APPENDIX

F

IDEA DIRECTIONS INCLUDING GREEN TEAM FEEDBACK

G

CREATING NEW WASTE STREAMS: OBSERVATION AND VISIT WITH PREZERO TO OPERATING THEATRE (OT) IN EMC

H

TONTO INSTRUCTIONS

I

CONTAINER

Appendix A

Graduation Project Brief

DESIGN FOR our future

TU Delft

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 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: Clercx Lao
initials: M.S. given name: María Sofía
student number: 4670450
street & no.:
zipcode & city:
country:
phone:
email:

Your master programme (only select the options that apply to you):
IDE master(s): ★ IPD ○ DfI ○ SPD
2nd non-IDE master:
individual programme: - - (give date of approval)
honours programme: ○ Honours Programme Master
specialisation / annotation: ★ Medisign
○ Tech. in Sustainable Design
○ Entrepeneurship

SUPERVISORY TEAM **

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

** chair: J.C. Diehl dept. / section: Design for Sustainability
** mentor: C.P.J.M Kroon dept. / section: Design for Sustainability
2nd mentor: Dr. P.J.F. De Jonge (Head of Gastroenterology Department)
organisation: Erasmus Medical Center
city: Rotterdam country: Netherlands

comments (optional): I found the mentoring by Caroline Kroon very succesful during the course Advanced Concept Design, which is why I elected her as my graduation mentor as well.

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.

Personal Project Brief - IDE Master Graduation

TU Delft

Towards circular endoscopy: waste mapping in endoscopy units — 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 25 - 09 - 2023 — 11 - 02 - 2024 end date

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, ...).

This document describes the direction for my graduation project for my masters in Integrated Product Design with a specialisation in Medisign.

The current Dutch healthcare market accounts for more than 8% share of the national carbon footprint (Pichler et al., 2019). Gastrointestinal endoscopy ranks in the top three most resource-intensive specialties that contribute significantly to a hospital's carbon footprint (De Santiago et al., 2022). Several studies on endoscopy procedures across the US have identified multiple sustainable intervention opportunities and challenges across systemic, procedural and product levels. These challenges and opportunities are equally relevant for ensoscopy units in the Netherlands and are highly similar to the proposed directions described by the Dutch magazine of the association of gastrointestinal doctors (MAGMA, 2022), in order to transition towards a more sustainable endoscopy unit. In 2021, 10.500 endoscopic procedures were performed in Erasmus MC (EMC) alone.

Multiple Green Teams have been set up in EMC and across several healthcare facilities, forming a national network that exchanges ideas and incentives to shift towards a circular healthcare stystem (Erasmus MC, 2022). With my graduation project I will be a part of the Sustainable Hospital Living Lab at the EMC.

Reduction and recycling of waste was described by a.o. Siddhi et.al (2021) as one of the priorities, alongside raising awareness among endoscopy staff. The main opportunities within this context encompass the collection and specifically the visualisation of data for the endoscopy department. This will be the overarching aim of my graduation project. From the waste audit, the main environmental hotspots can be identified followed by an initial set of circular interventions. For myself as a student it is a great opportunity to work closely together with the department, since I am able to work on-site at EMC. I also see this as a chance to have a hands-on approach during my graduation and to ensure that I have the most accurate data possible. The graduation period is not nearly enough to create a fully detailed system and waste map, however, it will be a good starting point for further research. Considering my position in this project as an industrial designer, another less obvious opportunity is starting to map and understand behaviour of staff towards waste and co-create the circular interventions with EMC. Only by understanding the culture and routines of the staff can it be changed to fit the transition towards a more circular endoscopy unit.
Main stakeholders: endoscopy staff (doctors, nurses), EMC, Sustainable Hospital Living Lab.

Sources:
1. De Santiago, E. R., Dinis-Ribeiro, M., Pohl, H., Agrawal, D., Arvanitakis, M., Baddeley, R., Bak, E., Bhandari, P., Bretthauer, M., Burga, P., Donnelly, L., Eickhoff, A., Hayee, B., Kamiński, M., Karlović, K., Lorenzo-Zúñiga, V., Pellise, M., Pioche, M., Siau, K., . . . Messmann, H. (2022). Reducing the environmental footprint of gastrointestinal endoscopy: European Society of Gastrointestinal Endoscopy (ESGE) and European Society of Gastroenterology and Endoscopy Nurses and Associates (ESGENA) Position Statement. Endoscopy, 54(08), 797–826. https://doi.org/10.1055/a-1859-3726 Erasmus MC. (2022).
2. Duurzaamheidsverslag 2021. In erasmusmc.nl. Retrieved September 5, 2023, from https://www.erasmusmc.nl/nl-nl/artikelen/het-duurzaamheidsverslag-2021-is-uit
3. Pichler, P., Jaccard, I. S., Weisz, U., & Weisz, H. (2019). International comparison of health care carbon footprints. Environmental Research Letters, 14(6), 064004. https://doi.org/10.1088/1748-9326/ab19e1
4.https://www.mdl.nl/magma/algemene-informatie

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introduction (continued): space for images

image / figure 1: **A grasp of the different types of waste created in the endoscopy room. Picture source: https://www.werkenbijerasmusmc.nl/vacature/85921/endoscopieverpleegkundige-06.28.23.td2**

