature of their work—long hours, high workload, deadline demands, and exposure to stressful situations—burnout is on the rise (Catalina Imaging, 2020). It may negatively impact the quality of patient care and contribute to higher staff turnover rates. Another significant social impact is that of patient no-shows, which can disrupt the operational workflow, waste resources, and delay patient diagnosis or treatment (Mieloszyk et al., 2019). Radiology plays an important role in ensuring the well-being of healthcare professionals and streamlining patient care delivery. By implementing ESG strategies and consistent measures to mitigate these challenges, Radiology departments can enhance operational efficiency, improve patient care, and promote a healthier work environment for their staff.

- **Governmental impact**

Government and healthcare authorities play an important role and have the power to enact rules and set standards. The Dutch government is set to implement the "Green Deal Sustainable Healthcare" with more than 200 public and private industry members; however, there is little clarity on the roadmap, specific deliverables, and governance model to manage the engagement and commitments of the participating organizations (Reeder et al., 2023). Therefore, the government must take ownership and adopt a more proactive and structured approach to drive change beyond ESG initiatives as voluntary and personal imitatives (Brassil & Torreggiani, 2019). Collaboration with other hospitals and medical associations is also essential for sharing knowledge, strategies, and an overarching future vision. Collaboration across the healthcare value chains and "open innovation" can drive significant improvements in sustainability (Lopes et al., 2017).

Chapter 4

Framing ESG Value and Impact in Radiology Workflow

The results of comprehensive data from qualitative and quantitative research are presented in this chapter, along with framed key results in the Radiology workflow. Following the introduction of an ESG definition for Radiology, this chapter also provides a structured healthcare ecosystem map.



4.1 Introduction to Results




This chapter encompasses the systemic framing of a healthcare ecosystem map in the Netherlands to address relationships and dependencies between the various actors from the perspective of the proposed ESG definition of Radiology in this study. In the next two sections of the chapter, significant ESG challenges and hotspots are mapped in the end-to-end Radiology workflow based on data collection and interpretation with selected experts in the field (see Table 4 for an overview of stakeholders who were interviewed and co-created). The final section of the chapter shifts to ESG opportunities and its potentials.

4.2 ESG Definition for Radiology

Radiology should take proactive steps to advocate for research and policies that promote a sustainable future, and research reveals promising opportunities to minimize a carbon footprint while maintaining patient care and safety (RSNA, 2021). Professionals in diagnostic and interventional Radiology are uniquely positioned to lead ESG efforts and make significant contributions to reducing healthcare's contribution to climate change (Woolen et al., 2023). Radiology departments should therefore pursue implementing sustainable practices, investing in ESG education, technology and infrastructure to promote and effectively embed environmental sustainability, diversity and inclusion in the workforce, advocating for social justice, and adhering to ethical and regulatory standards.

While Chapter 2.3 discusses the ESG framework's general implications for healthcare and what it entails, specific ESG factors for Radiology are necessary to help in assessing and implementing sustainable and responsible practices. The researcher outlines the proposed ESG elements for Radiology used in this study in Table 7, from the leading perspective of SDGs and considering ongoing ESG measurement initiatives as presented in the annual sustainability reports of considered university hospitals in the Netherlands for this study. In Chapter 6, these factors are incorporated to measure ESG strategic value and impact.

Table 7. ESG framework and SDGs for Radiology

Dimension	Factors	SDGs
Environmental (E)	<ul style="list-style-type: none"> • Energy • Water • Waste • Equipment long-life • Reusables 	
Social (S)	<ul style="list-style-type: none"> • Patient NPS • Workforce wellbeing • First-time-right • Workflow efficiency 	
Governance (G)	<ul style="list-style-type: none"> • ESG compliance • Workforce NPS • Green procurement • ESG investments • Circular revenue 	

4.3 Healthcare Ecosystem Map in the Netherlands

Healthcare ecosystems today face multiple challenges due to the complexity and are daunted by the prospect of generating value from their ecosystem investments (McKinsey & Company, 2019). Since 2015, the healthcare system in the Netherlands has been decentralized from the national level to municipalities. Municipalities are in charge and have responsibilities to bring the decision-making process closer to those it affects (Decentralisation of Government Tasks, n.d.). However, there is little attention to the resulted challenges of a decentralized healthcare ecosystem, which involves multiple stakeholders, complicated relationships, and complex agenda management. To better understand the context of decentralization in the Dutch healthcare industry, the researcher proposes developing a holistic and integrated view of the current system and its dynamics, presented in the form of a Healthcare Ecosystem Map (see Figure 6).

• What is the purpose?

The Healthcare Ecosystem Map is a systemic thinking approach and a visual tool that enables stakeholders at various levels inside a hospital and across the healthcare industry to collaborate on developing a simplified and shared understanding of their relevant ecosystem structure, dependencies, dynamics, and key facts. This map allows to observe complex system factors and drivers of power, influence as well as limitations. in a holistic view. This ecosystem map primarily focuses on the factors of influence to drive ESG transformation in Radiology as clinical domain by embedding ESG at the core of the Radiology clinical workflow.

• Stakeholders and their interests

Placing the patient at the centre, supported by patient networks, and surrounded by society and the planet in space, the five stakeholder groups and key actors are identified with their respective interests. The system changes required to drive and accelerate the ESG transformation are discussed during co-creation sessions (see Table 8).

• Information flows

The interactions between groups or actors can be explained by three flows: [1] the financing flow, [2] the clinical compliance flow, and [3] the ESG transformation flow. The ROI (Return on Investment) of each of the flows is denoted by dotted lines. The existence or absence of ESG reporting from healthcare providers to the government is significant in relation to these flows. In a structured governance model with hospitals, monitoring and measuring systems should be set in place by the government. In the Netherlands, although the Green Deals goals have been defined, it is unclear from the programs, timelines of activities, and ownerships how these initiatives are monitored and will be achieved. While the research is scoped to identify key drivers for ESG adoption into the Radiology workflow and industry at large, further research on the deeper level of introduced flows is recommended.

Figure 6. Healthcare Ecosystem Map in the Netherlands

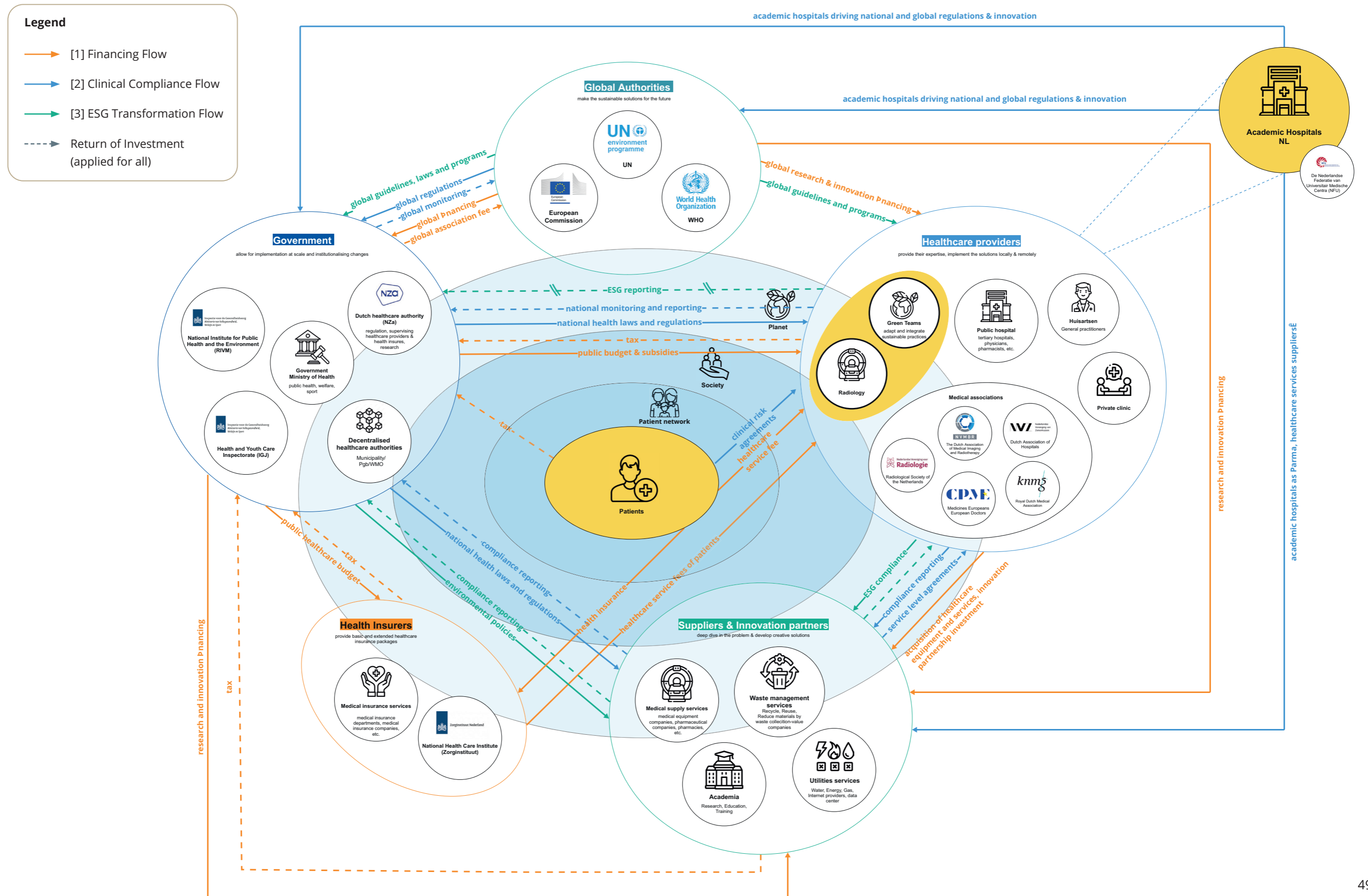


Table 8. Key entities, actors, roles and interests, and quotes

Key Entities	Key Actors	Roles and Interests	Quotes from Co-creation
Global Authorities	- EU - UN - WHO	- Responsible to define and implement the sustainable solutions for the future	-
Government	- The Ministry of Health - National Institute for Public Health and the Environment (RIVM) - Health and Youth Care Inspectorate (IGJ) - Dutch Healthcare Authority (NZa) - Decentralised healthcare authorities such as municipality, Persoonsgebonden budget (Pgb), and Social Support Act (WMO)	- Allow and enable implementation at scale and the institutionalisation of systemic structural industry changes (especially on ESG)	<i>"We are missing one integrated system for measuring how initiatives are being implemented, which the government (RIVM) could support."</i> <i>Radiologist of a MC</i>
Healthcare providers	- Academic hospitals (being part of NFU and including Radiology and Green Teams) - Teaching hospitals - General hospitals - Medical associations (including NVvR, KNMG, CPME, NVZ)	- Offer expertise and implement the solutions locally and remotely - Ensure better accessibility and quality of care close to politics, government, and other associations	<i>"Medical associations oversee national and local protocols, guidelines, which are important entity to embed ESG in the clinical workflow."</i> <i>Sustainability program manager of a MC</i> <i>"Hospitals measure performance under Green Deal, but there is no collective report, as each performs independently."</i> <i>Manager of department Radiology of a MC</i> <i>"We play more roles than most people are aware of, including that of suppliers to other hospitals and producers of our own medication."</i> <i>Procurement and sustainability lead of a MC</i>
Health insurers	- National Health Care Institute (Zorginstituut) - Medical insurance services	- Provide basic and extended healthcare insurance packages - Advise and clarify the contents of standard healthcare benefits for patients	-
Suppliers and innovation partners	- Medical supply services - Waste management services - Utilities services - Academia	- Provide Innovative solutions, services and technology that improve patient care and advance the overall quality and efficiency of the healthcare system	<i>"By 2023, only 25% of waste can be non-specific, and the remains must be recycled according to the Green Deal... suppliers should have ownership as hospital cannot solve alone."</i> <i>Technologist of a MC</i> <i>"Water utility services play a vital role in contrast media by supplying the necessary water supply dilution, cleaning, and patient safety."</i> <i>Radiologist of a MC</i>

Reflection on the mapping results

The received expert's feedback on the ecosystem map proved an unmet need and a great value in providing a holistic and simplified view of the actors, interests, and dynamics that can enable shared analysis on gaps, prioritization of initiatives, and co-creation of solutions within and across hospitals. The qualitative research and co-creation with experts concluded that ESG particularities lie in:

- calling for a higher authority than medical associations to act as an umbrella organization with full accountability for adopting, standardizing, and monitoring ESG initiatives across hospitals.
- acknowledging that each hospital has its own quality measurement system, but none that is aggregated across hospitals.
- emphasizing upstream the critical responsibilities played by national and local medical associations in influencing hospitals and participating in government relations.
- highlighting the long-term benefits and potential circular revenue that can result from prioritizing sustainability in procurement.
- suppliers' significant contribution in helping to achieve Green Deals goals, which aren't possible by hospitals alone.
- the important role NFU (Nederlandse Federatie van Universitair Medische Centra) has in coordinating the implementation and reporting on Green Deal objectives and programs, balancing increasing demand in healthcare, and reducing unnecessary scanning.
- the influential role NvVR has to drive prioritization, standardization, and effective collaboration on implementing ESG in Radiology regulations, protocols, and workflows. The low power and overwhelming experience for the patient to engage with the complexity of the healthcare system for general clinical services and, even more so, to act sustainably.

4.4 Identifying ESG Challenges in Radiology Workflow

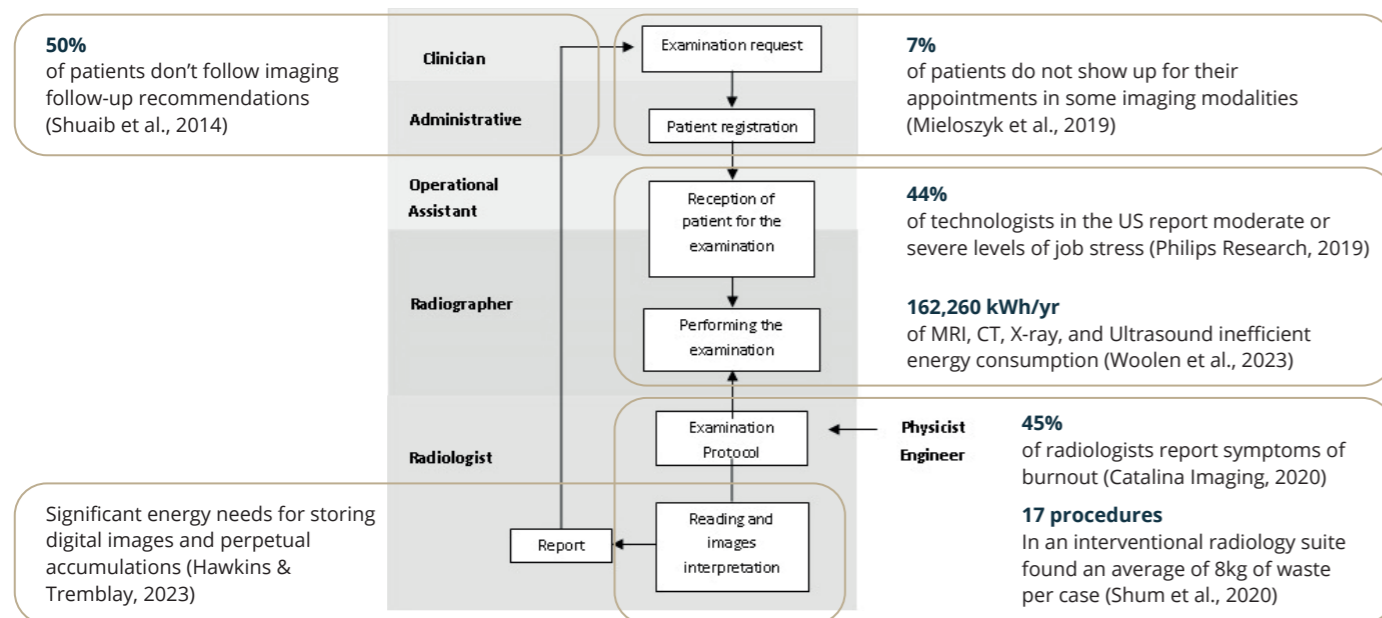
The optimization of Radiology workflow challenges is of the utmost importance since it affects quality of service delivery and is key to reducing operating expenses. The workflow in Radiology includes a number of actions such as ordering examinations, scheduling, image acquisition, storing and reading images, and reporting on Radiology exams. As described in Chapter 2.4, the current Radiology clinical workflow does not present major changes over time. ESG brings new challenges to the current protocols, and changes are inevitable in the context that multiple stakeholders, including patients, are involved. The key ESG challenges across the Radiology workflow are highlighted in Figure 7.

According to prior research, several important ESG challenges collide today:

- 7% of patients fail to show up or cancel their appointments, which is associated with a lower socioeconomic level, a distance from the appointment that makes transportation difficult, the weather, and a history of missed appointments (Mieloszyk et al., 2019), in addition to 50% of recommendations that are not followed through (Shuaib et al., 2014).
- A global study shows that in Germany, 97% of Technologists report severe work stress, which can pose a threat to the patient experience and the functioning of diagnostic services, outpacing the US at 44%, the UK at 54%, and France at 40% (Philips Research, 2019). Moreover, burnout among Radiologists is on the rise and accounts for 45% of cases, with a heavy workload and a lack of respect from administrators or colleagues as the main causes (Catalina Imaging, 2020).

- Radiology is particularly concerning from an environmental standpoint because it consumes the most energy, but it is even worse because 162,260 kWh/yr of MRI, CT, X-ray, and ultrasound are consumed inefficiently, such as overnight without use (Woolen et al., 2023). Digital images for data storage benefit the environment by minimizing waste, but the energy required to run and cool servers for storing images is substantial (Hawkins & Tremblay, 2023).
- The amount of hazardous waste produced by Radiology procedures has a worrying effect on the environment. Healthcare facilities in the United States produce more than 5.9 million tons of waste yearly (Voudrias, 2018). An Interventional Radiology suite audit of 17 procedures found an average of 8 kg of waste per case, with coiling (13.1 kg) and embolization (10.3 kg) cases having the highest waste loads – many of which many waste disposals are not recyclable (Shum et al., 2020).
- Contrast media is an important environmental concern in the clinical context of Radiology. In the US alone, over 40% of CT procedures utilize contrast media, which is a derivate substance based on Iodine (Recycling Iodine, 2022). Iodine is a non-renewable resource, and only about 18% of the current global demand is being reused (Expert Commentary, 2015). Furthermore, in most countries, due to high toxicity levels and inflammation risks, most countries, including the Netherlands, forbid transportation across highways, preferring depletion in local sewage. This has the risk of reaching drinking water and nature, affecting the health of people and the environment.

Figure 7. Radiology workflow mapped with key ESG challenges (flowchart from Maia, 2021)



4.5 Identifying ESG Hotspots in Radiology Workflow

Hotspots in Radiology workflow refer to critical points or stages in the process where inefficiencies, bottlenecks, or challenges may occur. As an outcome of data collection on several dimensions, the researcher proposes using Figure 8 as an alternative to Figure 7 to illustrate the top-most significant ESG hotspots appointed by experts involved in this study. These have a direct impact on the overall efficiency, productivity, and quality of Radiology services. The procurement cycle and waste management have both been added as they have a substantial impact on ESG within the lifecycle of medical equipment and Radiology workflow, as presented in Figure 8.

• Hotspot 1: ESG criteria missing in procurement processes

Sustainability is not currently integrated into the procurement function in a structured way. The procurement process is reactive, based on department-set criteria and industry tender trends for imaging modalities, equipment, disposables, and pharmaceuticals. Collectively, the amount reaches several million euros in spending. The healthcare sector needs to develop policies and standards for driving ESG, as well as the necessary skills, competencies, and know-how to make informed decisions about purchasing responsibly. That being said, hospitals already have the power to ask suppliers qualitative questions about their carbon reduction approach, environmental footprint, as well as extension and end-of-life solutions.