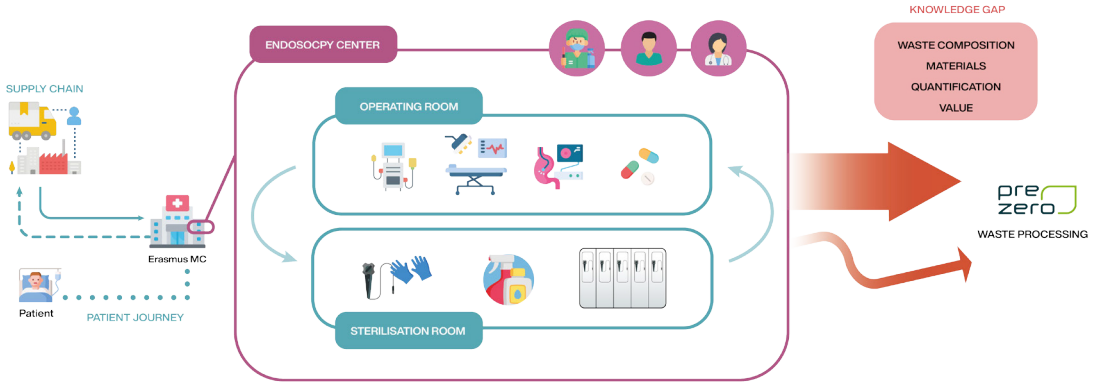


image / figure 2: Schematic overview of project focus: procedure & sterilisation waste streams in endoscopy center

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.

The current problem that EMC's endoscopy department is facing is that they have almost no waste source separation and are therefore are unable to quantify and determine different types of their waste. Waste is generated across multiple system levels and for different patient cases, as well as during endoscope sterilization.

The scope for this project was initially quite clear, and the main issues described by EMC are quantification and mapping of waste data, determination of environmental hotspots and designing a circular intervention based on one or two cases. The scope will be limited to procedural waste, meaning only waste that is generated during endoscopies.

I want to add another issue that is essential for a succesful basis for further research after my project.

The EMC's ambition for 2024 is to have 40% of their waste recycled (Erasmus MC, 2022). Additionally, to reduce their carbon footprint with 55%, EMC has described a.o. these crucial shifting points for their 2030 sustainable strategy:
- Profound implementation of waste source separation
- General waste reduction by 10%

Succesful recycling can only occur if the waste is separated as best as possible, hence the increase in waste source separation.

The aforementioned challenges can only be tackled from within the organization, meaning that behavioural awareness and adaptation in the endoscopy unit is necessary. With my graduation, I want to extensively research the endoscopy staff's interaction with waste streams in order to optimize their current waste separation and further reduce waste where possible.

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.

During my project I will map and visualise the endoscopy waste streams, followed by a sustainable product-service intervention that reduces the impact of one of the main environmental hotspots.

Three main goals can be described within my project:
Waste mapping, quantification and (partial) system analysis
Identifying and mapping all the different waste streams coherent with a single type of endoscopic procedure. Based upon the environmental hotspots, one of these hotspots will be chosen and analysed with LCA's. Additionally, a system map is needed for linking the waste streams to different stakeholders and interactors in a specific part of the system and to identify redesign opportunities across multiple levels.

Raising awareness in staff through visualision of data
One of the main interests of the endoscopy department is to raise awareness on waste within staff. Therefore, an important part of my project is to visualise the waste streams in such a way that it can improve the staff's understanding of their waste interaction and create awareness within staff.

Circular intervention with an Human-Centered Design (HCD) approach (co-creation with staff)
The third and last phase, including a redesign of (part of) the system for one of the main hotspots. The redesign encompasses a combination of a sustainable intervention that can change the staffs waste disposal "routine" for multiple endoscopic procedures, and hence can change (part of) the system. The product-service intervention will be tested with the staff and then analysed using an LCA to compare to the original system.

Initials & Name M.S. Clercx Lao Student number 4670450

Title of Project Towards circular endoscopy: waste mapping in endoscopy units

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.

Coming from a large family of doctors and other healthcare workers, I have always have an ingrained interest for the healthcare sector. Slowly but surely I understood how healthcare is bound to more than just treating patients and how as a designer, I can creat solutions that have impact on the quality of healthcare, which is why I decided to pursue the Medisign specialisation in my MSc programme.

Part of my drive for designing in the medical sector has to do with my realisation that design can play an important role in the wellbeing of patients and staff, without being a medical practitioner. Additionally, design is no longer limited to a single product but is crucial in the optimization of systems and services surrounding patients and staff, while understanding the emotional needs of stakeholders in this system. During my MSc programme I have been able to work on multiple projects centered around complex healthcare systems. In the course Advanced Concept Design with the Sophia Childrens Hospital (EMC), and the electives Cognitive Ergonomics for Complex Systems 1&2 and Health Systems Transformation, I gained more knowledge on how to create interventions for system changes for healthcare issues.

My curiosity for sustainability began at the very start of my career at the IDE faculty and has translated into my personal life activities. Frankly it is something that cannot "un-exist" in my life anymore and to me it feels logical to implement it in healthcare. Extracurricular activities and projects, such as organising a sustainability festival, participating in several design sprints, and my Advanced Embodiment Design project on aircraft seating, have helped me understand different aspects of sustainability that should be taken into account.