"It is necessary to prioritise sustainability factors in the procurement processes, such as climate, environment, biodiversity, and socioeconomics... The role of the procurement function is to provide an advising role rather than making any decisions themselves. It is important to ensure that the procurement process is carried out correctly and in accordance with Dutch tender law, which is based on European law."

Procurement and sustainability lead of a MC

"It is important to see the big picture and taking the time and effort to make sustainable choices. Trend of sustainability in the industry is growing and getting more importance of supporting the Green Team."

Manager of department CT of a MC

• Hotspot 2: Increasing unnecessary Radiology scans

All experts involved in the study raised the increasing demand in Radiology and misaligned exposure and contrast standards. According to the research, over 74% of the reports in CT scans and radiography were unnecessary, and fewer than 26% were actually required (Khosravi et al., 2023). Radiology centres across the country operate at full capacity, with low-to-no influence on reducing the demand for unnecessary scans, the duration of the Radiology workflow, or refusing patients and scans.

"We should reduce unnecessary procedure and focus on patient quality of life. While it is necessary for us to administer thrombolysis for a 94-year-old, we believe it may be over-treating the patient. Treating a 94-year-old patient may only improve the outcome by 15%, which may not justify the amount of treatment required."

Radiologist of a MC

"There is some standardisation in the case of rare diseases, but overall, there is still overconsumption of radiography exams."

Manager of department Radiology of a MC

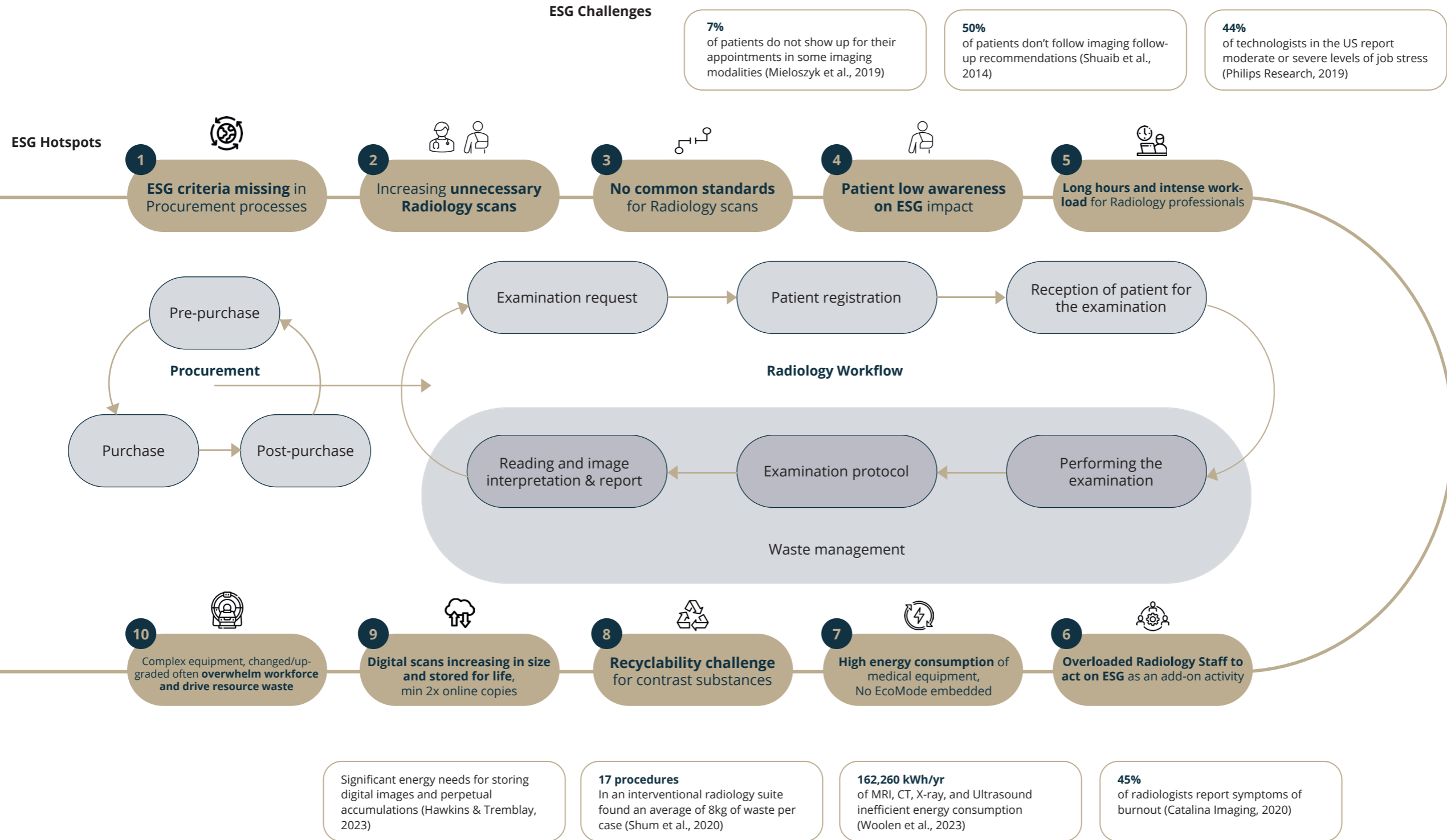
• Hotspot 3: No common standards for Radiology scans

Every hospital in the Netherlands conducts scans differently, even for the same type of scan. For example, one hospital may do a liver scan 30 second after injecting the contrast, while another hospital many wait for 35 seconds after the contrast injection. This may be one reason why hospitals prefer to treat their own patients rather than refer them to another hospital, as they have a better understanding of their own procedures. According to the experts involved, the differences in standards are driven by two main forces: technology as equipment requirements and economics as the competitive business models of hospitals.

"Why some basic CT scans cannot be done at hospitals closer to the patient's location, rather than requiring them to travel to a specialised hospital? Patients need to travel long distances for short procedures like 5-minute CT scans, as they could be done at a nearby hospital."

Technologist of a MC

Figure 8. Key ESG hotspots in Radiology workflow



- **Hotspot 4: Patient low awareness on ESG impact**

Radiology faces increasing patient no-show visits due to a variety of factors, including patient anxiety, rising healthcare expenses, or misunderstandings about the nature of tests and required patient preparation (Singh et al., 2017). However, every missed appointment represents a significant amount of environmental, economic, and social impact: loss of energy and consumables, lost revenue for healthcare, additional administrative work for staff, and lost opportunity for other patients to get the care they urgently need.

"I'm unable to dedicate as much time to sustainability efforts as we would like, due to a shortage of radiology technicians. This puts a lot of stress on me."

Technologist of a MC

- **Hotspot 5: Long hours and intense workload for Radiology professionals**

In the healthcare industry, there is an increasing demand for care and an excessive emphasis on profitability, which lead to a rise in workload, stress, and burnout for the medical workforce. Despite advancements in technology that have made machines more efficient and faster, additional skill requirements, increasing demand for scans from different clinical areas, and new service expectations from patients make the work environment for medical professionals more complex and challenging.

"Pressure from the government is to do more with less is exacerbating the situation. I feel that there are fewer staff but more patients, and the situation feels like a vacuum."

Manager of department Radiology of a MC

- **Hotspot 6: Overloaded Radiology staff to act on ESG as an add-on activity**

The biggest challenge is the shortage of time in the hospital for such initiatives, when done as add-ons. Several technologists across hospitals engaged in the study addressed the fact that they are unable to dedicate as much time to sustainability efforts as they would like, mainly due to the significant shortage of staff. This is a real and big pressure across Radiology and healthcare at large. On another level, as the Radiology Manager at Erasmus MC addressed, there is the challenge of maintaining motivation for sustainable practices once the novelty wears off. All involved in the study highlighted the importance of keeping flexibility in healthcare and embedding ESG at the core of the workflow, as a high workload can make it difficult to sustain ad-hoc activities.

"I'm unable to dedicate as much time to sustainability efforts as we would like, due to a shortage of Radiology technicians. This puts a lot of stress on me."

Technologist of a MC

- **Hotspot 7: High energy consumption of medical equipment, no EcoMode embedded**

Large diagnostic imaging systems such as MRI, CT, DXR, and US are the biggest energy consumers in the Radiology department. MRI in particular uses significant high energy, about the same as cooling a three-bedroom house for a day with central air conditioning (Buckley & MacMahon, 2021). Several Technologists addressed the fact that current installed base imaging equipment is designed to remain on at all times, whereas more advanced CT scanners are difficult to turn off and make errors when turned on in the morning, taking about 20–30 minutes to start up.

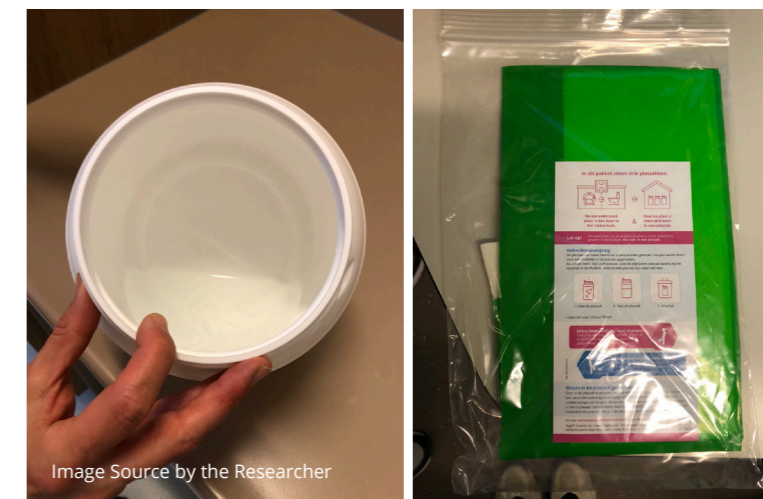
"I was at the hospital on a Sunday morning and noticed that all the CT scans were still on even though the last patient was scanned on Friday afternoon... We don't know how much energy is consumed per department, as there is only one bill for the entire hospital."

Technologist of a MC

- **Hotspot 8: Recycling challenge for contrast substances**

Regulations can sometimes work against positive initiatives. Hospitals are trying to restrict the amount of contrast used per patient, but they face challenges with the different sizes of contrast containers, which result in leftovers. Erasmus MC engages with their supplier to collect the unused contrast (See left image in Figure 9), whereas the Dutch government prohibits transporting the contrast on the highway due to toxicity concerns. As a result, 30 tons of contrast ended up in the sewage, and some of it ended up in drinking water. According to NVvR expert joining this study, more hospitals have adopted a urine bag that patients can use at home to collect urine with contrast agents after in-hospital scanning. This is a practical solution for reducing environmental water pollution by allowing patients to dispose of it with other waste in their household, making it incineration-proof (Amazing Erasmus MC, 2020). The right side of Figure 9 shows the patient's urine bag at Erasmus MC.

Figure 9. Leftover contrast stored in a container (left) and patient urine bag to surface water quality (right)



"The usage of contrast media has a considerable environmental impact, as does the amount of waste produced. In an ideal world, we would of course like to send those bags to suppliers so that they can extract the active ingredients and reuse them. But that's still in the future".

Manager of department Radiology and Technologist of a MC

- **Hotspot 9: Digital scans increasing in sizes and stored for life, min x2 online copies**

As diagnostic imaging technology advances, the size of Radiology imaging scans is increasing, leading to a growing amount of data that needs to be stored. Regulations require to retain patient imaging data for extended periods, typically for the lifetime of the patient, make double copies, and keep the data available always online. Many Radiology experts emphasized the need for a central or shared data centre where all the images can be stored safely and energy-efficiently and rethought standards on the duration of storage and ownership models for generated scans.

"In Denmark, the data is stored centrally, whereas in the Netherlands, each hospital has its own way and vision, which can be slow due to Dutch culture. Austria has a decentralized but also centralized system for gathering information."

Manager of department Radiology of a MC

- **Hotspot 10: Complex equipment, changed or upgraded often overwhelm workforce and drive recourse waste**

New complex equipment often requires training and additional resources, which can overwhelm staff that have to commit to upskilling alongside their other large responsibilities. Proactive collaboration between medical companies and hospitals is necessary to define common ESG goals and properly jointly measure the environmental and social impact of mutually beneficial outcomes.

“Medical companies should develop in a direction that aligns with the hospital’s strategic direction. This would allow for a more productive and advantageous relationship between the medical companies and their customers and users.”

Procurement and sustainability lead of a MC

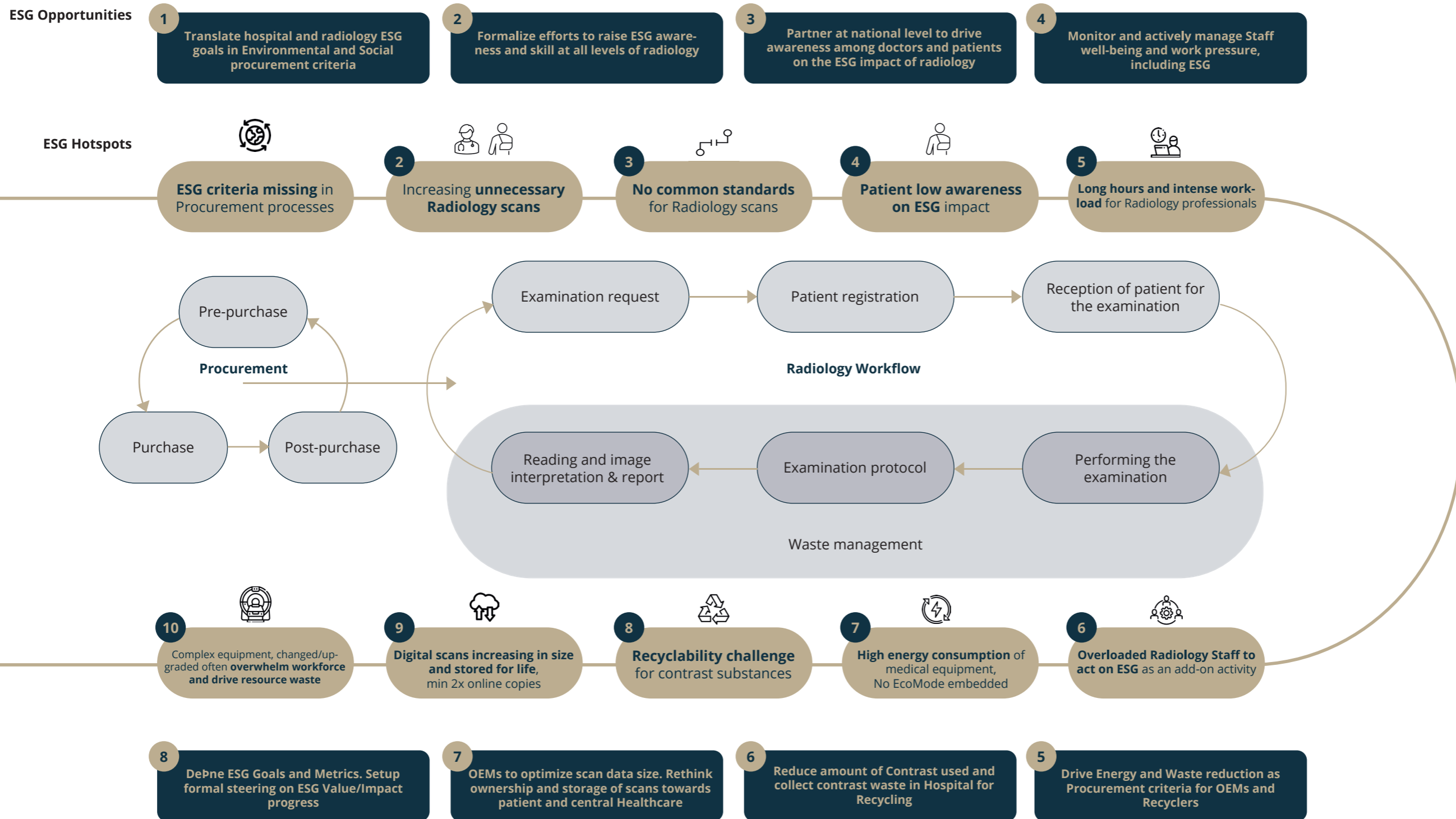
4.6 Opportunities to address ESG Hotspots in Radiology Workflow

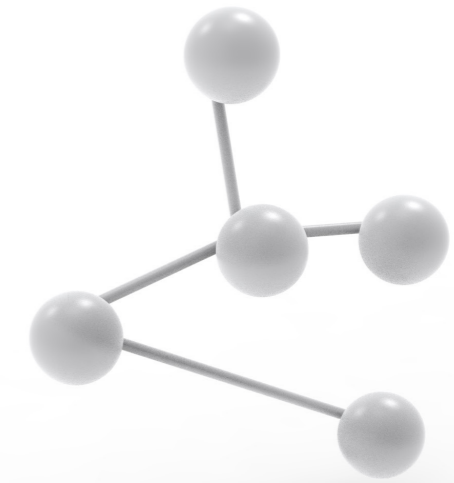
While the chapter’s previous section addressed the key ESG hotspots in the Radiology workflow, it is equally important to define prospects for change and future improvements so that organizations can take concrete actions. Ultimately, transforming hotspots into opportunities requires a proactive and collaborative approach, a willingness to identify and address underlying issues, and a commitment to continuous improvement. Solution directions for each of the selected priority hotspots are concluded based on data interview insights and processing as shown in Appendix B, followed by expert dialogue during co-creation as shown in Figure 10. The ESG and Radiology experts involved in this research proposed and selected the most impactful, pragmatic, and feasible solution directions, here defined as opportunities. Table 9 presents these opportunities prioritized for each of the ESG hotspots and highlights insights and considerations reached during the co-creation workshops.

Table 9. Prospecting opportunities from ESG hotspots

Hotspots	Opportunities	Co-creation Insights & Recommendations
1 ESG criteria missing in procurement processes	Translate hospital and Radiology ESG goals in Environmental and Social procurement criteria	Hospitals should ask questions, identify needs, and demand transparency from suppliers prior to tendering. This will give greater weight to efforts to promote social, environmental, and climate responsibility.
2 Increasing unnecessary Radiology scans	Formalize efforts to raise ESG awareness and skill at all levels of Radiology	The most effort is needed to overcome such awareness. One way to raise awareness is to provide educational in services that explain the benefits of energy conservation and describe specific actions to take (Hawkins & Tremblay, 2023).
3 No common standards for Radiology scans	Partner at national level to drive awareness among doctors and patients on the ESG impact of Radiology	Doctors must raise awareness of the ESG impact of ordering scans, which affects patient workflow and staff workload. Environmental considerations should be factored into healthcare regulations and combine forces to work on a single regulation.
4 Patient low awareness on ESG impact	Integrate ESG considerations into patient care practices	The greatest forms of ESG impact arise from patient travel, lifestyle, motivation towards sustainability. Some hospitals have implemented patient communication/education channels to promote ESG.
5 Long hours and intense workload for Radiology professionals	Monitor and actively manage staff well-being and work pressure, including ESG	Healthcare professionals face a tremendous workload, therefore improving motivation through a strong sense of teamwork and camaraderie can help.
6 Overloaded Radiology staff to act on ESG as an add-on activity	Incorporate ESG principles as part of Key Performance Indicators (KPIs) in job responsibilities	By aligning ESG goals with individual performance objectives, staffs are motivated to actively contribute to ESG into their daily workflow.
7 High energy consumption of medical equipment, no EcoMode embedded	Drive energy and waste reduction as procurement criteria for suppliers and recyclers	The Radiology department should collect data and analyse insights such as energy consumption and scan production rates to raise awareness and make improvements. Suppliers should consider ESG requirements when designing and manufacturing their product, such as the Eco-mode program for large equipment to hibernate and optimise the energy use.
8 Recycling challenge for contrast substances	Reduce amount of contrast used and collect contrast waste in hospital for recycling	Contrast in images can cause safety concerns but is needed to detect certain details in an image. Alternative container designs could be considered. Besides, urine bag should be standardised, which are gradually expanded across hospitals.
9 Digital scans increasing in sizes and stored for life, min x2 online copies	Suppliers to optimize scan data size. Rethink ownership and storage of scans towards patient and central healthcare	Digital images reduce waste but consume energy to operate and cool servers (Hawkins & Tremblay, 2023). Newer scanners in Radiology produce up to 20 GB of data per scan, making it crucial to balance data storage and relevance. Standardizing patient treatment ensures the best care, reducing waste and hiccups.
10 Complex equipment, changed or upgraded often overwhelm workforce and drive recourse waste	Define ESG goals and metrics. Setup formal steering on ESG value and impact progress	A steering group is essential for measuring ESG factors in hospitals, providing guidance, oversight, and strategic direction. They should ensure data accuracy, integrity, and transparency, involving internal and external stakeholders.

Figure 10. Opportunities to overcome ESG hotspots in Radiology workflow





Chapter 5

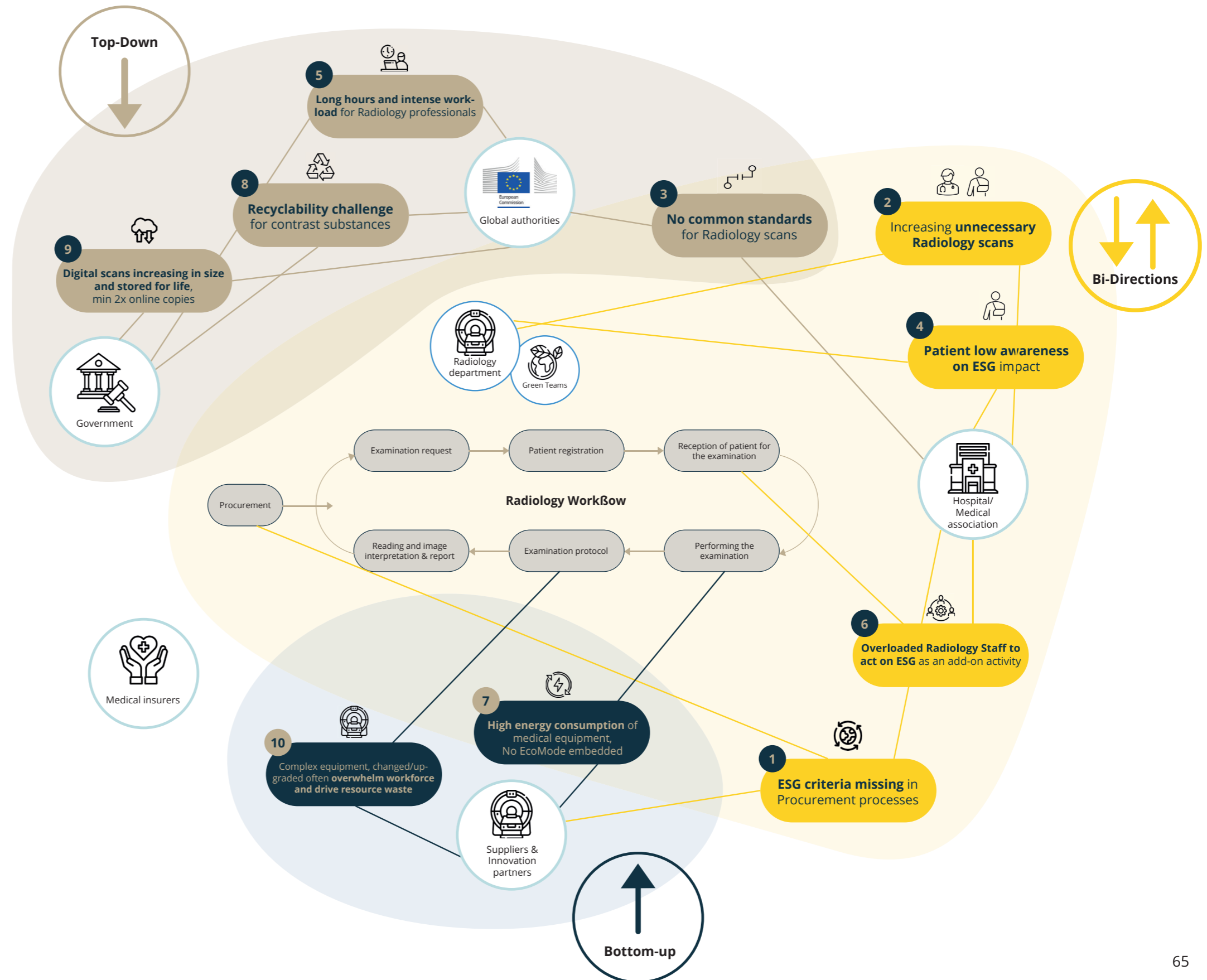
Positioning Radiology ESG Hotspots in the Healthcare Ecosystem

This chapter proposes a new strategic tool that maps ESG hotspots onto system levels. The chapter opens with an introduction to the ESG pathways and their positioning arguments based on co-creation.

5.1 Introduction to ESG Pathways on System Levels

The ESG Pathways aim to trigger and support stakeholder engagement regarding dependencies, and possible solution directions within the system, developing effective decision-making capabilities and necessary partnerships. The systemic approach to ESG acknowledges the complex and interconnected nature of sustainability and responsible practices (Verrier et al., 2022). We need to identify the entities or actors responsible for hotspots in the healthcare ecosystem and investigate ESG intervention pathways for structural and long-term solutions. Implications are drawn about three pathways: **bottom-up** (initiated and driven across the system by the Radiology department level itself), **top-down** (initiatives that must be driven by higher system levels for standardization and uniform transformation across the industry), and **bi-directional** (where parallel and collaborative top-down and bottom-up strategies are required to reach viable solutions). Figure 11 proposes an alternative approach of the system map of the healthcare system also integrating the Radiology workflow. This visual diagram will enable a holistic analysis with participants in the study and the marking of the required level and the pathway direction for the hotspots and opportunities in discussion in this study (Chapter 4.6, Figure 10). The following sections detail the discussions and arguments with stakeholders from various professions and hospitals as a result of the co-creation workshops.

Figure 11. ESG pathways of bottom-up, top-down, and bi-directional ESG hotspots



ESG Pathway Principles:

- [1] Who has ultimate decision power in the system
- [2] What is the shortest route to realization of solution
- [3] What can you / your department / hospital do independently, effectively and with impact, on short term

5.2 ESG Interventions Actionable by Radiology (Bottom-Up)

- **Hotspot 7: High energy consumption of medical equipment, no EcoMode embedded**
ESG Pathway: accelerated by department and supplier levels. The Radiology department can be the driving force, working internally with procurement and upstream suppliers to incorporate these ESG criteria. This relates to the Hotspot 1 argument that the ESG criteria are missed in the procurement process. For example, Erasmus MC reports the amount of energy consumed at the department level, which considerably increases awareness.
- **Hotspot 10: Complex equipment changed/upgraded often overwhelm workforce and drive resource waste**
ESG Pathway: interventions by department and supplier levels. The vendors can best rethink technology and medical operating systems, with an emphasis on ESG at large and reducing effort and skilling of the workforce specifically. Close collaboration between hospitals and suppliers is required for both solution design and business model alignments.

5.3 ESG Transformation at Industry Level by Systemic Change (Top-Down)

- **Hotspot 3: No common standards for Radiology scans**
ESG Pathway: uniformed by national level. Nvvr (The Radiological Society of the Netherlands) can play a leading and enabling role in driving standardization with durability. This cannot be led by a single hospital alone; rather, a national policy must be established in cooperation with hospitals.
- **Hotspot 5: Long hours and intense workload for Radiology professionals**
ESG Pathway: uniformed by national level. All Radiology experts in the co-creation sessions stressed the worsening workload over the last decades. The shortage of healthcare professionals is a global issue, and Radiology departments are similarly impacted. The government, or even the EU, must approach this from a systemic perspective to make sure the necessary resources, policies, and support are available to create a conducive workplace for Radiology staff.
- **Hotspot 8: Recyclability challenge for contrast substances**
ESG Pathway: driven by higher authority level. Despite being collected by a vendor or disposed of responsibly at home, leftover contrast is not permitted to be transported by road because of safety concerns if it contains radioactive or hazardous substances. The government or other higher authority should take action in this matter. By allowing the recyclability of contrast, the hospital may be able to make financial savings while also generating new sources of income.
- **Hotspot 9: Digital scans increasing in size and stored for life, min 2x online copies**
ESG Pathway: improved by national level, in co-creation across the system. Radiologists desire the highest-quality images possible, but if that means affecting the environment and implicitly the lives of others, they need to reconsider. Suppliers play a key role in innovating energy-efficient and environmentally positive digital solutions. However, this should be handled top-down, coordinated at the national level by organizations such as AVZ (Nederlandse Vereniging van Ziekenhuizen / Dutch Hospital Association) and engaged by all other relative parties for both reducing the size and energy of digital scans as well as finding alternative models of ownership and optimizing the management of scans; a never-ending data accumulation affects not just energy use but also implies high operating costs.

5.4 Bi-Directions of ESG Transformation

- **Hotspot 1: ESG criteria missing in procurement processes**
ESG Pathway: proactively collaborated among department, procurement, and hospital level. This hotspot led to the most different arguments among stakeholders. From a procurement standpoint, product category owners at the department level who are aware of how Radiology solutions should be considered in decision-making should facilitate the ESG criteria. Procurement is said to be an enabling function rather than one that determines the criteria. On the other side, Radiology experts, including radiologists, technologists, and the manager of the Radiology department, believe that hospitals should drive ESG procurement criteria definition since the Radiology department is underskilled on the topic and unable to drive the change on its own with current resourcing. The ESG criteria must be prioritized by the hospital board and enable procurement to include them when engaging with partners in the value chain.
- **Hotspot 2: ESG Increasing unnecessary Radiology scan**
ESG Pathway: standardised by department and cross-hospitals. According to Donnelly's research from 2005, the most significant causes of unnecessary CT scan requests are doctors' obsession with stereotyping rather than clinical examinations, broad psychological publicity for utilizing the most up-to-date medical techniques, and increased financial gain from stereotyping (Khosravi et al., 2023). Due to the greater radiation in the case of CT, the diagnostic modalities used today are still not completely safe, despite several advances in technology. LUMC recently took concrete measures to reduce the number of specialization exams by 15%. This opened up the conversation between the Radiology department and higher management in the hospital to invest in additional interventions and further reduce unnecessary scans. This is a great proof of the influence power departments can have through small steps and measured value. According to participating stakeholders, for additional efficiency in the system, national guidelines, cross-hospital alignment, and coordinated implementation at the department level are preferred.
- **Hotspot 4: Patient low awareness on ESG impact**
ESG Pathway: enhanced by both department and hospital level. According to discussions during the co-creation sessions, directly involved medical specialists, such as doctors or nurses, may have the greatest impact on increasing ESG awareness among patients. They could act as ESG ambassadors, educating patients on the consequences of their decisions (i.e., patient no-shows) and examination protocols. This undoubtedly calls for the training and skilling of the medical workforce on sustainability and ESG at large. The bottom-up efforts, though, need top-level commitment and public voicing. Hospitals have the power to influence society by bringing forward integrated narratives on human, society, and planet health and actively engaging patients in sustainable services and innovations. One such successful initiative is the introduction of urine bags for patients to use at home after scanning, which ensures responsible use and disposal in the household. This participatory effort shapes a new relationship and drives the shared success of hospitals, departments, and patients.
- **Hotspot 6: Overloaded Radiology staff to act on ESG as an add-on activity**
ESG Pathway: driven by department and hospital levels. Although hospitals have a group of Green Teams acting as ambassadors to raise awareness internally, however this is voluntary, and on top of their current clinical responsibilities and workload, due to the heavy clinical workload, they cannot always be on call for ESG or effectively shape and lead initiatives. The hospital's management should formalize ESG positions, effort allocation, and overarching goals. Giving them mandates, resources, and governance structures to enable them to effectively grow knowledge, develop capabilities, investigate, and lead ESG initiatives within their departments and across the hospital.



Chapter 6

Measurements of ESG in Hospital and Radiology

This chapter demonstrates prototypes for measuring ESG at the hospital and Radiology levels. The chapter provides instructions for using each measurement tool, called as ESG Value-Impact Scorecard, beginning with the question of how ESG may be measured as a business value.

6.1 How can ESG be measured a Business Driver?

Whereas the previous section of chapter discussed how to address hotspots in the systemic context of the Radiology workflow, this section guides how to “measure” those hotspots in a strategic business approach. As highlighted in the ESG pyramid in chapter 3.1, the integration and synergy between ESG policy programs and reporting framework is essential and must be developed.

*“What gets measured gets done.”
- Peter Drucker*

At hospital and department levels, monitoring the extent of ESG hotspots or interventions is still relatively new. This has the potential to provide necessary information to understand and prioritize ESG interventions, and concretely measure the sustainability impact and economic value of made investments. The following section recommends a strategic approach to ESG goals setting and metrics definition of impact and value, framed within the wider hospital, regional and global ESG context.

- **ESG Impact goals and metrics** are to be defined along the pillars of “Environment”, “Social” and “Governance”, linked to the global SDG framework and relevant global ESG goals the hospital committed and contributes to. This constitutes the upper part of the scorecard, in two different sections: “2030 Global ESG Goals” and “2030 Hospital ESG Goals”.
- **ESG Business Value** is proposed to be defined by operational and financial performance KPIs, reflecting the productivity, efficiency, as well as spendings, savings and new (circular) revenues of ESG interventions investments. This completes the second part of the scorecard, in two other sections: “Department ESG Scorecard” and “Circular Economy”.

Figure 12. ESG impact-value scorecard for hospital

6.2 ESG Impact-Value Score Card for Hospitals

The proposed ESG Impact-Value scorecard is intended to provide a structured framework for defining, measuring and continuous monitoring of ESG performance in hospitals. The scorecard provides an integrated overview across departments or areas where hospitals can improve their sustainable and social impact, each with its specific ESG priorities and targets.

The scorecard is developed as an ESG framework, coupling hospital and department goals to SDGs and broader global goals and programs. Such an ESG scorecards can be envisioned as a digital dashboard, by design. This makes it dynamic and relatively easy to integrate within existing protocol software or other internal operational systems used across the hospitals, simplifying access and adoption for hospital staffs.

The researcher, in validation with ESG leaders and Radiology experts, consolidated in one integrated overview, the sustainability impact and economic value of ESG, as illustrated in Figure 12:



6.3 ESG Impact-Value Score Card for Radiology

To drive ownership and transformation of ESG, at speed and scale across the healthcare industry, increasing transparency and formalizing goals setting and performance monitoring is necessary to be adopted across all levels of the ESG pyramid, from UN and WHO to specific hospital department level (see Figure 4, Chapter 3.2).

Building on Radiology as study case in this research, an ESG Impact-Value card blueprint at department level has been designed and proposed for validation towards the engaged ESG and Radiology experts. All 5 hospitals as well as the national Radiology association in the Netherlands have been acknowledging that this in the most important gap to close in order to grow awareness, enable relevant dialogue on ESG investments and accelerate transformation through collaboration on shared urgencies and priorities, within the hospital, across the industry and wider value chains.

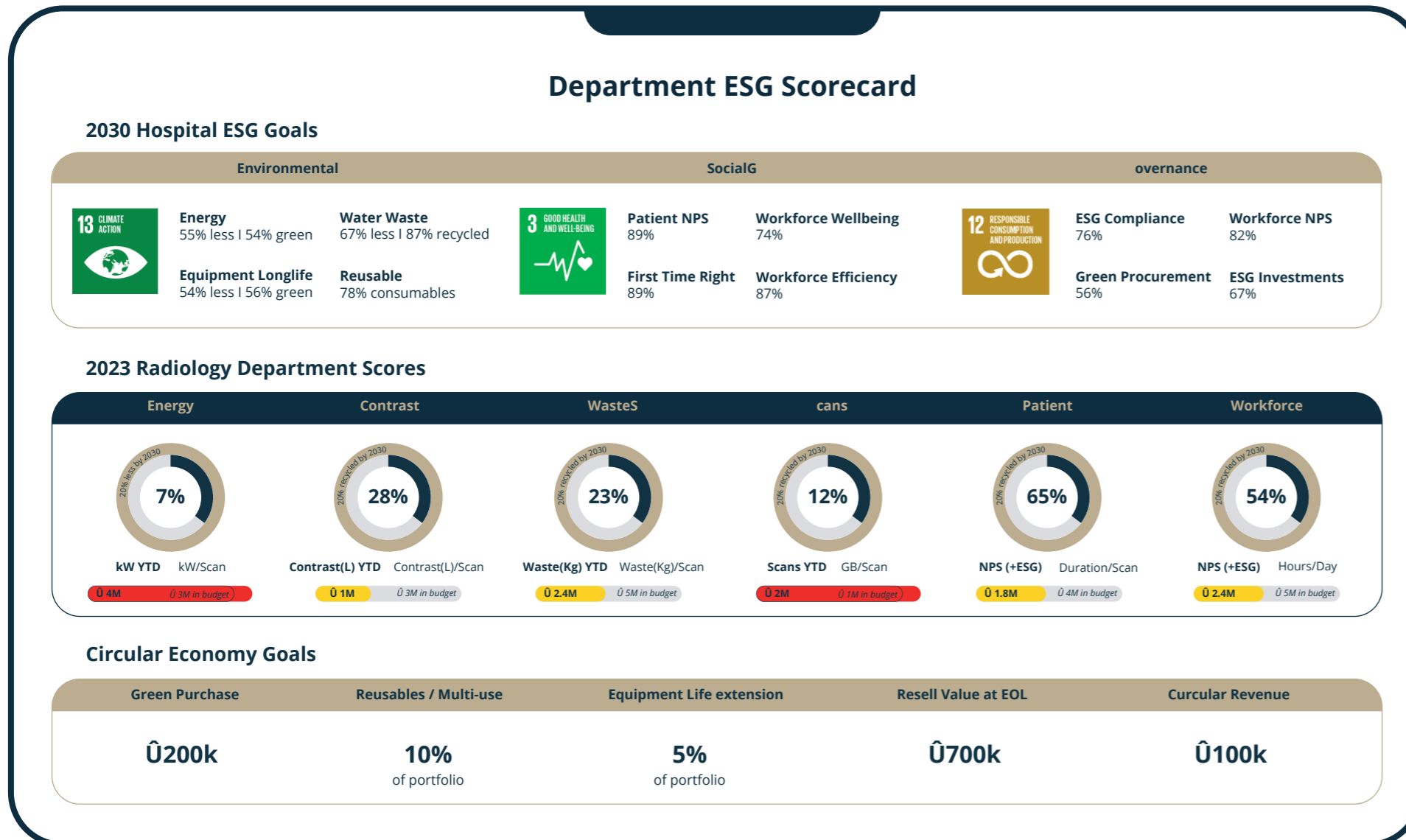
"This is a valuable measuring tool especially for Green Teams, because it provides transparency and progress of ESG investments across departments!"

Sustainability program manager of a MC

Figure 13 presents the proposed blueprint for the Radiology department ESG Impact-Value Scorecard. In the top part, as header and north star, the overarching hospital ESG goals are mentioned. These are then translated in Radiology specific ESG goals and KPIs in the section "Department ESG Scorecard". The proposed Radiology domains for ESG monitoring presented in this section are concluded based on the conducted research data analysis of ESG impact, challenges, and opportunities across the Radiology workflow (see 3.2.4 Data Collection and Interpretation, Chapter 2); as well as cross-hospital dialogue and expert validation on key ESG priorities in Radiology, system positioning of corresponding interventions and key impact- value indicators.

The last section of the ESG scorecard is dedicated to the Circular Economy transition of healthcare, where, in co-creation with participants in this study, four indicators have been prioritized at Radiology department level: [1] Green Purchase; [2] Reusable / Multi-use; [3] Equipment Life extension; [4] Resell Value at EOL; and [5] Circular Revenue.