Lastly, I have always had a passion for art and visualisation and it thrills me that a part of my project is focused around the visualisation of the findings for the EMC staff. I have been a TA at IDE Design Drawing department which has helped me develop major skills in visualisation for presentation. I believe that showing a tangible picture to the EMC's endoscopy staff will be able to make the difference between a good and a great project.

The reason I chose this project in endoscopy is because it offers me an opportunity to simultaneously work on my main three interests as designer: healthcare, visualisation and sustainability. Being able to combine these areas of design in one project is a really exciting conclusion to my studies at TU Delft.

To conclude, my personal competencies and interests are well in line with the project brief. However, I want to define my personal ambitions and knowledge gaps for this project as follows:
First, I want to broaden my knowledge on assessment tools like LCA's and circular strategies. Previously I have used LCA's merely based on rough estimates, while at EMC I will be able to use accurate input.
Secondly, being able to work on-site at EMC and the Sustainable Hospital Living Lab hopefully allows me to have a go at co-creating with the endoscopy staff and to dive deeper into Human-Centered Design. I want to validate my project doing extensive user testing which will require effective planning.
Lastly, as an IPD student I feel challenged to manage and execute a long-term project by myself. I expect this to be one of the largest lessons to take away from this project.

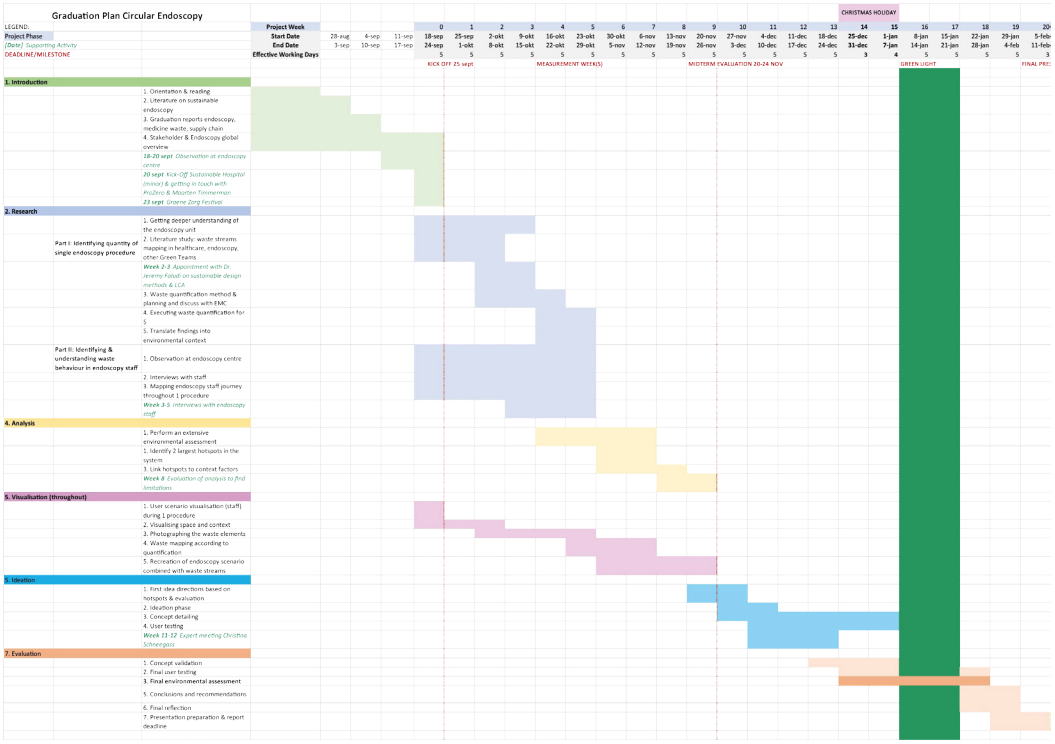
FINAL COMMENTS

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

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 25 - 9 - 2023 11 - 2 - 2024 end date



Initials & Name M.S. Clercx Lao Student number 4670450

Title of Project Towards circular endoscopy: waste mapping in endoscopy units

Appendix B

The anatomy of an endoscope

Types of endoscopes

It is important to know the anatomy and type of an endoscope to understand the additional devices and consumables needed for endoscopies, such as biopsy forceps and guide wires.

The type of endoscope needed for a procedure is dependent on the intestines to be screened, see Figure B1. The variations on the scopes are determined by their length, flexibility, diameter and the configuration of the water, air and insertion channels. An upper GI scope is thinner than a colonoscope, for example.