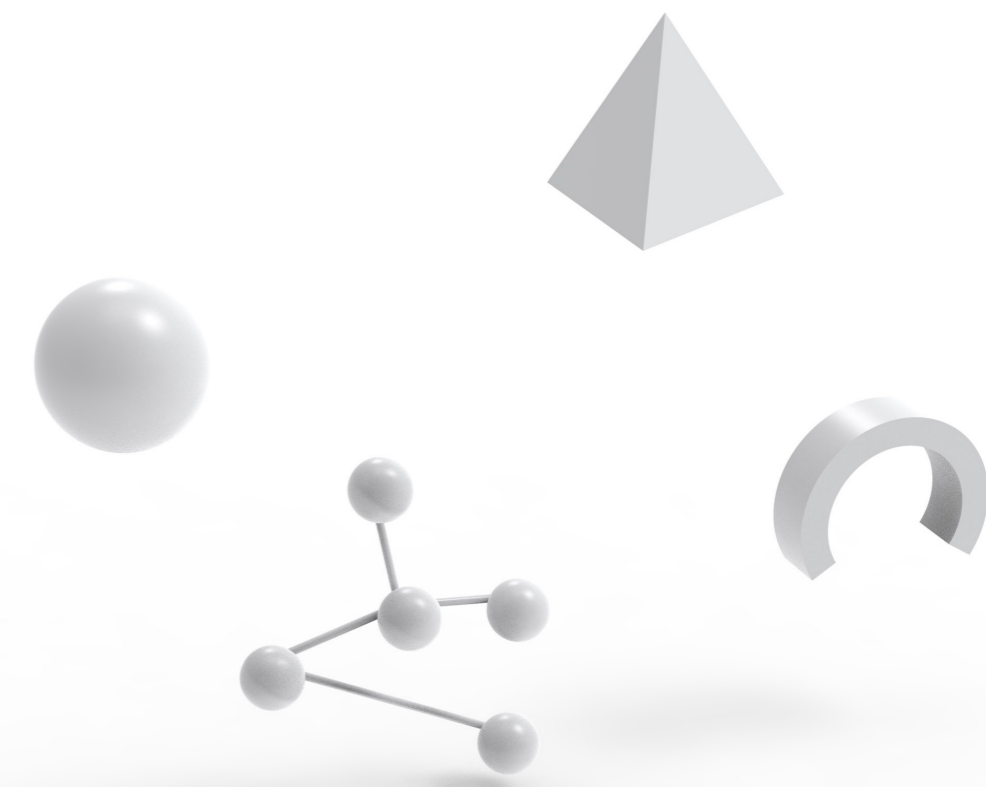
Figure 13. ESG impact-value scorecard for Radiology



An instrument such as the ESG Value-Impact Scorecard needs formal program setting, clear ownership, and continuous development. Chapter 7 in the next chapter proposes an end-to-end strategic design process to help healthcare entities in contextualizing, defining, and steering toward their specific ESG goals. It is then essential to centrally position, share and operate on these instruments across the hospital and with other relevant entities in the healthcare ecosystem. In this way it becomes an integrated part of healthcare decision making, operations and workflows.

"Measurement is the first step that leads to control and eventually to improvement. If you can't measure something, you can't understand it. If you can't understand it, you can't control it. If you can't control it, you can't improve it."

H. James Harrington



Chapter 7

Consolidating ESG Strategy Toolkit

This chapter provides, as the final design step, the ESG strategic design toolkit that was initiated, developed, and evaluated throughout the research. It can serve as start point and blueprint for any entity within the healthcare system, or any other industry, that wants to act on ESG. Additionally, it presents a summary of significant discussions.

7.1 Summary of ESG Strategy Value and Impact Toolkit

As one of the goals of the research is the design and validation of a widely applicable and easy to adopt strategic design process for embedding ESG at core of healthcare workflows, the researcher consolidated all learnings, validations, and developed supporting tools in a four steps strategic design process, as presented in Figure 14. This process has been validated and refined during co-creation workshops. All stakeholders participating in this study were inspired, felt practically helped and were eager to adopt such a process. They appreciated at most the simplification of topic and process, its fit for purpose and adaptability to different organizational contexts. The toolkit is designed for low maintenance, adaptability, is digital-proof and represents a practical support for complex dialogues across the levels of the ESG pyramid.

Overall, the process aims to reduce complexity, increase speed, and enable steering on ESG investments made by organizations and institutions. The steps and tools only cannot guarantee high performance outcomes. Table 10 below introduces a proposed governance model to maximize outcomes of the ESG strategic design process. Clear ownership and decision-making criteria are essential to effectively identify, prioritize, resource and successfully implement ESG initiatives. The proposed governance model was discussed and validated with experts and stakeholders for relevance and feasibility. Unanimously, all involved had full support on the value of this process and added extra time to refine together the methodology.

Figure 14. Systemic Design Process and ESG Strategic Toolkit

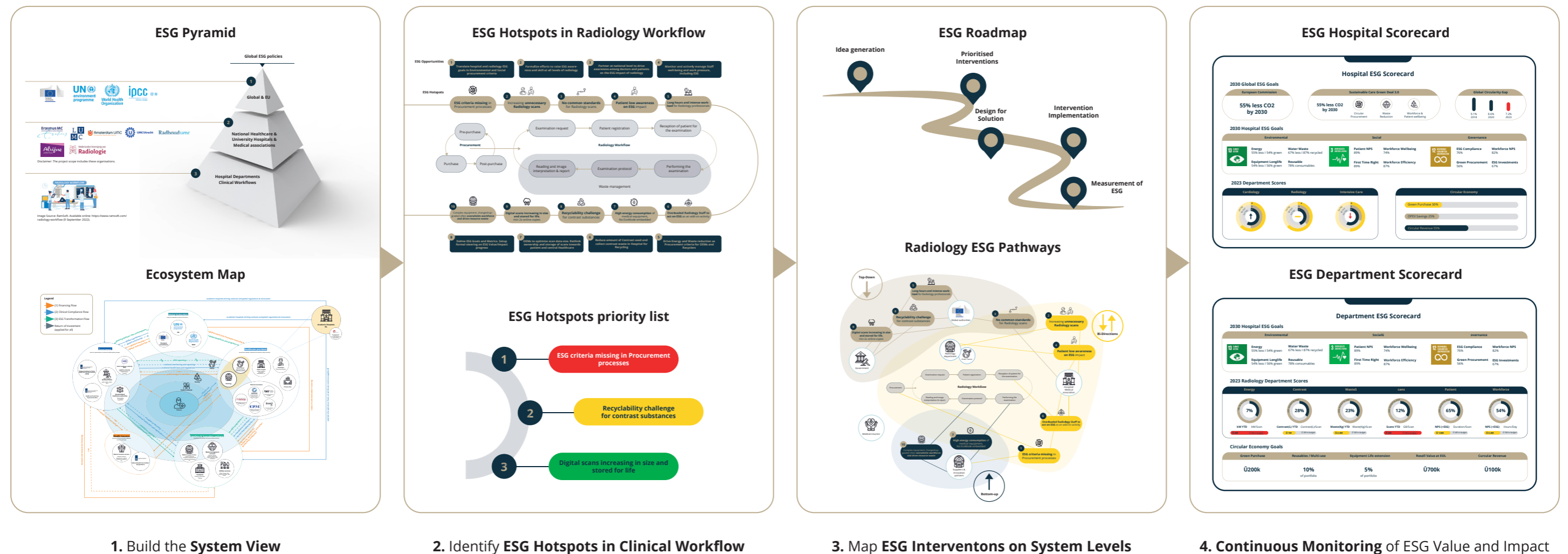


Table 10. Governance Model of Systemic Design Process (supported by ESG Strategic Toolkit)

Systemic Design Step	Description	Tools	Strategic Value	Owners	Governance	Users
1 Build the System View	Consolidate all ecosystem actors, dynamics and key insights on decision making power	ESG Pyramid	- Foundation for strategy design, evaluating dependencies and risk; identifying key partnerships	Sustainability / ESG lead	Yearly	All
		Ecosystem Map	- Overarching reference internally; dialogue support externally	Sustainability / ESG lead	Half year	All
2 Identifying ESG Hotspots in Clinical workflow	Collect and prioritize sized ESG challenges and opportunities	Clinical workflow	Using the common clinical nominator to introduce ESG	Clinical expert	Yearly	All
		ESG Hotspots priority list	Clear structure and criteria to select and prioritize initiatives	Clinical expert	Quarterly	All
3 Mapping ESG Interventions on System levels	Design in co-creation strategies for investment and realization of ESG priorities	ESG Roadmap	One ESG north star across hospital and departments	Hospital / Department Sustainability / ESG lead	Yearly	All
		ESG Pathways	Evaluated and detailed collaboration and implementation of ESG initiatives	Department Sustainability / ESG lead	Quarterly	Green Teams
4 Continuous Monitoring of ESG Value and Impact	Simplified overarching view on ESG progress, impact and added value	ESG Department Scorecard	Internal ESG Reporting solution and ESG business steering support	Clinical expert	Monthly	All
		ESG Hospital Scorecard	Overarching solution for ESG goals setting, department break down, progress and ROI monitoring	Sustainability / ESG lead	Quarterly	All

7.2 Building the System View

Starting outside-in and top-down when acting on ESG is important, especially in current times, when policy frameworks, collaboration platforms and transformation programs are already in motion, at all system levels (global, regional, national).

A first required step in strategic system redesign is conducting an extensive desk and field study to identify the leading entities in driving ESG at global and national level, specific ESG goals and programs already defined. It is important to understand then how do these connect, the underlying system dynamics and how to best drive collaboration across various system structures and levels. The focus of this study has been set on healthcare and specifically Radiology, in order to conduct such a systemic research and an end-to-end strategic design assessment.

Two enabling tools have been developed for this step. These require active participation of cross-disciplinary experts and leaders, at all system levels: department, hospital, national level and above. The enabling tools help stakeholders define, refine, and use a contextualized holistic view for strategic decision making:

- **ESG Healthcare Pyramid** simplifies the external context of a department or hospital. It helps to preliminary identify system levels and relevant entities relevant for developing and executing on strategic ESG interventions.
- **ESG Healthcare Ecosystem Map** enables stakeholders across different system levels to co-develop a simplified and shared understanding of their specific ecosystem structure, with key dependencies, dynamics, and important facts.

Both these tools support value case developments for ESG investments, as well as strategic partnering for accessing funds, programs and collaboratively executing on defined ESG agendas. They require an annual update at minimum, preferably every six months.

7.3 Identifying ESG Hotspots in Clinical Workflow

The scope of our research has been set on the Radiology clinical workflow, covering both diagnostic and interventional procedures. Using Radiology as study case for healthcare, the researcher consolidated and validated a generic, broadly applicable, clinical workflow. This result was based on preliminary desk and field research, followed by 1:1 refinements and group validation sessions. The concluded Radiology workflow process was then used as guide to identify ESG hotspots and ideate on possible interventions or solution directions.

This step in the ESG strategic design process can be best setup in two phases and enabled by specific tools:

- **Clinical Workflow** maps and presents core operational process steps in a representative simple format, validated by stakeholders of various backgrounds, roles, and functions. In this way a common nominator enabling effective dialogue and decision-making is created. Chapter 4 presents the concluded Radiology workflow in this study.
- **ESG Hotspots Priority List** is the result of a structured process to assess and evaluate significant area of ESG impact. Clear ESG criteria and metrics need to be defined to trust and use such measurements by various stakeholder groups. In this research, defining in depth criteria were not possible due to time and expert access constraints. Therefore, an expert-lead prioritization methodology was applied, voting based. The concluded ESG Hotspot priority list is next mapped onto the workflow for an integrated and contextualized ESG narrative, as shown in Figure 10.

Mapping out core operational process, their current footprint and social value tensions, are a standard second step in the ESG strategic design process. This approach and corresponding steps are applicable to any other clinical area or industry.

7.4 Mapping ESG Interventions on System Levels

The third step in the ESG strategic design process enables stakeholders to define solution directions and ecosystem engagement strategies, with the ultimate goal of resource optimization and impact-value maximization. This step helps in framing the value case, required ownership, and collaboration models. Two dimensions are proposed at this step:

- **ESG Roadmap**, though out of scope for this research, it is acknowledged as core need by the researcher and stakeholders. Having an overarching formal ESG Roadmap at hospital and department level would entitle action and optimize efforts. The researcher recommends that the ESG roadmap is developed as an integrated part of organization's business roadmap protocol. Business roadmap strategic design is a common and widely implemented process by organizations and institutions, usually on a yearly basis, and presenting a short-, mid- and long- term horizons. Specifying ESG goals and priorities under existing business roadmap processes would be preferred. Alternatively, entities can extrapolate such processes for ESG steering specifically. However, *"Before we can effectively build new habits, we need to get a handle on our current ones."*

James Clear (Atomic Habits) James Clear (Atomic Habits)

- **ESG Pathways** are protocols that enable the assessment of systemic dependencies, power structures and strategic directions to implement structural solutions. In the Radiology study case, the available resources did not allow reaching the methodology in depth. This however can represent a great research topic for fellow students interested in system design. Co-creation is the methodology chosen for in this study and three principles are considered for ESG Pathways design of selected hotspot interventions: [1] Who has ultimate decision power in the system [2] What is the shortest route to realization of solution [3] What can you / your department / hospital do independently, effectively and with impact, on short term. These principles triggered rich dialogues on system structure, influential entities and available strategies for driving ESG initiatives forward, for maximum impact and value. Figure 11 presents the resulted strategies for identified Radiology ESG interventions. Three types of directions have been proposed to frame ESG Pathways: **bottom-up**, **top-down** or **bi-directional** as presented in Chapter 5. ESG leads can best govern and regularly advance these strategies and corresponding partnerships across hospital and industry.

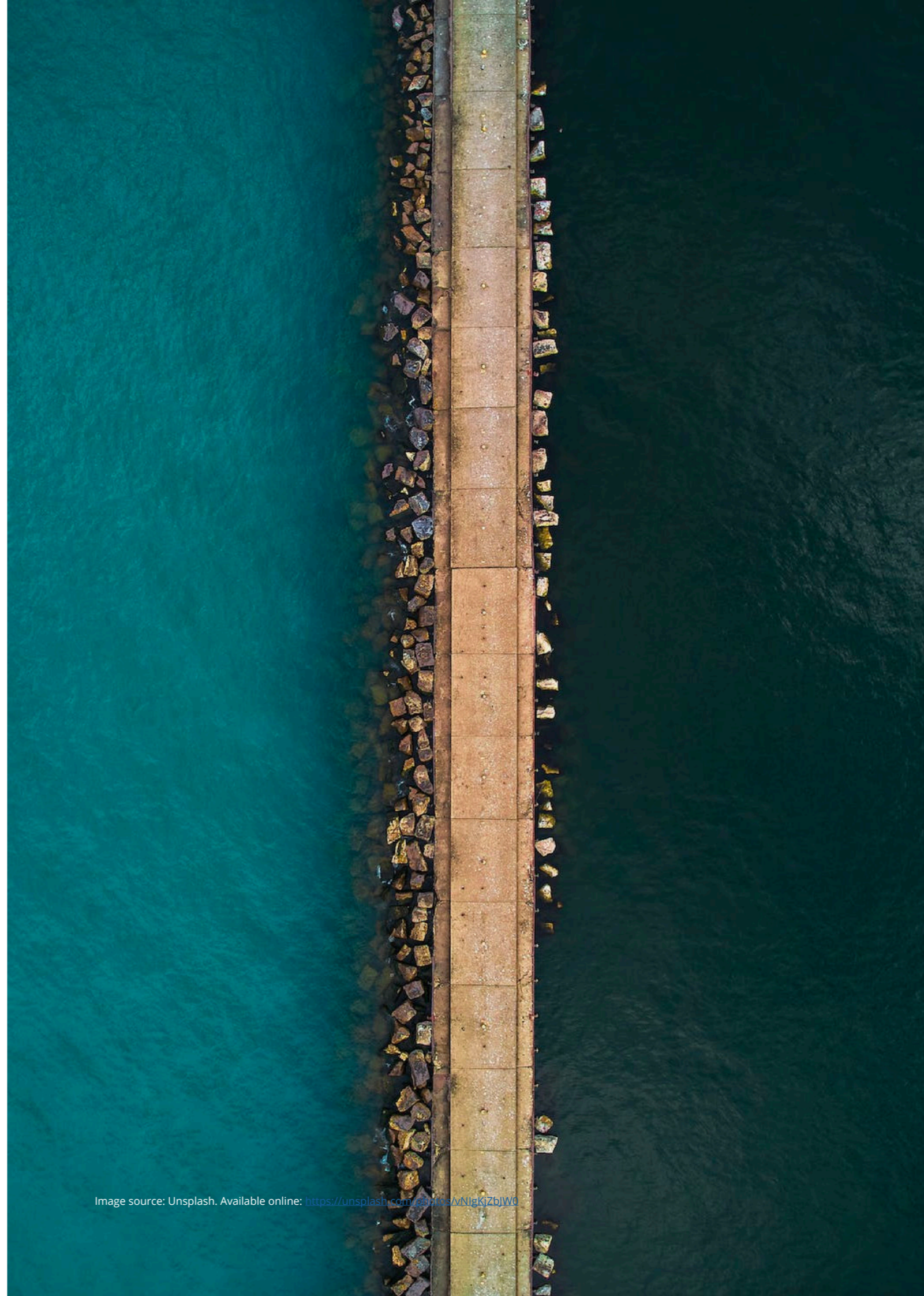
7.5 Continuous Monitoring of ESG Value and Impact

Last and probably the most important step of all, is setting up an ESG impact-value measurement for continuous monitoring and active steering. To drive change and transformation, implementing such instrument and process is required at both hospital and department level. Chapter 6 presents in detail the architecture and definitions of proposed indicators in the **ESG Value-Impact Scorecards**. Such simplified and cross-integrated dashboard helps entities across system levels in ESG Goals definition efforts, ESG metrics development and progress monitoring.

Chapter 8

Conclusion

The research conclusion is presented in this chapter. The main research question and the secondary goals that were previously defined are discussed in the first section, including the limitations that were faced. Furthermore, recommendations on future research are shared forward towards academia, sustainability ambassadors and the healthcare industry at large. Last but not least, the chapter ends with a reflection from the researcher.



8.1 Conclusion

The complexity of the healthcare system, as well as the need of addressing equally and effectively all three pillars of sustainability (Environment, Social, and Economic), asks for a radical new holistic approach. This will enable informed and effective decision making when investing, changing regulations and protocols, or redesigning the healthcare system.

The project started with the goal of providing guidance and an end-to-end toolkit for hospitals, Green Teams, and particularly Radiology departments, to strategically define and manage ESG goals. The research proposes and proves the value of a system-oriented mindset for understanding external dynamics and internal structures, facilitating decision making on optimal position and framing of ESG initiatives. In the following section the main outcomes of the research are briefly summarised and related back to the overarching research question:

“How can ESG principles/policies be embedded in Radiology workflows?”

Based on the theoretical definition of system thinking and systemic design, the researcher proposes an end-to-end strategic design process, supported by specific tools at each step (see Chapter 7), to simplify, contextualize and systematically steer ESG transformation in Radiology and healthcare at large. A wide range of data collection methods are used at each step of the process, including desk research, in-depth interviews, field research, surveys, and co-creation workshops. These led to field learnings on current ESG definitions, priorities and initiatives at hospital and Radiology clinical domain level.

The research takes on ambitious macro- and micro- objectives, addressing complex and interrelated challenges concerning the planet, the people and the systemic transformation processes in healthcare. Therefore, the research design process requires a number of steps of insights gathering, context setting and forward looking, in co-creation with multiple stakeholders. The proposed research design process is illustrated in Figure 1 and has five steps: [1] analysing the ESG pyramid as the fundamental base (Chapter 3), [2] framing ESG value and impact (Chapter 4), [3] positioning interventions of Radiology ESG hotspots (Chapter 5), [4] measuring ESG in Radiology and at Hospital level (Chapter 6), and [5] consolidating ESG strategy toolkit with the research conclusions (Chapter 7).