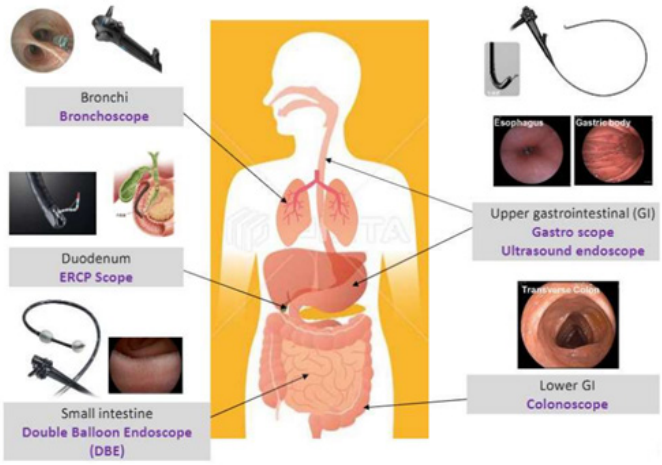
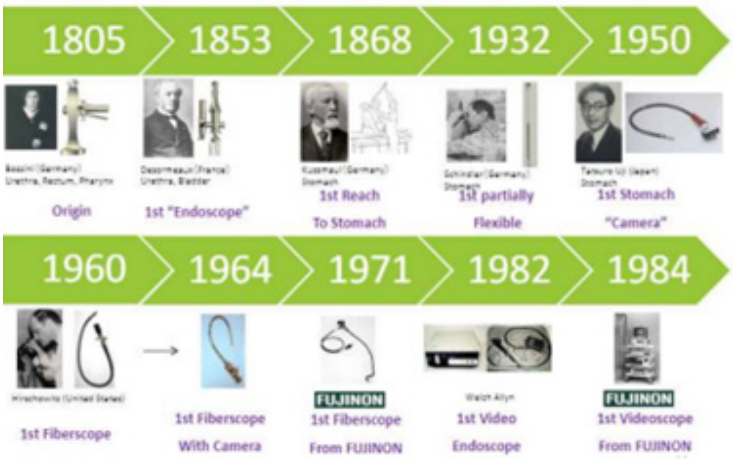


Figure B1: Slides showing the endoscope types for different organs (FMH Medical, n.d.).



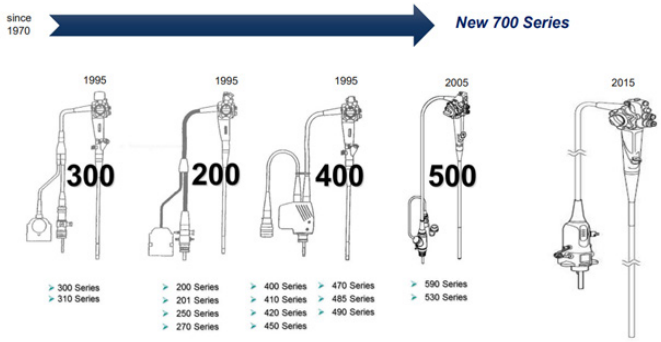


Figure B2: Slides showing the evolution of the endoscope (FMH Medical, n.d.).

A brief timeline of endoscopes

Endoscope design dates back as far as 1805, but the first partially flexible endoscope was only developed in 1932. Hereafter, visibility of the intestines improved due to different techniques such as fiber-optics (fiberscope) and the addition of camera's. The development of the video endoscope is fairly recent, starting in 1982. These types of endoscopes use peripheral imaging equipment and has now expanded to irrigation (water) and insufflation (gas) equipment.

Sections

The exterior of an endoscope consist of a control section, an insertion section and a connector section (Figure B3).

During an endoscopic procedure, the connector section is attached to the main body of devices for image processing, insufflation and irrigation (Figure B4).