The research involves 11 cross-disciplined stakeholders from six university hospitals and the national Radiology healthcare association in the Netherlands. Research findings indicate the need for continuous cross-hospital dialogue to structurally frame, define, and embed ESG into clinical workflows, industry regulations and protocols. The systemic and collaborative approach of addressing ESG transformation in Radiology, as proposed in this study, is validated by engaged stakeholders as representative clinical case study for the industry. The ESG strategic design toolkit can optimize dialogue on value and impact of ESG interventions at all levels across the healthcare ecosystem, enabling hospitals and Radiology stakeholders to define specific ESG goals, programs and structurally measure their progress. Such simplified and transparent way of working has the potential to increase awareness, collaboration and significantly reduce ESG spendings.

The research takes a unique holistic approach of defining and designing an end-to-end strategic design process for ESG goals setting and value-impact measurement. Different than other prior studies, this research takes initially a top-down view on the ESG challenges in the healthcare system. Based on wide contextual research and a novel pyramid global healthcare view (Chapter 3), the first strategic design step proposed is the development of an ESG healthcare ecosystem map for the Netherlands, from the perspective of Radiology (Chapter 4). The ESG pyramid and the ESG Healthcare Map complement each other in identifying the role and influence of key stakeholders within the broader ecosystem; formally defined ESG goals, and existing dynamics. Such perspective helps to streamline collaboration,

implementation and transformation across global/EU, Dutch hospitals, and Radiology clinical workflow levels.

Data on operational insights, ESG priorities, ongoing initiatives, and key challenges is collected in collaboration with the selected group of ESG leads and Radiology experts. As a result, a blueprint for ESG hotspots, and opportunities in the Radiology workflow is being developed (Chapter 5). Interventions on ESG hotspots are then considered and positioned at the corresponding influence level within the system (Chapter 6). Depending on the solution direction for selected ESG hotspots, three different system implementation pathways were concluded: bottom-up (initiated and driven upwards and wider in the system by the Radiology department level itself), top-down (initiatives that must be driven by higher system levels to ensure standardization, transformation and efficiency across the industry), or bi-directional (where driving the interventions, in parallel and collaborative, top-down and bottom-up, is required to drive engagement and reach viable solutions). The ESG Hotspots in the Radiology workflow are presented in Chapter 4, and proposed pathways for their interventions integrated into the ESG pathways are illustrated in Chapter 5.

Most importantly, the research concludes on the immense value of measuring the short- and long- term progress and the return of ESG investments. The proposed ESG Value-Impact Scorecards at department and hospital level are simple and practical instruments that bring focus, transparency, and reliable data-driven insights. These enable effective dialogue and collaboration across hospital and industry. By incorporating the ESG scorecards at the core of hospital and department operations, these can drive awareness, engagement and be proved contribution towards the national and global 2030 ESG goals.

Despite the complexity of the healthcare ecosystem and the large number of involved actors, embedding ESG interventions into the clinical workflow lies in the hand of departments and responsible experts. All stakeholders involved found great value in conducted efforts, endorse the reached research findings and look forward to adopting the proposed end-to-end ESG toolkit and effectively setup, collaborate and accelerate the ESG transformation in their practices.

“We still have a long way to go. Especially in the area of circularity. Collaboration is the key. Cooperation within the whole chain is very important: suppliers, manufacturers, hospitals, banks, insurers, ministries, and municipalities. The awareness is certainly there, but now we all have to put our money where our mouth is.”
Sustainability program manager of a MC

Choosing Radiology as study case in this research has proven to be a well-made strategic and representative choice for understanding how to advance ESG in healthcare. The strong engagement and commitment of involved hospitals and clinical experts in the study, reassures on the importance of the chosen research question and is an eye-opener on how many efforts are currently conducted by individuals, departments, hospitals, and industry level. The research gave the opportunity to address the ESG impact of Radiology – from the challenge of recycling contrast, the accumulation of digital scans, to the overloaded radiology staff. In spite of the industry complexity to drive ESG forward and at core, the formal commitments of academic hospitals for the Green Deal 3.0 national program, is a first step forward to change and a foundation for sharing ESG goals. This platform will further accelerate innovation and interventions across the industry, such as the implementation of urine-bags for safe disposal in households, currently in pilot with several academic hospitals.

In conclusion, this research contributes with a strategic mechanism to connect bottom-up efforts to national and global healthcare ESG goals. By understanding the ecosystem context, key bottlenecks and existing system structures, hospitals and departments can more effectively scope, measure and prove the value of their ESG investments. This study hopes to be a guide in defining the “why”, “what”, “who” and “how” of ESG interventions, in narrow and large healthcare contexts.

8.2 Limitations

This research has a limited breadth and depth, involving stakeholders representing only several hospitals and healthcare associations in the Netherlands. However, a firm conclusion of the study is the value of continuous evolution and collaboration in driving ESG embodiment in the clinical workflow. Undoubtedly this remains a challenge of mandate, timeline and availability of resources.

- **Resource and time constraints**

Although the researcher applied a snowball sampling method to maximize the representation per hospital and relevant healthcare associations, stakeholders sampling was limited due to limited access to entities and stakeholders, the research timeline and availability of engaged experts. These constraints reasoned the narrow focus on the healthcare system in the Netherlands, and more specifically the Radiology clinical area. This enhanced the project's feasibility and a certain richness level of the achieved outcomes.

- **A lack of shared goals across hospitals**

Throughout the data collection, it was prominent that hospitals do not share a common set of goals and objectives, and even protocols in the Radiology workflow vary widely between hospitals. This lack of standardization can pose challenges to implement ESG consistently and efficiently across operational processes in the industry. To a certain extent, the researcher collaborated with the Radiological Society of the Netherlands (NVvR) to understand prior efforts, ongoing programs and future opportunities. NvVR is a highly influential platform that can bring entities together and efficiently steer the ESG transformation across the Radiology practice in the Netherlands.

8.3 Recommendations to Future Research

Further research could shed light on other ESG hotspots and interventions, and how these could be strategically addressed. Leveraging the proposed ESG strategic design toolkit would be an important feedback and advancement opportunity.

- **ESG transformation strategy through the integration funnel**

The current research ends with a proposal of interconnected and integrated measurement of ESG, across different levels in a hospital. Instruments like the ESG scorecard can simplify and improve operational and strategic business decision making. To drive the ESG transformation, a clear value management system needs to be setup. Aside tools to help business case, business steering and business value proof efforts, a strategic ESG value roadmap needs to be defined, financed and managed to return. Though initially in scope for this research, due to time and effort constraints, the researcher only conducted preliminary research and concept design of such a strategic ESG investment management methodology (Appendix E). The proposed approach is setting up an ESG integration funnel that enables prioritization, risk assessment, implementation readiness and return of investment measurements. The researcher intends to continue helping future research in this space post-graduation, aside here involved mentors, supervisors and Radiology stakeholders.

- **Testimonials through a case study across hospitals**

The research revealed that there is a deep understanding on urgency with the engaged stakeholders and a strong desire for embedding ESG into the Radiology workflow. Stakeholders confirmed the great value of taking a systemic approach in their decision making and the intension of adopting the tools and instruments co-developed. Identifying ESG hotspots was highly appreciated, creating a shared understanding between of areas that need attention. Furthermore and mostly, stakeholders appreciated cross-hospital collaboration on ESG initiative prioritization and scoping. An open dialogue on power

structures and pathways in the system to accelerate action on ESG interventions was the most insightful step in the research. Stakeholders shared and gathered deeper insights in the structure and dynamics of the shared clinical practice, as Radiology. Last, and by far the most valued deliverable of the study, are the ESG value-impact scorecards, developed to cross-connect goals, efforts and results within the hospital structure and above. All participating hospitals in the study will pilot these, post publishing, at Radiology department level.

Ultimately, the researcher desires hospitals to incorporate all lessons learned, key insights, developed processes and tools into their protocols and operational processes. It is equally important for experts to continue collaboration and coordination of efforts, to accelerate ESG transformation for and across hospitals in the Netherlands.

8.4 Personal Reflection

The project allowed me an unique opportunity to explore the larger industry of healthcare and understand how I can create future shared benefits for patients, healthcare professionals, the broader society, and our planet. Through a systemic approach, I was able to bring together the macro, mezzo, and micro aspects of the global healthcare system into concise and clear maps and blueprints. It was also exceptional to collaborate with multidisciplinary stakeholders from several university hospitals and national entities, to co-develop towards the future of Radiology and healthcare.

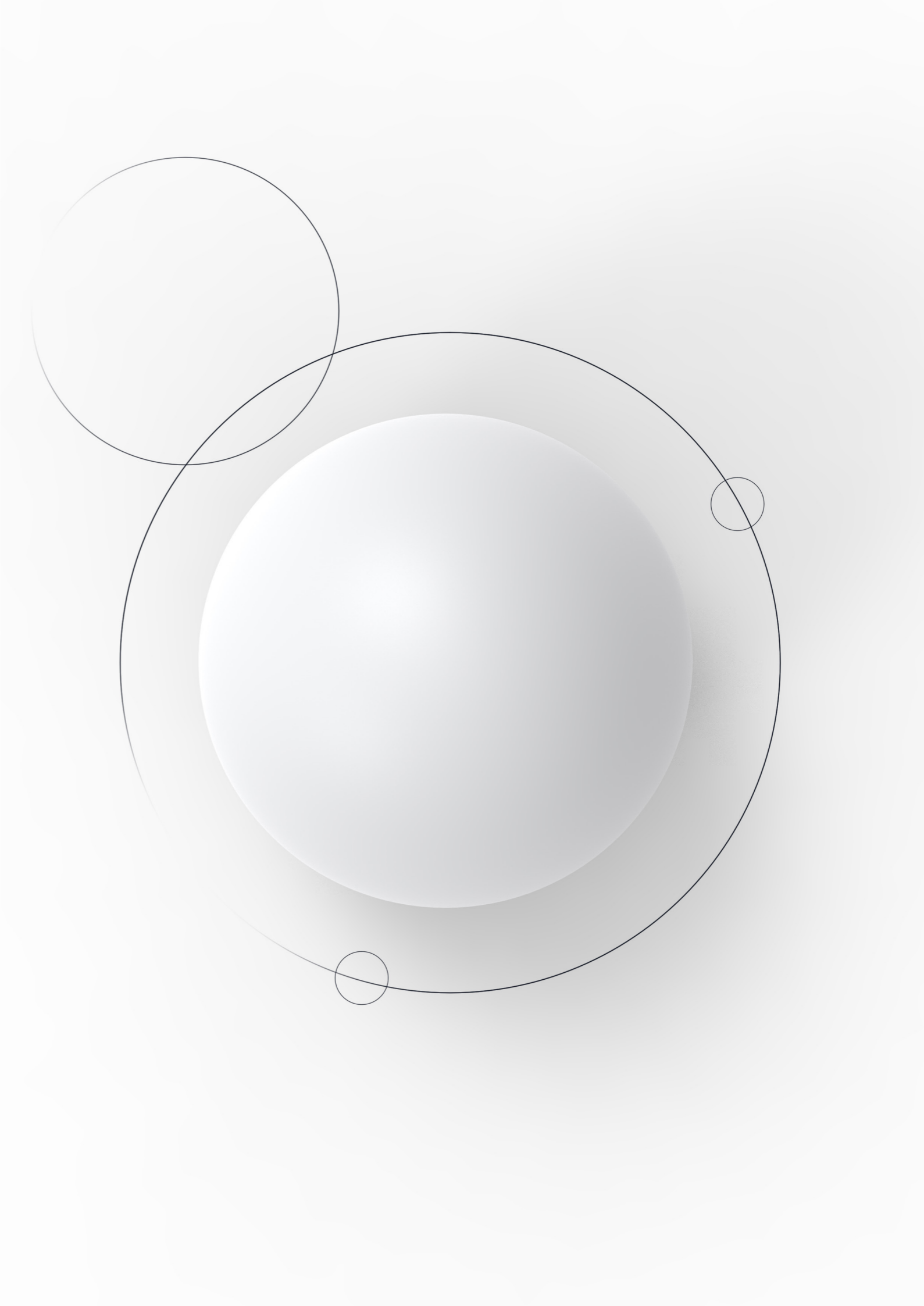
Looking back on the project kick-off at the beginning of January 2023, I had very ambitious goals, driven by the vision and mission to contribute to a more inclusive and responsible healthcare, however, at that point, it was unclear to me what results my research would bring. The timelines of this study forced narrowing down initial ambitions and defining a structured process to navigate the access and complexities of healthcare. To effectively engage with stakeholders, I had to anticipate, simplify and prepare interactions ahead. Agility and discipline were needed to navigate the low and changing availability of stakeholders. Despite their exhausting schedules, stakeholders showed deep interest and extreme committed to the topic of ESG, allowing their lunchtime, part-time, and even scanning time (during break) to contribute in interviews and co-creation sessions. I highly appreciate everyone who consistently supported, strongly believed, and valued the topic, recognising how urgent change must happen. One important lesson I learnt is how to be at ease with complexity and have confidence while moving forward without full control. Undertaking a systemic design approach was new to me, and challenged my expectations and planning. Due to its nature and end goals, it needs extensive research time, joint effort across stakeholders, several validation iterations, and continuous development. The invested time and effort resulted in more than a map of the system. It activated and interconnected stakeholders, who ultimately are the driving force behind a system.

I hope this research contributes to address the **URGENCY** of addressing ESG structurally in healthcare. Today the industry impact exceeds 7% of the national footprint in terms of CO2 emission in the Netherlands (Steenmeijer et al., 2022), Radiology professionals' wellbeing is further at risk due to increasing diagnostic and treatment demands (Catalina Imaging, 2020), and the shift of roles and responsibilities due to technological advancements (Brady et al., 2022).

A systemic strategic design approach of ESG is in somewhat new in the field of healthcare, however needed when dealing with the complexity of ESG across entities and industries. My ultimate hope is that this study will serve as a foundation for future research. Furthermore, there is a strong likelihood that the developed ESG strategic toolbox during the design process could be applicable to other clinical workflows or even other industries.

This project goes beyond the academic research for my graduation; I will continue taking on these difficult challenges and forging connections that help in achieving short- and long-term national goals. With a significance and relevance of the research findings in the field, I feel privileged that these efforts will be published in a scientific paper with my thesis committee, the participating hospitals and NVvR.

It is imminent that Radiology or other clinical workflows further adopt ESG dimensions, in order to advance knowledge and industry transformation on this topic!



References

- 2030 Climate Target Plan. (n.d.). Climate Action. https://climate.ec.europa.eu/eu-action/european-green-deal/2030-climate-target-plan_en
- Afspraken in de Green Deal Duurzame zorg. (n.d.). Afspraken in De Green Deal Duurzame Zorg | Publicatie | Rijksoverheid.nl. <https://www.rijksoverheid.nl/documenten/publicaties/2020/01/13/afspraken-in-de-green-deal-duurzame-zorg>
- Agarwal, B., Gautam, R. S., Jain, P., Rastogi, S., Bhimavarapu, V. M., & Singh, S. (2023, February 10). Impact of Environmental, Social, and Governance Activities on the Financial Performance of Indian Health Care Sector Firms: Using Competition as a Moderator. *Journal of Risk and Financial Management*, 16(2), 109. <https://doi.org/10.3390/jrfm16020109>
- Amsterdam UMC. (2020). Strategic plan 2020-2023 Amsterdam Public Health research institute . Retrieved 2020, from <https://www.amsterdamumc.org/download/strategic-plan-aph-2020-2023-.htm>
- AR6 Synthesis Report: Climate Change 2023 — IPCC. (n.d.). AR6 Synthesis Report: Climate Change 2023 — IPCC. <https://www.ipcc.ch/report/sixth-assessment-report-cycle/>
- Assessing Radiology's Impact on the Environment. (2021, August 11). Impact on the Environment | RSNA. <https://www.rsna.org/news/2021/august/Impact-On-The-Environment>
- Bawaneh, K., Ghazi Nezami, F., Rasheduzzaman, M., & Deken, B. (2019, October 4). Energy Consumption Analysis and Characterization of Healthcare Facilities in the United States. *Energies*, 12(19), 3775. <https://doi.org/10.3390/en12193775>
- Biermann, F., Hickmann, T., Sénit, C. A., Beisheim, M., Bernstein, S., Chasek, P., Grob, L., Kim, R. E., Kotzé, L. J., Nilsson, M., Ordóñez Llanos, A., Okereke, C., Pradhan, P., Raven, R., Sun, Y., Vijge, M. J., van Vuuren, D., & Wicke, B. (2022, June 20). Scientific evidence on the political impact of the Sustainable Development Goals. *Nature Sustainability*, 5(9), 795–800. <https://doi.org/10.1038/s41893-022-00909-5>
- Bijl-Brouwer, M. V. D., & Malcolm, B. (2020). Systemic Design Principles in Social Innovation: A Study of Expert Practices and Design Rationales. *She Ji: The Journal of Design, Economics, and Innovation*, 6(3), 386–407. <https://doi.org/10.1016/j.sheji.2020.06.001>
- Bijzonder duurzaamheidsproject: vang urine met contrastmiddelen op in plaszak - Amazing Erasmus MC. (2020, October 8). Amazing Erasmus MC. <https://amazingerasmusmc.nl/biomedisch/bijzonder-duurzaamheidsproject-vang-urine-met-contrastmiddelen-op-in-plaszak>
- Brady, A. P., Beets-Tan, R. G., Brkljačić, B., Catalano, C., Rockall, A., & Fuchsjäger, M. (2022, June 4). The role of radiologist in the changing world of healthcare: a White Paper of the European Society of Radiology (ESR). *Insights Into Imaging*, 13(1). <https://doi.org/10.1186/s13244-022-01241-4>
- Brassil, M. P., & Torreggiani, W. C. (2019, March 18). Recycling in IR, What IR Specialists Can Do to Help. *CardioVascular and Interventional Radiology*, 42(6), 789–790. <https://doi.org/10.1007/s00270-019-02206-9>
- Brundtland, G. H. (1987). Our Common Future—Call for Action. *Environmental Conservation*, 14(4), 291–294. <https://doi.org/10.1017/s0376892900016805>
- Buckley, B. W., & MacMahon, P. J. (2021, September). Radiology and the Climate Crisis: Opportunities and Challenges—Radiology In Training. *Radiology*, 300(3), E339–E341. <https://doi.org/10.1148/radiol.2021210851>
- Catalina Imaging. (2020, January 6). Radiologist Burnout | Catalina Imaging. Mobile CT Rental - Mobile Imaging Rental and Lease. Retrieved April 29, 2023, from <https://catalinaimaging.com/radiologist-burnout/>
- Cooper, R. (2016, October 18). Decoding Coding via The Coding Manual for Qualitative Researchers by Johnny Saldaña. *The Qualitative Report*. <https://doi.org/10.46743/2160-3715/2009.2856>
- Creswell, J. W., & Poth, C. N. (2017, January 25). *Qualitative Inquiry and Research Design: Choosing among Five Approaches*.
- da Costa Junior, J., Diehl, J. C., & Snelders, D. (2019). A framework for a systems design approach to complex societal problems. *Design Science*, 5. <https://doi.org/10.1017/dsj.2018.16>
- Decentralisation of government tasks. (n.d.). Decentralisation of Government Tasks | Municipalities | Government.nl. <https://www.government.nl/topics/municipalities/decentralisation-of-government-tasks>
- DeTombe, D. J. (2001, January). Methodology for handling complex societal problems. *European Journal of Operational Research*, 128(2), 227–230. [https://doi.org/10.1016/s0377-2217\(00\)00065-5](https://doi.org/10.1016/s0377-2217(00)00065-5)
- DiCicco-Bloom, B., & Crabtree, B. F. (2006, April). The qualitative research interview. *Medical Education*, 40(4), 314–321. <https://doi.org/10.1111/j.1365-2929.2006.02418.x>
- Do patients care about sustainability? – Better Business Center. (2019, February 11). Do Patients Care About Sustainability? – Better Business Center. <https://betterbusiness.torkusa.com/sustainable-hospitals-healthcare/>

Dorst, K. (2011, November). The core of 'design thinking' and its application. *Design Studies*, 32(6), 521–532. <https://doi.org/10.1016/j.destud.2011.07.006>

Duurzaam Alrijne - Alrijne Ziekenhuis. (n.d.). Alrijne Ziekenhuis. <https://www.alrijne.nl/duurzaam/>

Duurzaamheid - UMC Utrecht. (n.d.). Duurzaamheid - UMC Utrecht. <https://www.umcutrecht.nl/nl/duurzaamheid>

Duurzaamheid | LUMC. (n.d.). Duurzaamheid | LUMC. <https://www.lumc.nl/over-het-lumc/het-lumc/maatschappelijk-verantwoord-ondernemen/duurzaamheid2/>

Duurzame zorg. (2021, January 22). Duurzame Zorg - Radboudumc. <https://www.radboudumc.nl/over-het-radboudumc/impact-2021/onze-impact-in-2021-voor/impact-2021-maatschappij/duurzaamheid-in-het-radboudumc/duurzame-zorg>

EBA publishes its Report on management and supervision of ESG risks for credit institutions and investment firms - European Banking Authority. (2021, June 23). European Banking Authority. <https://www.eba.europa.eu/eba-publishes-its-report-management-and-supervision-esg-risks-credit-institutions-and-investment>

Eppich, W. J., Gormley, G. J., & Teunissen, P. W. (2019). In-Depth Interviews. *Healthcare Simulation Research*, 85–91. https://doi.org/10.1007/978-3-030-26837-4_12

Erasmus MC . (n.d.). Sustainability report 2021. EUR Sustainability. Retrieved April 29, 2023, from <https://sustainabilityreport.eur.nl/sustainability-report-2021>

Erasmus MC. (2021). DUURZAAMHEIDS VERSLAG 2021. https://www.erasmusmc.nl/-/media/erasmusmc/pdf/2-themaoverstijgend/erasmusmc_duurzaamheidsverslag_2021_def.pdf.