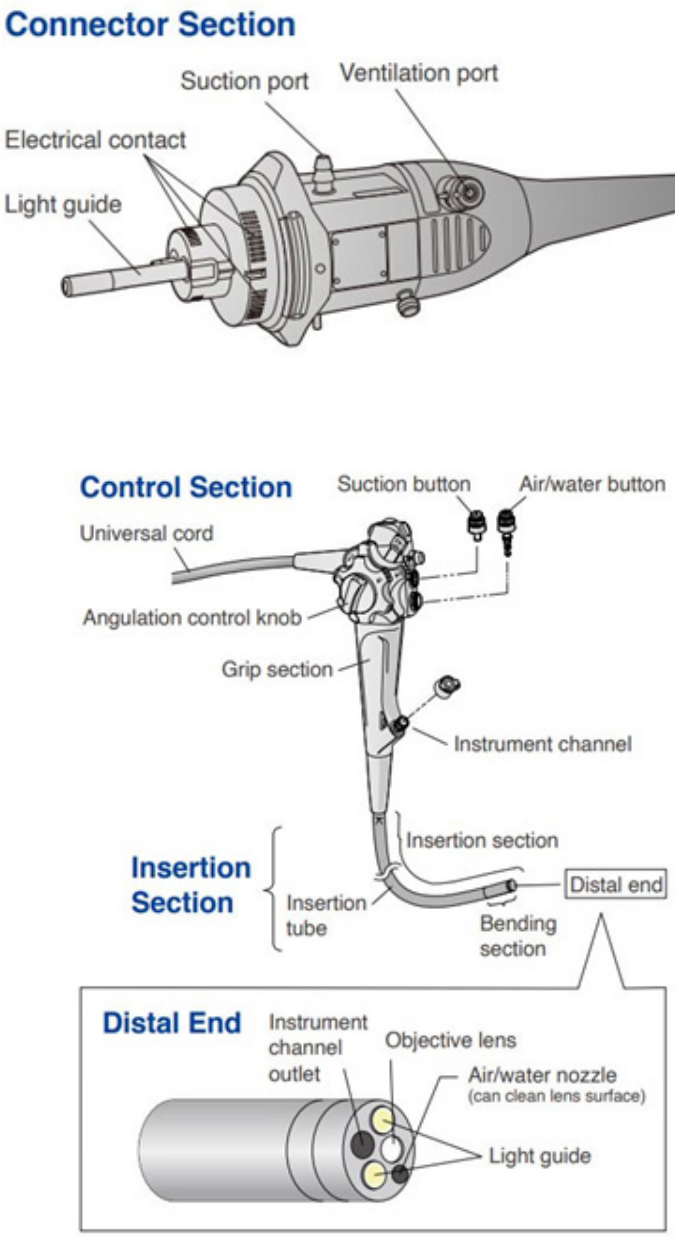


Figure B3: Control and connector sections of an endoscope (Olympus Global, n.d.)

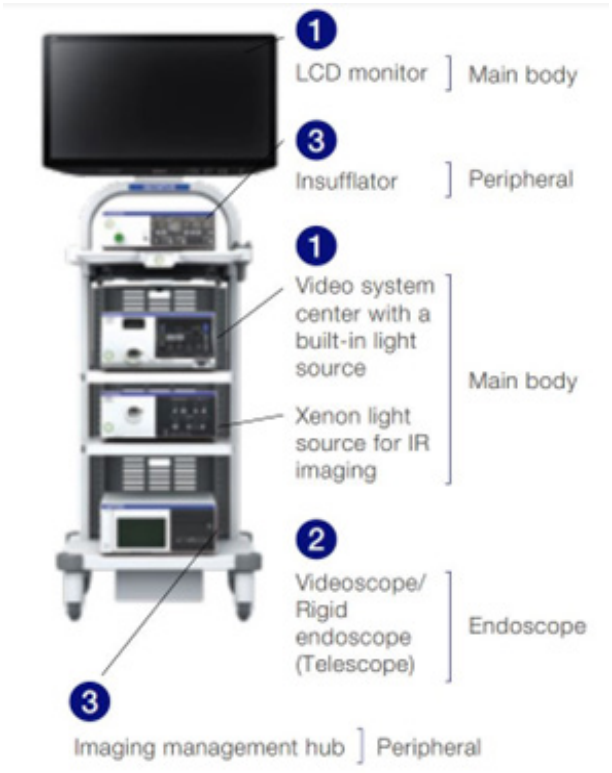


Figure B4: Main body of imaging devices and peripheral equipment (Olympus Global, n.d.)

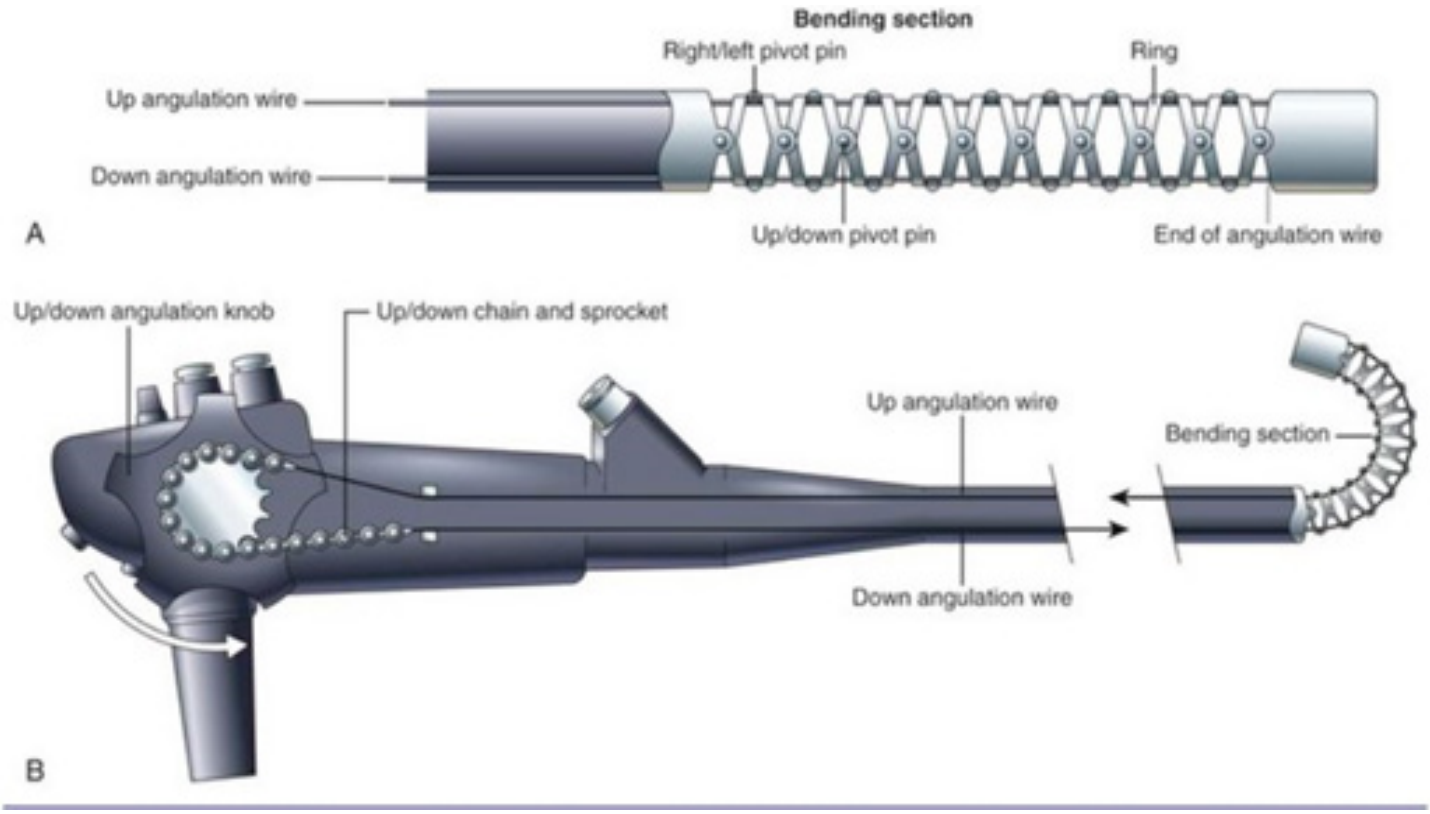


Figure B5: Design for varying stiffness in endoscope (Kohli & Baillie, 2019).

Stiffness

Endoscopes also have varying stiffness areas in order to be able to navigate the different angulations of the intestine (Figure B5). The endoscopist manipulates the movement of the endoscope using the angulation control knob with one hand, as well as manoeuvring the insertion tube with the other hand into the patient's intestine. The mechanism that allows for this function requires a large part of the endoscope to consist of metal elements, which are critical materials.

Configuration of channels

Connected to the body of equipment, the endoscope forms a system of air, water, and suction through internal channels and their connection to peripheral devices (Figure B6)

The system of channels and valves is what allows the endoscopist to perform diagnostics and surgical procedures at once. Through these channels and insertion tubes, a variety of medical instruments (SUDs) can be guided through the endoscope to perform (small) surgical treatments, such as biopsies and polypectomies.

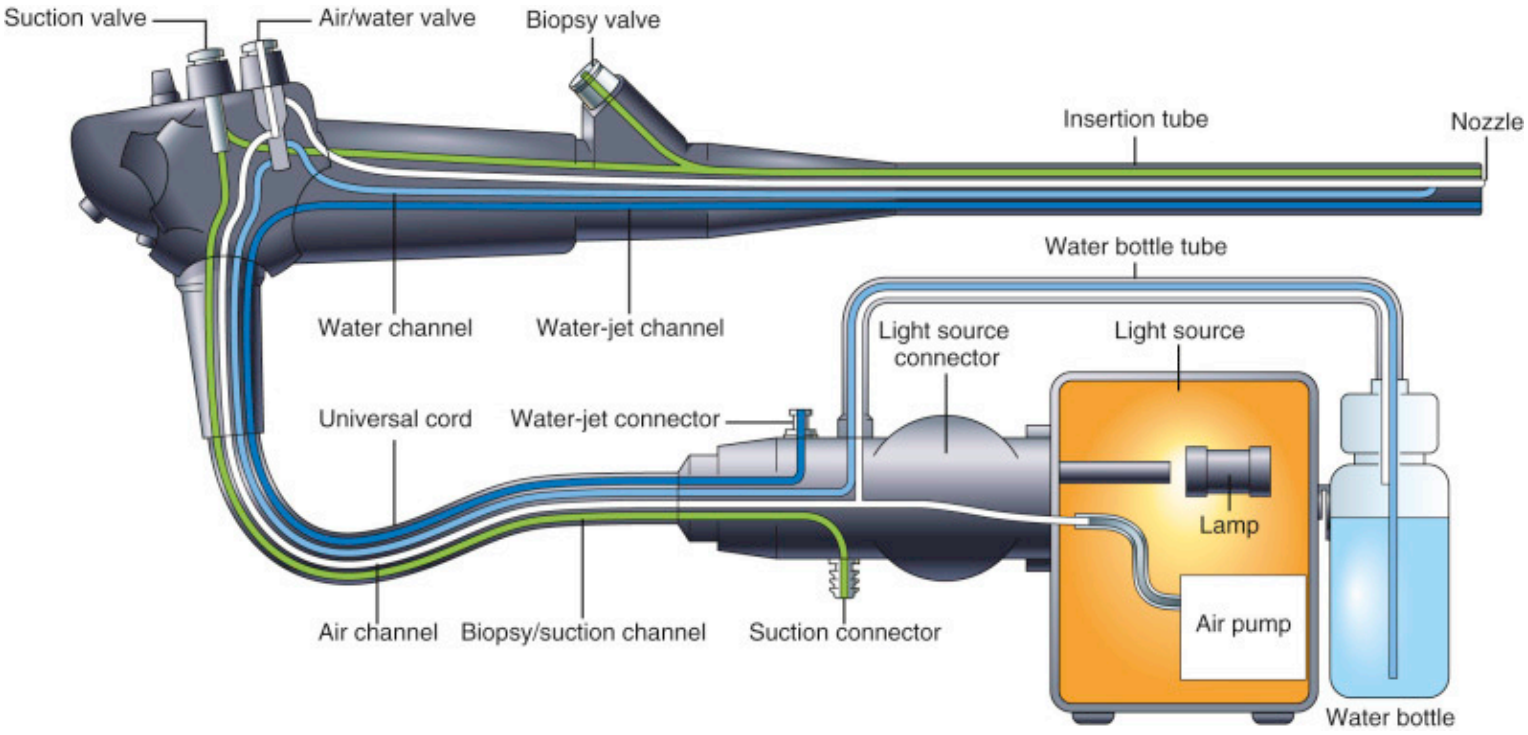


Figure B6: Configuration of the air, water, light and suction systems in the endoscope (Kohli & Baillie, 2019).