Erdal, E. (2018, October 31). The Impact of Technology Trends on Healthcare Systems: A Study on Opportunities and Threats. *International Journal of Trend in Scientific Research and Development*, Volume-2(Issue-6), 1574–1578. <https://doi.org/10.31142/ijtsrd18901>

Espinosa, A., Harnden, R., & Walker, J. (2008, June). A complexity approach to sustainability – Stafford Beer revisited. *European Journal of Operational Research*, 187(2), 636–651. <https://doi.org/10.1016/j.ejor.2007.03.023>

European Commission, C. B. (2002, July 2). /* COM/2002/0347 final */. CELEX1, Communication from the Commission concerning Corporate Social Responsibility: A business contribution to Sustainable Development. Communication From the Commission Concerning Corporate Social Responsibility: A Business Contribution to Sustainable Development - Publications Office of the EU. Retrieved June 14, 2023, from <https://op.europa.eu/en/publication-detail/-/publication/6e2c6d26-d1f6-48a3-9a78-f0ff2dc21aad/language-en>

Expert Commentary: Iodine Recycling - WIA - World Iodine Association. (2015, October 14). WIA - World Iodine Association. <https://www.worldiodineassociation.com/production/>

Five ways that ESG creates value. (2019, November 14). McKinsey & Company. <https://www.mckinsey.com/capabilities/strategy-and-corporate-finance/our-insights/five-ways-that-esg-creates-value>

Future Health Index | Philips. (2021). Philips. Retrieved 2021, from <https://www.philips.com/c-dam/corporate/newscenter/global/future-health-index/report-pages/experience-transformation/2021/philips-future-health-index-2021-report-healthcare-leaders-look-beyond-the-crisis-global.pdf>

Get inspired! Sustainability in Amsterdam UMC. (2022, May 20). Get Inspired! Sustainability in Amsterdam UMC. <https://www.amsterdamumc.org/en/research/news/get-inspired-sustainability-in-amsterdam-umc.htm>

Green Deal Samen werken aan duurzame zorg (Green Deal 3.0) | Greendeals. (2022, November 4). Green Deal Samen Werken Aan Duurzame Zorg (Green Deal 3.0) | Greendeals. <https://www.greendeals.nl/green-deals/green-deal-samen-werken-aan-duurzame-zorg-green-deal-30>

Green Deal Samen werken aan duurzame zorg | Greendeals. (2022, November 4). Green Deal Samen Werken Aan Duurzame Zorg | Greendeals. <https://www.greendeals.nl/green-deals/green-deal-samen-werken-aan-duurzame-zorg>

Hawkins, J. E., & Tremblay, B. (2023, March). Nurses and Climate Change: Ten Strategies for Reducing Carbon Emissions in the Radiology Department. *Journal of Radiology Nursing*, 42(1), 39–42. <https://doi.org/10.1016/j.jradnu.2022.10.003>

Health care climate footprint report. (2019, September 10). Health Care Without Harm. <https://noharm-global.org/documents/health-care-climate-footprint-report>

Health workforce. (2023, April 3). Health Workforce. https://www.who.int/health-topics/health-workforce#tab=tab_1

Heye, T., Knoerl, R., Wehrle, T., Mangold, D., Cerminara, A., Loser, M., Plumeyer, M., Degen, M., Lüthy, R., Brodbeck, D., & Merkle, E. (2020, June). The Energy Consumption of Radiology: Energy- and Cost-saving Opportunities for CT and MRI Operation. *Radiology*, 295(3), 593–605. <https://doi.org/10.1148/radiol.2020192084>

Hinrichs-Krapels, S., Diehl, J. C., Hunfeld, N., & van Raaij, E. (2022, June 23). Towards sustainability for medical devices and consumables: The radical and incremental challenges in the technology ecosystem. *Journal of Health Services Research & Policy*, 27(4), 253–254. <https://doi.org/10.1177/13558196221110416>

Homepage | Practice Greenhealth. (n.d.). Homepage | Practice Greenhealth. <https://practicegreenhealth.org/>

How the best companies create value from their ecosystems. (2019, November 21). McKinsey & Company. <https://www.mckinsey.com/industries/financial-services/our-insights/how-the-best-companies-create-value-from-their-ecosystems>

<https://www.iso.org/obp/ui/#iso:std:iso:26000:ed-1:v1:en>. (n.d.). <https://www.iso.org/obp/ui/#iso:std:iso:26000:ed-1:v1:en>

Khaled, R., Ali, H., & Mohamed, E. K. (2021, August). The Sustainable Development Goals and corporate sustainability performance: Mapping, extent and determinants. *Journal of Cleaner Production*, 311, 127599. <https://doi.org/10.1016/j.jclepro.2021.127599>

Khosravi, H., Hamidi, M., Nikzad, S., & Tapak, L. (2023, February 22). Evaluating the Outcome of an Unnecessary Request for CT Scan in Be'sat Hospital of Hamadan. *Radiology Research and Practice*, 2023, 1–6. <https://doi.org/10.1155/2023/3709015>

Korhonen, J., Honkasalo, A., & Seppälä, J. (2018, January). Circular Economy: The Concept and its Limitations. *Ecological Economics*, 143, 37–46. <https://doi.org/10.1016/j.ecolecon.2017.06.041>

Kumar, R., Verma, A., Shome, A., Sinha, R., Sinha, S., Jha, P. K., Kumar, R., Kumar, P., Shubham, Das, S., Sharma, P., & Vara Prasad, P. V. (2021, September 6). Impacts of Plastic Pollution on Ecosystem Services, Sustainable Development Goals, and Need to Focus on Circular Economy and Policy Interventions. *Sustainability*, 13(17), 9963. <https://doi.org/10.3390/su13179963>

Li, T. T., Wang, K., Sueyoshi, T., & Wang, D. D. (2021, October 21). ESG: Research Progress and Future Prospects. *Sustainability*, 13(21), 11663. <https://doi.org/10.3390/su132111663>

List of parties to the United Nations Framework Convention on Climate Change - Wikipedia. (2005, November 15). List of Parties to the United Nations Framework Convention on Climate Change - Wikipedia. https://en.wikipedia.org/wiki/List_of_parties_to_the_United_Nations_Framework_Convention_on_Climate_Change

Lopes, C. M., Scavarda, A., Hofmeister, L. F., Thomé, A. M. T., & Vaccaro, G. L. R. (2017, January). An analysis of the interplay between organizational sustainability, knowledge management, and open innovation. *Journal of Cleaner Production*, 142, 476–488. <https://doi.org/10.1016/j.jclepro.2016.10.083>

Maia, M. (2021, December). OP318 Health Technology Assessment And Decision-Making Processes: The Purchase Of Magnetic Resonance Imaging Technology. *International Journal of Technology Assessment in Health Care*, 37(S1), 13–13. <https://doi.org/10.1017/s0266462321000970>

Mieloszyk, R. J., Rosenbaum, J. I., Hall, C. S., Hippe, D. S., Gunn, M. L., & Bhargava, P. (2019, April). Environmental Factors Predictive of No-Show Visits in Radiology: Observations of Three Million Outpatient Imaging Visits Over 16 Years. *Journal of the American College of Radiology*, 16(4), 554–559. <https://doi.org/10.1016/j.jacr.2018.12.046>

More sustainability in the care sector. (n.d.). More Sustainability in the Care Sector | Sustainable Healthcare | Government.nl. <https://www.government.nl/topics/sustainable-healthcare/more-sustainability-in-the-care-sector>

Organization. Regional Office for the Eastern Mediterranean, W. H. (2020, June 1). World Health Organization annual report 2019 WHO Country Office Lebanon: health for all. World Health Organization Annual Report 2019 WHO Country Office Lebanon: Health for All. <https://apps.who.int/iris/handle/10665/333249>

Overview of sustainable finance. (2021, August 27). Finance. https://finance.ec.europa.eu/sustainable-finance/overview-sustainable-finance_en

P. (n.d.). How health organizations can integrate ESG priorities. PwC. <https://www.pwc.com/us/en/industries/health-industries/library/esg-health-industry.html>

Philips. (2019). Radiology staff in focus. Retrieved 2019, from <https://www.philips.com/c-dam/b2bhc/master/Specialties/radiology/radiology-staff-in-focus/radiology-staff-in-focus.pdf>

Pianykh, O. S., Jaworsky, C., Shore, M., & Rosenthal, D. I. (2017, July). Improving Radiology Workflow with Automated Examination Tracking and Alerts. *Journal of the American College of Radiology*, 14(7), 937–943. <https://doi.org/10.1016/j.jacr.2017.03.019>

Radboudumc. (2021). Duurzaamheidsbeleid 2021-2025. Retrieved 2021, from <https://www.radboudumc.nl/getmedia/7cf7384b-e933-43fa-9e1f-fa5ea837051e/Duurzaamheidsbeleid-2021-2025-Definitieve-versie.aspx>

Radiology - Wikipedia. (2020, October 19). Radiology - Wikipedia. <https://en.wikipedia.org/wiki/Radiology>

Recycling Iodine: How Hospitals Are Keeping Contrast Media in the Circular Economy. (2022, March 29). Recycling Iodine: How Hospitals Are Keeping Contrast Media in the Circular Economy | GE HealthCare (United States). <https://www.gehealthcare.com/insights/article/recycling-iodine-how-hospitals-are-keeping-contrast-media-in-the-circular-economy>

Reeder, A. D., Hendriks, P., - van der Plas, H. P., Zweers, D., M. van Overbeeke, P. S., Gravendeel, J., H. Kruimer, J. W., van der Meer, R. W., & Burgmans, M. C. (2023, March 20). Sustainability within interventional radiology: opportunities and hurdles - CVIR Endovascular. SpringerOpen. <https://doi.org/10.1186/s42155-023-00362-1>

Renewed sustainable finance strategy and implementation of the action plan on financing sustainable growth. (n.d.). Finance. https://finance.ec.europa.eu/publications/renewed-sustainable-finance-strategy-and-implementation-action-plan-financing-sustainable-growth_en

Reports — IPCC. (n.d.). Reports — IPCC. <https://www.ipcc.ch/reports/>

Sanders, E. B. N., & Stappers, P. J. (2008, March). Co-creation and the new landscapes of design. *CoDesign*, 4(1), 5–18. <https://doi.org/10.1080/15710880701875068>

Sanders, L., & Stappers, P. J. (2014, October 1). Convivial Toolbox: Generative Research for the Front End of Design.

SDGs, the Compass for ESG Management | MEDIASK | SKBLOG. (2021, June 22). MEDIASK | SKBLOG. Retrieved May 21, 2023, from <https://mediask.co.kr/90001-246>

SEN, A. (2001, January 1). Health Equity: Perspectives, Measurability, and Criteria. OUP Academic. <https://doi.org/10.1093/acprof:oso/9780195137408.003.0006>

Serafeim, G. (2013). The Role of the Corporation in Society: An Alternative View and Opportunities for Future Research. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.2270579>

Shuaib, W., Vijayasarithi, A., Johnson, J. O., Salastekar, N., He, Q., Maddu, K. K., & Khosa, F. (2014, March 11). Factors affecting patient compliance in the acute setting: an analysis of 20,000 imaging reports - *Emergency Radiology*. SpringerLink. <https://doi.org/10.1007/s10140-014-1209-1>

Shum, P. L., Kok, H. K., Maingard, J., Schembri, M., Bañez, R. M. F., Van Damme, V., Barras, C., Slater, L. A., Chong, W., Chandra, R. V., Jhamb, A., Brooks, M., & Asadi, H. (2020, July 17). Environmental sustainability in neurointerventional procedures: a waste audit. *Journal of NeuroInterventional Surgery*, 12(11), 1053–1057. <https://doi.org/10.1136/neurintsurg-2020-016380>

Singh, N., Mohacsy, A., Connell, D., & Schneider, M. (2017, May). A snapshot of patients' awareness of radiation dose and risks associated with medical imaging examinations at an Australian radiology clinic. *Radiography*, 23(2), 94–102. <https://doi.org/10.1016/j.radi.2016.10.011>

Steenmeijer, M. A., Rodrigues, J. F. D., Zipp, M. C., & Waaijers-van der Loop, S. L. (2022, December). The environmental impact of the Dutch health-care sector beyond climate change: an input-output analysis. *The Lancet Planetary Health*, 6(12), e949–e957. [https://doi.org/10.1016/s2542-5196\(22\)00244-3](https://doi.org/10.1016/s2542-5196(22)00244-3)

Strategic Plan 2022–2025 | UNDP. (n.d.). UNDP. <https://strategicplan.undp.org/>

Strategic procurement in the European healthcare sector. (2019, December 18). Health Care Without Harm. <https://noharm-global.org/documents/strategic-procurement-european-healthcare-sector>

Teisberg, E., Wallace, S., & O'Hara, S. (2020, May). Defining and Implementing Value-Based Health Care. *Academic Medicine*, 95(5), 682–685. <https://doi.org/10.1097/acm.0000000000003122>

The Global Compact Leaders Summit 2004 – Final Report | UN Global Compact. (2004, January 1). The Global Compact Leaders Summit 2004 – Final Report | UN Global Compact. <https://unglobalcompact.org/library/255>

The United Nations. (2017). Report on the implementation of the Sustainable Development Goals, Kingdom of the Netherlands. <https://sustainabledevelopment.un.org/content/documents/16109Netherlands.pdf>

The world could be short of 13 million nurses in 2030 - here's why. (n.d.). World Economic Forum. <https://www.weforum.org/agenda/2022/01/health-care-nurses-attrition-mental-health-burnout/>

Transforming our world: the 2030 Agenda for Sustainable Development | Department of Economic and Social Affairs. (n.d.). Transforming Our World: The 2030 Agenda for Sustainable Development | Department of Economic and Social Affairs. <https://sdgs.un.org/2030agenda>

UMC Utrecht. (2020). Duurzaamheidsbeleid 2020-2025. Retrieved 2020, from https://assets-eu-01.kc-usercontent.com/546dd520-97db-01b7-154d-79bb6d950a2d/18e2512d-856b-40df-a09d-ad200d97f29b/iPDF%20Duurzaamheidsbeleid%202020-2025_mrt2021_v2.pdf

UN Global Compact Strategy 2021–2023 | UN Global Compact. (2021, January 1). UN Global Compact Strategy 2021–2023 | UN Global Compact. <https://unglobalcompact.org/library/5869>

Velte, P. (2017, June 13). Does ESG performance have an impact on financial performance? Evidence from Germany. *Journal of Global Responsibility*, 8(2), 169–178. <https://doi.org/10.1108/jgr-11-2016-0029>

Verrier, B., Smith, C., Yahyaee, M., Ziemski, M., Forbes, G., Witt, K., & Azadi, M. (2022, January). Beyond the social license to operate: Whole system approaches for a socially responsible mining industry. *Energy Research & Social Science*, 83, 102343. <https://doi.org/10.1016/j.erss.2021.102343>

Voudrias, E. A. (2018, May). Healthcare waste management from the point of view of circular economy. *Waste Management*, 75, 1–2. <https://doi.org/10.1016/j.wasman.2018.04.020>

Wan, G., Dawod, A. Y., Chanaim, S., & Ramasamy, S. S. (2023, June). Hotspots and trends of environmental, social and governance (ESG) research: a bibliometric analysis. *Data Science and Management*, 6(2), 65–75. <https://doi.org/10.1016/j.dsm.2023.03.001>

Welch, J. K., & Patton, M. Q. (1992). Qualitative Evaluation and Research Methods. *The Modern Language Journal*, 76(4), 543. <https://doi.org/10.2307/330063>

Whiteford, H. A., Degenhardt, L., Rehm, J., Baxter, A. J., Ferrari, A. J., Erskine, H. E., Charlson, F. J., Norman, R. E., Flaxman, A. D., Johns, N., Burstein, R., Murray, C. J., & Vos, T. (2013, November). Global burden of disease attributable to mental and substance use disorders: findings from the Global Burden of Disease Study 2010. *The Lancet*, 382(9904), 1575–1586. [https://doi.org/10.1016/s0140-6736\(13\)61611-6](https://doi.org/10.1016/s0140-6736(13)61611-6)

WHO global strategy on health, environment and climate change: the transformation needed to improve lives and wellbeing sustainably through healthy environments. (2020, February 9). WHO Global Strategy on Health, Environment and Climate Change: The Transformation Needed to Improve Lives and Wellbeing Sustainably Through Healthy Environments. <https://www.who.int/publications/i/item/9789240000377>

Woolen, S. A., Kim, C. J., Hernandez, A. M., Becker, A., Martin, A. J., Kuoy, E., Pevec, W. C., & Tutton, S. (2023, April). Radiology Environmental Impact: What Is Known and How Can We Improve? *Academic Radiology*, 30(4), 625–630. <https://doi.org/10.1016/j.acra.2022.10.021>

World Health Organization. (2001, April 12). Decentralization of Health Services. <https://library.cphs.chula.ac.th/Ebooks/HealthSectorReform/WHO/Decentralization%20of%20health%20services.pdf>

Żelazna, A., Bojar, M., & Bojar, E. (2020, June 1). Corporate Social Responsibility towards the Environment in Lublin Region, Poland: A Comparative Study of 2009 and 2019. *Sustainability*, 12(11), 4463. <https://doi.org/10.3390/su12114463>