The water jet system is used for cleaning the lens and for irrigation of the intestine (for visibility). The air channel is used for air or CO2 insufflation, to aid in the navigation of the endoscope within the patient's intestine. The suction channel is used for removing any excess body liquids or debris.

Appendix C

Literature review (mid-term)

Sustainable healthcare context

SUSTAINABILITY GOALS: GREEN DEAL

The climate crisis is the largest threat to public health, leading to increasing healthcare challenges and costs (Medicine, 2023). Health care's transition into a climate neutral and sustainable economic model is necessary to build resilience to significant and growing health impacts from climate change (Health Care Without Harm & Arup, 2019). Therefore, healthcare institutions around the globe are feeling an urgency for transitioning into a climate-neutral model in order to prevent further global warming and its threats to public health (Green Deals, n.d).

Multiple healthcare institutions including Erasmus MC in the Netherlands have signed the Green Deal 3.0, to reach legally bound climate targets to reduce emissions by at least 55% in 2030 (Delivering the European Green Deal, 2021).

The purpose of the Green Deal is to create an irreversible transformation to healthcare with minimal impact on climate, environment and living environment in 2050 (Green Deals, n.d.). It relies on five pillars:

Figure C1: "The extent to which consulted participants agree with the following statements", a figure from the evaluation report of the Green Deal 2.0 (Ministerie van Volksgezondheid, Welzijn en Sport, 2022)

1. Promote health among patients, clients and employees
2. Raise awareness and understanding of the impact of healthcare on climate and vice versa
3. Reduce CO2 emissions by 55% by 2023 and to be climate neutral by 2050
4. Reduce the consumption of primary raw materials by 50% by 2023 and maximise circularity in healthcare by 2050
5. Reduce environmental harm caused by use of medication

While green deals are not meant as a means for subsidising the transition, authorities can contribute to the transition by changing legislation (ActiZ, n.d.). This is a key finding for designing new sustainable interventions, since changing the systems in healthcare facilities are mostly bound to protocols and laws.

In the evaluation of the green deal 2.0 (Ministerie van Volksgezondheid, Welzijn en Sport, 2022) the following discrepancy stood out: while the awareness of urgency for transition was felt among 73% of participants of the Green Deal in governance levels, only 36% of participants in the workplace felt the same. This could mean that an increase in perceived urgency among the workforce might positively influence the adoption of sustainable interventions in the workplace and enhances the seriousness of improving awareness amongst staff. According to the Ministry of VWS (2022), 63% of participating organisations are going to focus on increasing awareness around sustainability.

Besides improving awareness in different organisational levels, the main improvements that are included in the Grean Deal 3.0 also include concretising sustainability goals and integrating sustainability in all levels of the care path, instead of it being added to the existing care system as an ‘extra’ or an financial addition to neutralize carbon emissions.

MAIN CHALLENGES IN CLIMATE NEUTRAL HEALTHCARE

Transformative action for the climate crisis involves the actions of stakeholders across all societal levels. Besides the high environmental impact, the healthcare community has a unique role as a trusted voice to show climate leadership and advocacy, providing evidence for action, and taking responsibility for climate resilience and decarbonization of healthcare systems (Campbell-Lendrum et al., 2023).

Three overarching challenges in climate change and future health are described by Campbell-Lendrum et al. (2023) as:

1. Promote actions that both reduce carbon emissions and improve health
2. Build better, more climate-resilient and low-carbon health systems
3. Implement public health measures to protect from the range of climate risks to health

It is clear that tackling these challenges requires major government involvement. However, according to the World Health Organization's health and climate change global survey report (2021), the largest barrier to overcome when implementing national health and climate change plans is the lack of finance or budget (Figure C2). This is in line with the evaluation of the Green Deal Zorg 2.0 in the Netherlands, where it is stated that 26% of participants need financial support in different modes of entry which are not limited to subsidiary support, but also include changing current financial structures and mechanisms, e.g. adapting the procurement strategies (Ministerie van Volksgezondheid, Welzijn en Sport, 2022).

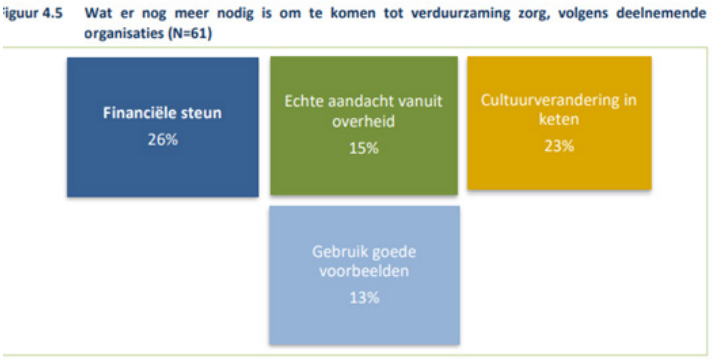


Figure C3: What is needed to induce sustainable change in healthcare, according to participants (Ministerie van Volksgezondheid, Welzijn en Sport, 2022)

Fig. 3 | Main barriers to implementation of national health and climate change plans. Data from the WHO Climate and Health Country Survey[10]; 46 country respondents, multiple responses possible.