Appendix A

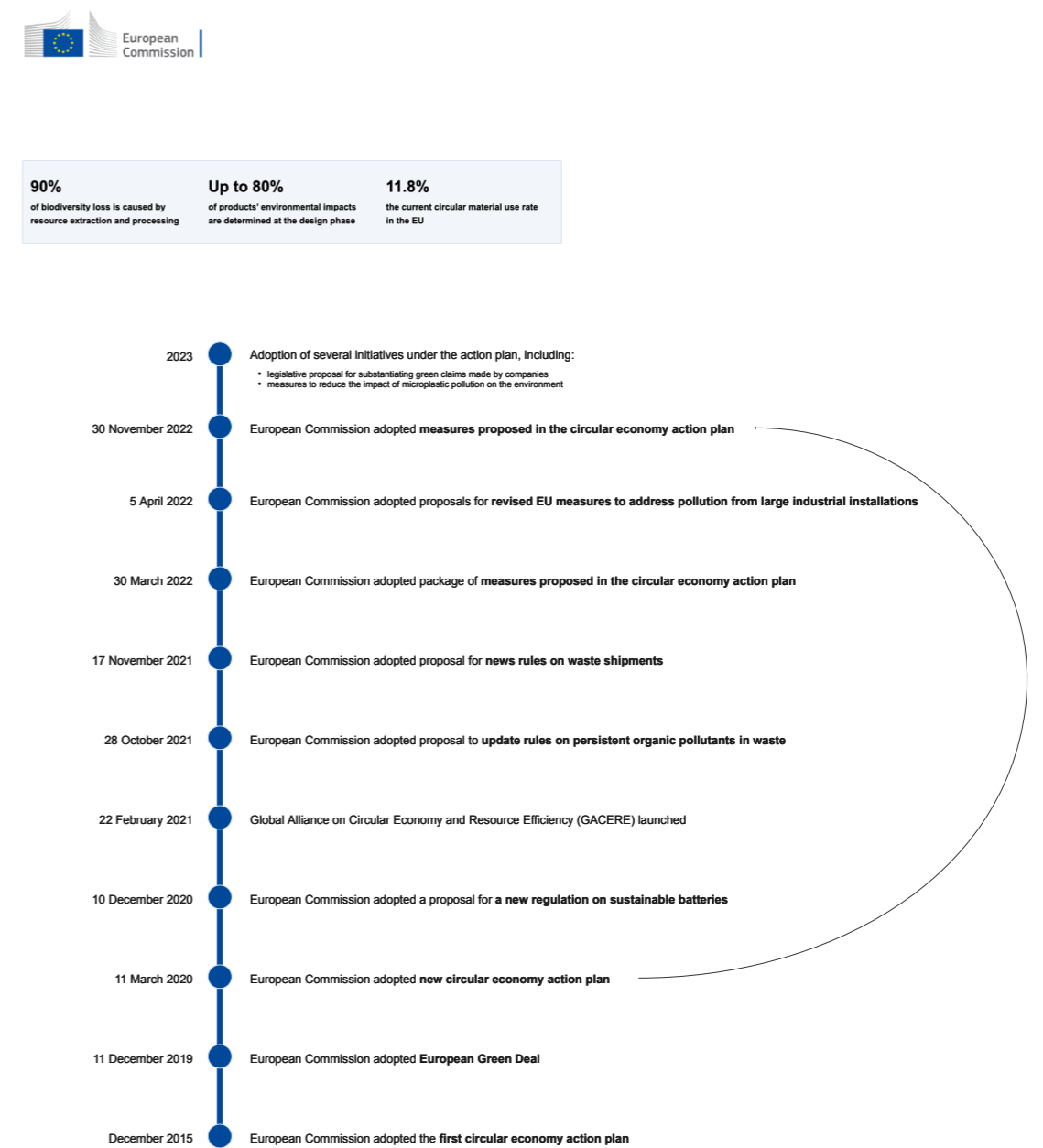
EU and Dutch University Hospitals' ESG Goals and Roadmap

The researcher sought to integrate, compare, and provide a comprehensive understanding of the global, national, and hospital structures as shown in Figure A.1. This complements the substantial desk research on global forces, ESG programs and frameworks as illustrated in Chapter 3

A.1 EU ESG Goals and Roadmap

To facilitate effective dialogue with and among the stakeholders participating in this research, the researcher simplified and integrated key EU ESG goals and roadmap steps (See Figure A.1).

Figure A.1. EU ESG Goals and Roadmap



A.2 Dutch University Hospitals' ESG Goals and Roadmap

This study first examined five university hospitals in the Netherlands, with an eagerness to learn and cross-collaborations on the topic of ESG in Radiology. Results from a preliminary analysis of ongoing ESG initiatives by hospitals have been aggregated and compared with the goals and roadmap of the EU (See Figure A.2). This provided valuable cross-hospital view on ESG hospital specific initiatives, achieved results, and established as a good foundation for collaboration dialogues for the future.

Figure A.2. Dutch University Hospitals' ESG Goals and Roadmap



Appendix B

ESG opportunities in Radiology workflow (comprehensive interview insights)

Empirical studies have shown operational challenges and bottlenecks when embedding ESG interventions into the Radiology workflow. Additionally, a key role in driving transformation is concluded to be procurement. This function has the potential to drive education, standards and change upwards in the value chain. Increased transparency may drive innovation and collaboration on new circular models downstream.

The aim of the research is to reframe challenges into opportunities, taking a systemic design approach. As such, the insights obtained from collective interviews are visually represented in Figure B to identify specific areas "where and what" ESG interventions can be incorporated to achieve long-term global and ESG goals, thereby creating strategic value. The emphasis on "how" key ESG hotspots can strategically entrenched, measured, and scaled is addressed in the Chapter 4.

B.1.1. Procurement

Pre-purchase

- **Articulation of needs and desires by clear goals and roadmap**

Hospitals should set clear goals and make firm demands for suppliers' transparency. In this way, efforts made by medical companies in social, environmental, and climate responsibility should be given more weight in decision making processes.

- **Increase capabilities**

The healthcare sector needs to develop its own procurement function with the necessary skills, competencies, and know-how to make informed decisions about purchasing equipment. By making these demands, hospitals could help drive the industry in a more sustainable and socially responsible direction.

- **Sustainable decision on vendor selection**

During a tender process, hospitals should ask questions regarding ESG in holistic manner and these answers should be quantified to calculate over 10 years of use.

- **[external efforts] Proactive early engagement with companies**

It is important to ask questions and identify the needs and activities happening before the tender process begins. For example, "Do we only need to look at the cost? Shouldn't we also calculate the benefits for environment?" asked by a procurement lead at Erasmus MC.

Purchase

- **Sustainable decision to purchase**

Stakeholders involved in the tender process should aim for circularity in the equipment by repurposing components from old equipment to build new ones.

B.1.2. Operational workflow (general)

- **Proactive Green teams**

The department must tackle sustainability issues on all fronts, activating sustainability ambassadors in every department, sharing ideas, inspirations, and initiatives through monthly meetings, Intranet, and trainings to increase its visibility among all employees.

- **Leadership involvement**

There is an increasing desire to participate in a nationwide trial with 6 hospitals in the Netherlands, even if it means spending money to make sustainability improvements. The leadership needs to step up and emphasise how important it is to integrate sustainable practices into the workflow.

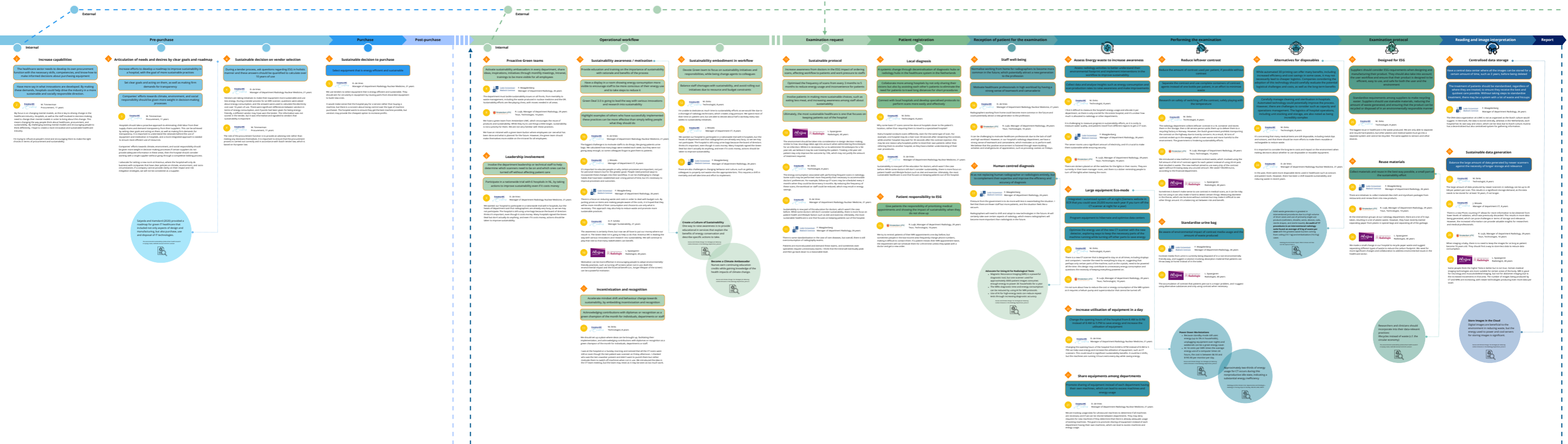
Figure B. ESG value-impact opportunities in Radiology workflow

ESG (Environment, Social, Governance) Value-Impact Opportunities in Radiology workflow

Radiology of University Hospitals in the Netherlands in example

Legends

- Blue flow represents Procurement process
- Green flow represents Radiology workflow process
- ◆ Diamond represents key opportunities
- Circle represents key insights
- Bubble represents Literature Insights



The poster is created as the results of collaboration efforts across Radiology and Sustainability experts in the hospitals in the Netherlands. The interview insights, public reports, and scientific literatures are framed in the ESG Value-Impact Opportunities in Radiology workflow. As a graduation project, Hyelin Lee from MSc Strategic Product Design at TU Delft framed and designed the poster with guidance from Jan-Carel Diehl (prof. & supervisor), Saba Hinrichs Krapels (prof. & supervisor), and Elena Pupazan (mentor).

Credits

Hyelin Lee (1506483) Strategic Product Design, TU Delft
Graduation project: ESG in Radiology Workflow to drive Strategic Business Value of Erasmus MC
April 2023



- **Sustainability awareness / motivation**

The most effort is needed to overcome such a challenge. One way to raise awareness is to provide educational in services that explain the benefits of energy conservation and describe specific actions to take (Hawkins & Tremblay, 2023). A live display in a room showing energy consumption can be more visible to encourage staffs to be more conscious of their energy use and to take action to reduce it.

- **Incentivization and recognition**

Acknowledging contributions with diplomas or recognitions as “Green champion of the month” for the departments or individuals can accelerate their mindset shift and behaviour change towards sustainability.

- **Sustainability embodiment in workflow**

Staff shortages must be balanced with sustainability to avoid rolling out initiatives due to resource and budget constraints. It requires delegating responsibilities to Green Team members to concentrate on initiatives while also acting as a change agent for colleagues.

- **[external efforts] Collaboration synergy across entities**

Hospitals in the Netherlands should collaborate with one another and with other organizations such as suppliers, manufacturers, hospitals, universities, insurers, ministries, and municipalities to address climate concerns, which is one of the biggest issues to tackle.

- **[external efforts] Regulation and standardisation taking ESG into account**

Regulations should be clear, and decisions should be made about what can and cannot be done, particularly in the field of Radiology. Environmental considerations should be factored into healthcare regulations and combine forces to work on a single regulation.

B.1.3. Examination request

- **Sustainable protocol**

Doctors must raise awareness of the ESG impact of ordering scans, which affects patient workflow and staff workload. They might involve patients in adopting more sustainable choices, such as eating less meat, and raise sustainability awareness among staff.

B.1.4. Patient registration

- **Local diagnosis**

Many stakeholders in the Dutch healthcare system envision a systemic change through the decentralisation of diagnostic or Radiology hubs. Connecting with local hospitals and adopting specialized protocols can make scans easier and more successful.

- **Patient responsibility to ESG**

Patients should also be responsible for prioritizing medical appointments and acknowledging the impact of no-show on sustainability.

B.1.5. Reception of patient for the examination

- **Staff well-being**

Healthcare professionals face a tremendous workload, therefore improving motivation through a strong sense of teamwork and camaraderie can help. This positive environment is fostered through team-building activities and small gestures of appreciation, such as providing cookies on Fridays, according to Technologists at Amsterdam UMC.

- **Human centred diagnosis**

AI as not replacing human Radiographer or Radiologists entirely, but to complement their expertise and improve the efficiency and accuracy of diagnosis. The usage of AI for MRI protocols can reduce diagnostic time and energy consumption, while it can also reduce repeat tests through increasing diagnostic accuracy (Hawkins & Tremblay, 2023).

B.1.6. Performing the examination

- **[Energy] Assess energy waste to increase awareness**

It is essential to assess Radiology operations to better understand their environmental footprint and implement interventions in the workflow to improve sustainability. The Radiology department should collect data and analyse insights such as energy consumption and scan production rates to raise awareness and make improvements.

- **[Energy] Large equipment Eco-mode**

The fact that over two-thirds of the energy used by CT is consumed in this inactive stage suggests a significant energy inefficiency (Buckley & MacMahon, 2021). The large equipment should have an Eco-mode program to hibernate and optimise the energy use.

- **[Energy] Increase utilization of equipment in a day**

Changing the opening hours of the hospital from 8 AM to 8 PM instead of 8 AM to 5 PM can help save energy and increase the utilisation of equipment. This could result in significant sustainability benefits. It could be 2 shifts, but the machines are running 3 hours extra every day while saving energy.

- **[Energy] Share equipment among departments**

Departments should promote sharing of equipment instead of each department having their own machines, which can lead to excess machines and energy usage.

- **[Contrast] Reduce leftover contrast**

Contrast has been shown to safety concern, according to study, but it can also make it difficult to detect certain details in an image. Hospitals and suppliers should consider different container designs in an effort to minimize waste.

- **[Contrast] Standardise urine bag**

Contrast media from urine is currently being disposed of in a non-environmentally friendly way. Such urine bag initiatives, which are currently being implemented in a number of hospitals, should be standard.

- **[Waste] Alternative for disposables**

While automated 3D printing can offer many benefits, including increased efficiency and cost savings in some cases, it may not necessarily lead to cheaper logistics. Companies considering the adoption of this technology should carefully evaluate the potential logistical challenges and costs, as well as the long-term benefits.

B.1.7. Examination protocol

- **Designed for ESG**

Suppliers should consider ESG requirements when designing and manufacturing their product. They should also take into account the user workflow and ensure that their product is designed to be efficient, easy to use, and safe for both the user and the environment.

- **Reuse materials**

Hospital needs several initiatives of collecting materials and reusing them in the best way possible as a small part of the sustainability effort. For instance, LUMC initiated a project to recycle waste materials like cloth and Styrofoam boxes from restaurants into brand-new products.

B.1.8. Reading and imaging interpretation - report

- **Centralised data storage**

The treatment of patients should be standardized, regardless of where they are treated, to ensure they receive the best and quickest care possible. Without taking steps to standardize treatment, there may be a system with a lot of waste and hiccups.

- **Sustainable data generation**

Digital images benefit the environment by reducing waste, but they also take a lot of energy to operate and cool the servers that store those images (Hawkins & Tremblay, 2023). Moreover, the large amount of data produced by newer scanners in Radiology can be up to 20 GB per patient per scan. It is important to balance between the amount of data and the need for longer storage and relevance.

Appendix C

Survey Results

Prior to the co-creation workshop, survey research was introduced to synthesize and evaluate key findings from in-depth interviews and desk research with involved stakeholders. This made it easier for the participants to understand the researcher's interpretation and proposed design tools, which were then discussed in the co-creation sessions. The survey was filled out using Microsoft Forms, which is easy and intuitive to use. Enquiries were conducted anonymously in order to encourage more honest and unbiased responses. The survey results can be seen following the five questions (see Figure C.1) in Figure C.2.

Figure C.1. Survey questions blueprint

ESG in Healthcare to Drive Strategic Business Value

Thank you for taking the time to complete the survey for my graduation project at Strategic Product Design of TU Delft. Your responses will be valuable in helping me to better understand how ESG drives strategic business value in Ecosystem. If you have any further comments or feedback, please do not hesitate to contact me. Best regards, Hyelin Lee

ESG (Environmental, Social, and Governance): ESG is a framework designed to be embedded into an organization's strategy to generate value for all stakeholders in relation to environmental, social, and governance criteria. Following its formal proposal in 2004, the sustainable development of the global economy and society called ESG principles have been developed for 17 years (Li et al., 2021).

* Required

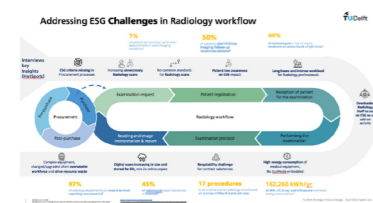
1. Do you report on ESG at hospital level? *

- I don't know
- Yes
- No

2. Do you report on ESG at Radiology department level? *

- Yes
- No
- I don't know

3. We have highlighted **Hotspots in Radiology Workflow** based on the key insights from the interviews. What **top 3 Hotspots** would you give the highest priority based on the highest impact on the ESG and the possibility for action and influence by radiology in the hospital? *

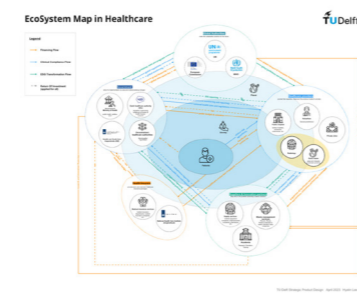


Please select at most 3 options.

- ESG criteria missing in Procurement processes
- Increasing unnecessary Radiology scans across healthcare
- No common standards for Radiology scans (in the Netherlands)
- Patient low awareness on ESG impact
- Long hours and intense workload for Radiology professionals
- Overloaded Radiology staff to act on ESG as an add-on activity
- High energy consumption of medical equipment, No EcoMode embedded
- Recyclability challenge for contrast substances for hospitals
- Digital scans increasing in sizes and stored for life in multiple online copies
- New/upgraded equipment often overwhelm workforce due to additional training requirement

4. What other Hotspots do you take into account besides those listed on the slide from Question 3?

5. Does the Ecosystem Map below represent all actors and the complexity in the Healthcare system in the Netherlands (to address identified Hotspots)? If not, which other actors would you include or exclude, and why? *



This content is neither created nor endorsed by Microsoft. The data you submit will be sent to the form owner.

Microsoft Forms

Figure C.2. Survey results

ESG in Healthcare to Drive Strategic Business Value

5 Responses | 05:06 Average time to complete | Active Status

1. Do you report on ESG at hospital level?

Yes	3
No	2
I don't know	0



2. Do you report on ESG at Radiology department level?

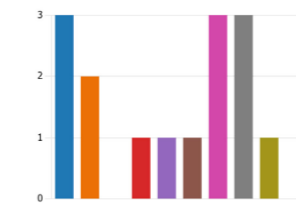
Yes	3
No	2
I don't know	0



3. We have highlighted **Hotspots in Radiology Workflow** based on the key insights from the interviews. What **top 3 Hotspots** would you give the highest priority based on the highest impact on the ESG and the possibility for action and influence by radiology in the hospital?

What **top 3 Hotspots** would you give the highest priority based on the highest impact on the ESG and the possibility for action and influence by radiology in the hospital?

ESG criteria missing in Procurem...	3
Increasing unnecessary Radiolo...	2
No common standards for Radi...	0
Patient low awareness on ESG L...	1
Long hours and intense workloa...	1
Overloaded Radiology staff to a...	1
High energy consumption of m...	3
Recyclability challenge for contr...	3
Digital scans increasing in sizes...	1
New/upgraded equipment ofte...	0



4. What other Hotspots do you take into account besides those listed on the slide from Question 3?

3 Responses

Latest Responses
 "Digital scans increasing in size no common standards"
 "The problem is that the mentioned hotspots are not all taken into account..."

5. Does the Ecosystem Map below represent all actors and the complexity in the Healthcare system in the Netherlands (to address identified Hotspots)? If not, which other actors would you include or exclude, and why?

5 Responses

Latest Responses
 "map is difficult to interpret"
 "Sorry, the resolution is insufficient for reading"
 "The patient social network (or NOT having one!!!): direct family, relatives, L..."

Answers on Q4.

- Separate waste for reuse intensively.
- The problem is that the mentioned hotspots are not all taken into account in the first place. A common reaction with regards to scans is that for research purposes it is inevitable to have high numbers of scans, which i beg to differ. Is it really true that more scans lead to more reliable research input?
- Digital scans increasing in size

Answers on Q5.

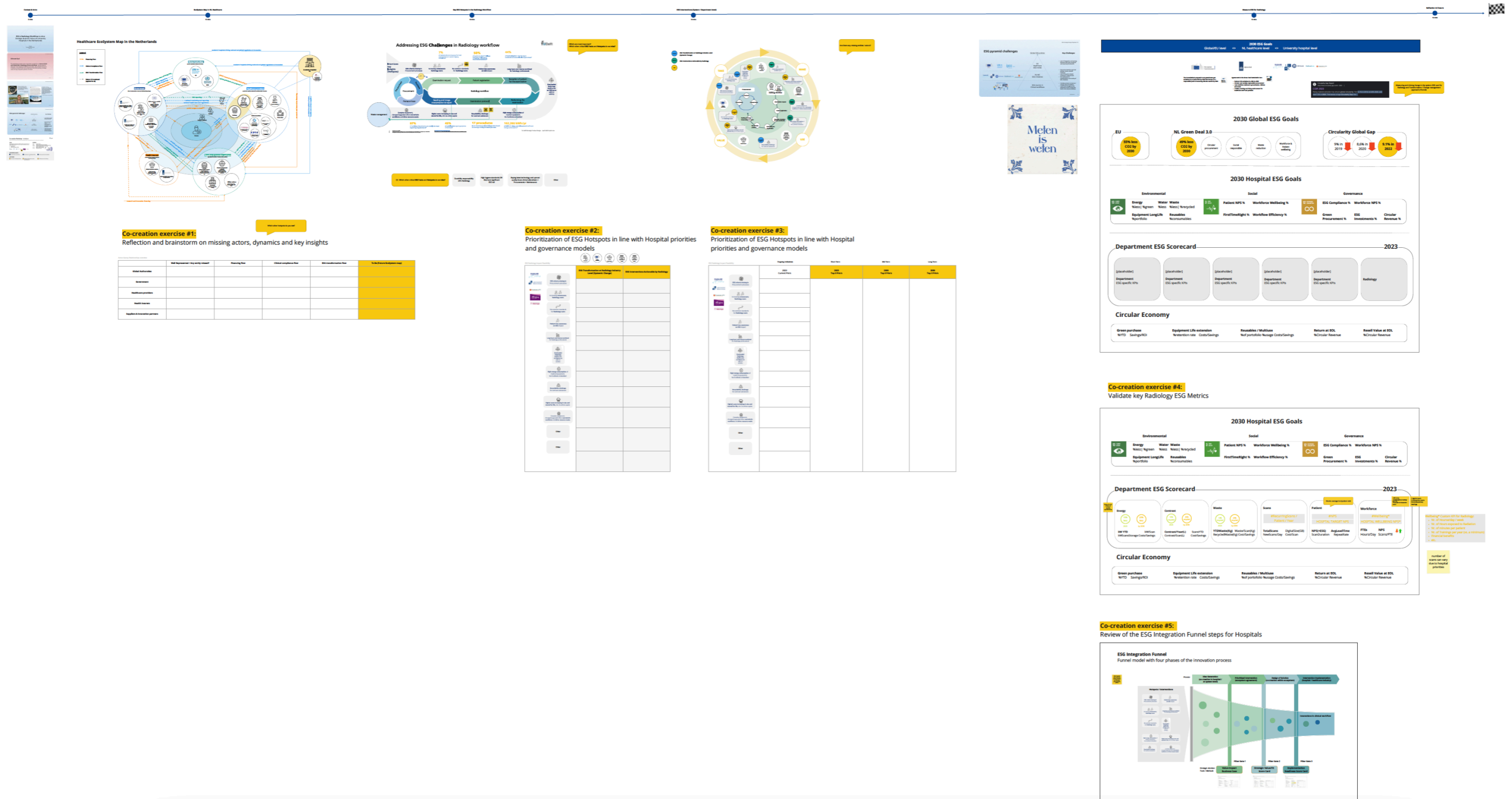
- Yes, I think so.
- I guess.
- The patient social network (or NOT having one!!!): direct family, relatives, friends, neighbours...
- Sorry, the resolution is insufficient for reading
- Map is difficult to interpret

Appendix D

Co-creation Blueprint

Several co-creation workshops were held to enrich the depth of data collection on the ecosystem context, ESG hotspots and opportunities in the Radiology workflow. A structured strategy and pre-planned workshop blueprint were created, as shown in Figure D.1, to enable an effective interaction with the extremely busy stakeholders.

Figure D.1. Co-creation Blueprint



Appendix E

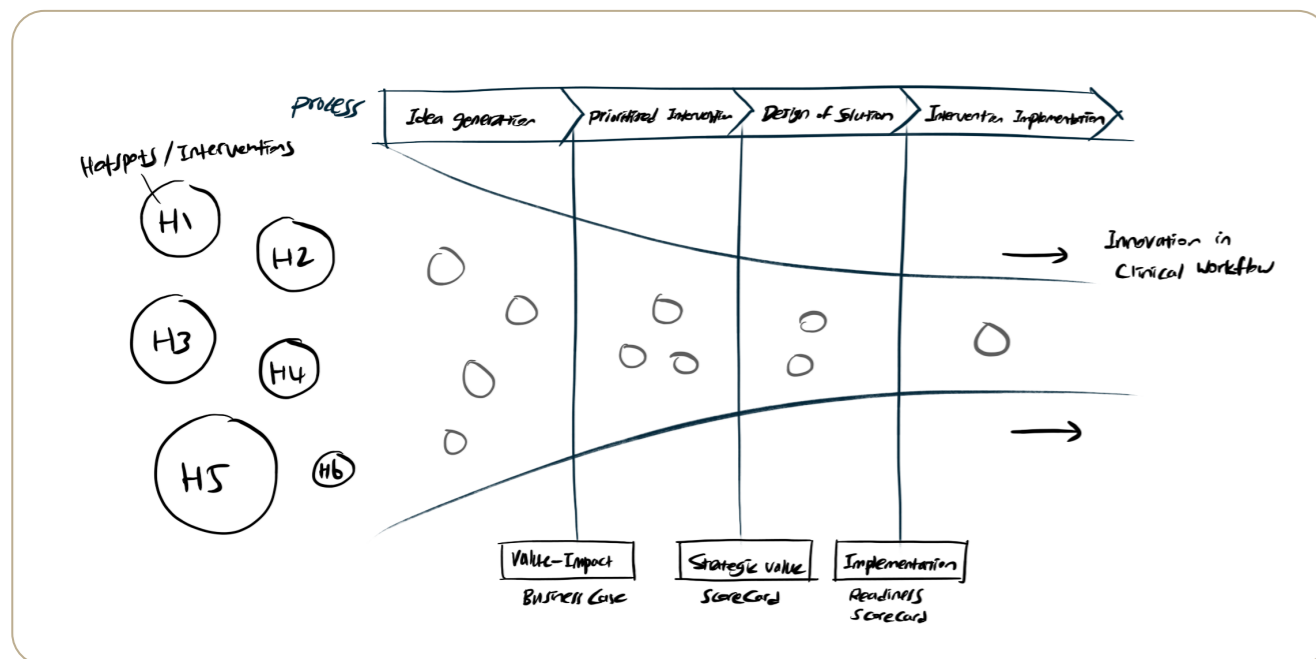
ESG Transformation Strategy through the Integration Funnel

ESG transformation is much needed and very complex, especially in highly regulated, public-private industries such as healthcare. Adding layers and functions in such industries and organizations is slow and ineffective. Furthermore, in decentralized healthcare systems such as those in the Netherlands, collaboration and resourcing of topics such as ESG might be challenging.

The learnings in this study tend to conclude that the most effective way to drive ESG forward, is by embedding ESG principles into the current way of working, even more so in the investment decision-making processes. Figure E envisions and recommends an ESG innovation and transformation process that can be incorporated into existing change management processes as well as a stand-alone process. Five main steps are proposed to carry the ideation, investment decision making and deployment of ESG interventions: [1] Identification and collection of ESG hotspots; [2] ESG Idea generation with value-impact business case (for prioritized hotspots); [3] Prototyping selected ESG initiatives; [4] Development of approved ESG initiatives based on strategic fit-, impact-, and viability criteria; [5] Go/NO-GO for ESG intervention Implementation.

Building such ESG integration funnels and processes can answer the transformation needs of specific departments, hospitals, or broader ecosystems. The need and proposed concept were discussed with stakeholders during interviews and workshops. High relevance and a strategic need were concluded. As time and resources were limited, the researcher shares forward the recommendation for further future explorations on the topic.

Figure B. ESG integration funnel



Appendix F - Project Brief

DESIGN
FOR OUR
future

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser

STUDENT DATA & MASTER PROGRAMME

Save this form according to the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy". Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1!

family name <u>Lee</u> initials <u>HL</u> given name <u>Hyelin</u> student number _____ street & no. _____ zipcode & city _____ country _____ phone _____ email _____	Your master programme (only select the options that apply to you): IDE master(s): <input type="radio"/> IPD <input type="radio"/> DfI <input checked="" type="radio"/> SPD 2 nd non-IDE master: _____ individual programme: _____ (give date of approval) honours programme: <input type="radio"/> Honours Programme Master specialisation / annotation: <input checked="" type="radio"/> Medisign <input type="radio"/> Tech. in Sustainable Design <input type="radio"/> Entrepreneurship
--	---

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right!

** chair <u>Prof. Dr. Ir. J.C. Diehl</u>	dept. / section: <u>IDE/SDE</u>
** mentor <u>Prof. Dr. S. Hinrichs-Krapels</u>	dept. / section: <u>TPM</u>
2 nd mentor <u>Elena Pupazan</u>	
organisation: _____	
city: _____	country: _____

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v.

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

comments (optional)
:
:
:

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair Prof. Dr. Ir. J.C. Diehl date 17 - 01 - 2023 signature _____

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair. The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 30 EC

Of which, taking the conditional requirements into account, can be part of the exam programme _____ EC

List of electives obtained before the third semester without approval of the BoE

YES all 1st year master courses passed

NO missing 1st year master courses are:

name R. den Braber date 23 - 05 - 2023 signature _____

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **. Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: **APPROVED** **NOT APPROVED**

Procedure: **APPROVED** **NOT APPROVED**

comments

name _____ date _____ signature _____

ESG in Radiology Workflow to drive Strategic Business Value of EMC project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 02 - 01 - 2022 end date 09 - 06 - 2022

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

What is ESG?
 ESG stands for Environmental, Social, and Corporate Governance, and refers to the three key factors when measuring the sustainability and ethical impact of an investment in a business or company. While it is easy to explain what each letter stands for, its implications particularly in healthcare are more complex.

Problem
 Behind ESG is the fundamental principle of improving human and planetary health. However, at the same time, the healthcare system today contributes to the climate crisis, accounting for nearly 4.4% of global CO2 net emissions, and majority stems from its supply chain. It is twice as much as the aviation industry (Health Care Without Harm, 2019). The 2030 Agenda for Sustainable Development and the IPCC report address the global context of urgency, while the EU published its action plan on sustainable finance in 2018. Several initiatives are being undertaken by medical centers in the Netherlands to move them toward a more sustainable future.
 However, there are still several operational challenges in healthcare sector to meet ESG goals. In this graduation project we will focus on the Radiology department in hospitals. Radiology has a huge challenge on workflow. Imaging technologists over the globe report moderate or severe levels of job stress, while patients don't show up for their appointments in some imaging modalities, which add up to \$1,000,000 in lost revenue (Rosenbaum JI, et al., 2018). MRI, for example, have a significant carbon impact; rare earth substances like Helium; high energy consumption; heavy shipment, many non-recyclable materials used. As a result, proactive support in understanding ESG solutions and monitoring and measuring their goals while operations are running is necessary.

Call to action
 The graduation project aims to provide a guidance on how to frame and embed ESG in Radiology Clinical workflow. Taking systemic approach and engaging healthcare providers, the research strives to co-define a shared vision and understand the ESG business strategic value for key ecosystem partners involved. In order to have a bigger impact and conclude value, the following parties will be engaged: TU Delft, Erasmus MC, LUMC, Amsterdam UMC, UMC Utrecht, and OEMs. The main client is Nicole Hunfeld from Erasmus MC.

- Abbreviations
- ESG Environmental, Social, and Corporate Governance
 - EMC Erasmus University Medical Center
 - CO2 Carbon dioxide
 - UN United Nations
 - SDG Sustainable Development Goals
 - IPCC Intergovernmental Panel on Climate Change
 - EU United Nations
 - MRI Magnetic Resonance Imaging
 - LUMC Leiden University Medical Center
 - OEM Original Equipment Manufacturer

space available for images / figures on next page

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair Prof. Dr. Ir. J.C. Diehl date 17 - 01 - 2023 signature _____

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair. The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 30 EC

Of which, taking the conditional requirements into account, can be part of the exam programme _____ EC

List of electives obtained before the third semester without approval of the BoE

YES all 1st year master courses passed

NO missing 1st year master courses are:

name R. den Braber date 23 - 05 - 2023 signature _____

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **. Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: **APPROVED** **NOT APPROVED**

Procedure: **APPROVED** **NOT APPROVED**

comments

name _____ date _____ signature _____

ESG in Radiology Workflow to drive Strategic Business Value of EMC project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 02 - 01 - 2022 end date 09 - 06 - 2022

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

What is ESG?
 ESG stands for Environmental, Social, and Corporate Governance, and refers to the three key factors when measuring the sustainability and ethical impact of an investment in a business or company. While it is easy to explain what each letter stands for, its implications particularly in healthcare are more complex.

Problem
 Behind ESG is the fundamental principle of improving human and planetary health. However, at the same time, the healthcare system today contributes to the climate crisis, accounting for nearly 4.4% of global CO2 net emissions, and majority stems from its supply chain. It is twice as much as the aviation industry (Health Care Without Harm, 2019). The 2030 Agenda for Sustainable Development and the IPCC report address the global context of urgency, while the EU published its action plan on sustainable finance in 2018. Several initiatives are being undertaken by medical centers in the Netherlands to move them toward a more sustainable future.
 However, there are still several operational challenges in healthcare sector to meet ESG goals. In this graduation project we will focus on the Radiology department in hospitals. Radiology has a huge challenge on workflow. Imaging technologists over the globe report moderate or severe levels of job stress, while patients don't show up for their appointments in some imaging modalities, which add up to \$1,000,000 in lost revenue (Rosenbaum JI, et al., 2018). MRI, for example, have a significant carbon impact; rare earth substances like Helium; high energy consumption; heavy shipment, many non-recyclable materials used. As a result, proactive support in understanding ESG solutions and monitoring and measuring their goals while operations are running is necessary.

Call to action
 The graduation project aims to provide a guidance on how to frame and embed ESG in Radiology Clinical workflow. Taking systemic approach and engaging healthcare providers, the research strives to co-define a shared vision and understand the ESG business strategic value for key ecosystem partners involved. In order to have a bigger impact and conclude value, the following parties will be engaged: TU Delft, Erasmus MC, LUMC, Amsterdam UMC, UMC Utrecht, and OEMs. The main client is Nicole Hunfeld from Erasmus MC.

- Abbreviations
- ESG Environmental, Social, and Corporate Governance
 - EMC Erasmus University Medical Center
 - CO2 Carbon dioxide
 - UN United Nations
 - SDG Sustainable Development Goals
 - IPCC Intergovernmental Panel on Climate Change
 - EU United Nations
 - MRI Magnetic Resonance Imaging
 - LUMC Leiden University Medical Center
 - OEM Original Equipment Manufacturer

space available for images / figures on next page

introduction (continued): space for images



image / figure 1: Urgency of immediate transformation for our ONE planet (source: Unsplash)



image / figure 2: ESG Ratings underlying Pillar and Theme Exposures and Scores (source: FTSE Russell)

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

Today, there is a gap in how ESG can drive Strategic Business Value through clinical workflows. We are missing one Ecosystem map that connects ESG trends and initiatives to clinical workflow to make the concept operational, impact bigger and visible. Radiology, in particular, faces significant challenges not only in operational workflow but also in ESG impact.

Most stakeholders understand "why" we should change, but not "how." As a consequence, it is necessary to look systemically and map all facts and dynamics from global to EU, hospital, and radiology workflow, resulting in one Ecosystem map and ESG value - impact opportunities.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

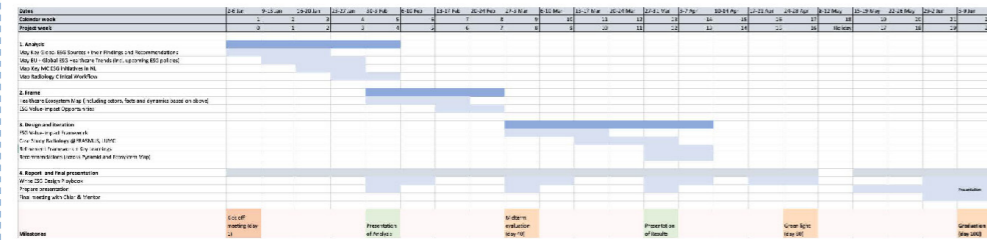
I will deliver a new ESG Value-Impact Framework for Healthcare to drive strategic business value, which is easy, transparent, and intuitive to use at the operational level, by leveraging all SPD learnings and in-depth intakes from analysis. The framework design will be piloted and validated in the Radiology workflow at Erasmus MC / LUMC.

1. Analysis
 - 1.1. Map Key Global ESG Sources + their Findings and Recommendations
 - 1.2. Map EU + Global ESG Healthcare Trends (incl. upcoming ESG policies)
 - 1.3. Map Key Medical Center ESG initiatives in NL
 - 1.4. Map Radiology Clinical Workflow
2. Frame
 - 2.1. Healthcare Ecosystem Map (including actors, facts and dynamics based on above)
 - 2.2. ESG Value-Impact Opportunities
3. Design and iteration
 - 3.1. ESG Value-Impact Framework
 - 3.2. Pilot Radiology Workflow @ ERASMUS, LUMC
 - 3.3. Refinement Framework + Key Learnings
 - 3.4. Recommendations (across Pyramid and Ecosystem Map)
4. Report and final presentation
 - 4.1. ESG Strategic Design Playbook and Final Presentation

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 2 - 1 - 2022 end date 9 - 6 - 2022



Time
In the given 20 weeks, the graduation project should be efficiently run in plan (Gantt chart is attached on page 6). To be effective, it is important to focus on key stakeholders to move steps forward.

Stakeholders engagement and active sharing
The studies requires supports and engagement with MC stakeholders and active input sharing to drive the process and allow appropriate time for design and iteration.

Open-source data
Any confidential information or data may not be included in the final report. It will be retained in the appendix and shared only with key stakeholders; it will not be publicly disclosed.

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... - Stick to no more than five ambitions.

In parallel to my study in TU Delft, I have been working for healthcare industry as a product designer for several years. For me, the SPD program accelerates my professional development and broadens my expertise. My passion for ESG sustainability in healthcare comes from my both professional and personal experience, where I have seen and felt the sense of urgency. In addition, in order to challenge the current business, one must be provocative in this regard, considering the impact to my family, friends, colleagues, future generations and myself!

Throughout the SPD program, I have learnt a breadth of knowledge, practices, skills and insights on strategizing business and design. I will leverage all the learnings from qualitative and quantitative research, framing problem to solution, systemic design for complexity, value of strategic design and so on.

The aim of my thesis is to provide as an open source that can inspire, engage, and benefit as many healthcare businesses and leaders as possible. The customer voice insights will be transparently shared and appropriately framed in design architecture to drive vision and value case. Long-term, I am hoping this will have a greater positive impact in Radiology or elsewhere, improving people's health and well-being as well as that of their communities.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