Figure C2: Main barriers to implementation of national health and climate change plans (WHO, 2021).

Additionally, almost a quarter of Dutch participants of the Green Deal Zorg 2.0 also emphasized the need for ca cultural change along the entire care path.

Taking these findings into account, it can be concluded that there is a need for national governmental action in terms of budget and a cultural change along the whole care chain (read: including all stakeholders) in order to support health facilities in the Netherlands (and globally) in implementing sustainable interventions.

Below you can find a description of other factors that might complicate and/or influence the effects of (sustainable) interventions and strategies.

Safety legislation and product liability

The healthcare sector is strictly regulated through extensive safety regulations, including EU medical device regulation (MDR), In Vitro Diagnostic Medical Devices regulation (IVDR) and the framework of Product Liability Directive (PLD). The current PLD regime allows consumers who can prove that they have suffered harm as a result of a defect in a product to obtain compensation without the need to show fault on the part of the producer (MedTech Europe, 2022). The ongoing revision of the current PLD framework might result in an even more constrictive regulatory environment maximising the liability for manufacturers, which might impede sustainable strategies such as reusing or reprocessing from being implemented in the healthcare sector.

Since patient wellbeing is paramount to healthcare, safety concerns about potential device malfunction, infection risk and the ethical dilemma about reprocessing - due to the absence of patient consent to the use of such devices - form a steep barrier to the adoption of reprocessing single-use devices (Kwakye et al., 2010). This is why healthcare system has increasingly adopted the standard choice for single-use medical devices, given that they reduce liability and complexity for hospitals (Benedettini, 2022). Though labelled as single use by their Original Equipment Manufacturer (OEM), many types of single-use devices can be reprocessed one or more time (Benedettini, 2022). However, medical device manufacturers desiring to market a device as reusable must have sufficient data to demonstrate that the device can be reused and that the validated processing instructions will consistently bring forward a device appropriate for use (Themes, 2021).

From single-use to reprocessing of devices: insufficient data

A recent publication by (McGrath et al., 2023) presents a greatly extensive evidence review by the Dublin Health Research Board (HRB) on reprocessing of SUDs, combining the outcomes of numerous studies that included one or more of the following themes: patient safety, device safety and function, environmental impacts, and/or financial costs (to patients or health facilities/systems). In spite of its rigour, no hard conclusions could be made to deem certain SUDs safe for reprocessing due to inconsistencies with the HRB's definition of reprocessing, inconsistent statistical outcome reporting in the studies and heterogeneity of the products in question. Thus, more standardised and narrowed down research on reprocessing devices labelled as single-use on the part of the OEMs is needed before scaling up reprocessing of medical devices.

Cost of energy transition in the Dutch healthcare market

It is estimated that the sustainability transition in the Dutch healthcare sector will cost around 1,6-3,4 billion euro as one time investment plan, as well as additional annual costs of 350-750 million euro (Vereniging Gehandicaptenzorg Nederland, 2023). This costs may include adaptation of infrastructure and real estate, as well as the transition to the use of renewable energy, and moreover training the workforce to function within the new system parameters.

Safety and protocols in hospitals

All healthcare protocols have two primary focus points: staff and patient safety, and adequate care path. The guidelines shaping the protocols are set by the Werkgroep Infectie Preventie (WIP). The most recently reviewed guidelines date back to 2017 (RIVM, n.d.).

As mentioned before, the preference for SUDs comes from the consensus that human error is the most common cause behind inadequate reprocessing (Voiosu et al., 2023). This results in full liability on the processor. However, adequate reprocessing can be addressed by training programs and standardized education (Beilenhoff et al., 2017).

Changing behaviour and mental models along the care pathway

Previously it was mentioned that healthcare's need for cultural change (Ministerie van Volksgezondheid, Welzijn en Sport, 2022). While healthcare professionals are expected to adapt to a culture of sustainability, there is no blueprint for developing this corporate culture (Ramirez et al., 2013).

Challenges such as having enough resources (money, time, people) or lack of knowledge or training to get an intervention to happen, are clear examples of why implementation of sustainable interventions can be difficult. However, understanding the mental models of various actors in implementation can provide crucial information for understanding, anticipating, and overcoming implementation challenges, but it is often overlooked (Holtrop et al., 2021).

The Dutch healthcare system is based around shared decision-making (SDM) and advanced care planning (ACP) in complex care paths (Cooperatie VGZ, n.d.). While the healthcare professional has a great influence on the patients care path, the patient retains full autonomy in their own care journey, which often results in greater efficacy of treatment. Therefore, not only healthcare staff but also the patient must be considered as an important stakeholder in implementing sustainable interventions along the entire care path. At the same time, it might influence the environmental impact in some way and therefore the role of the patient needs to be further explored.

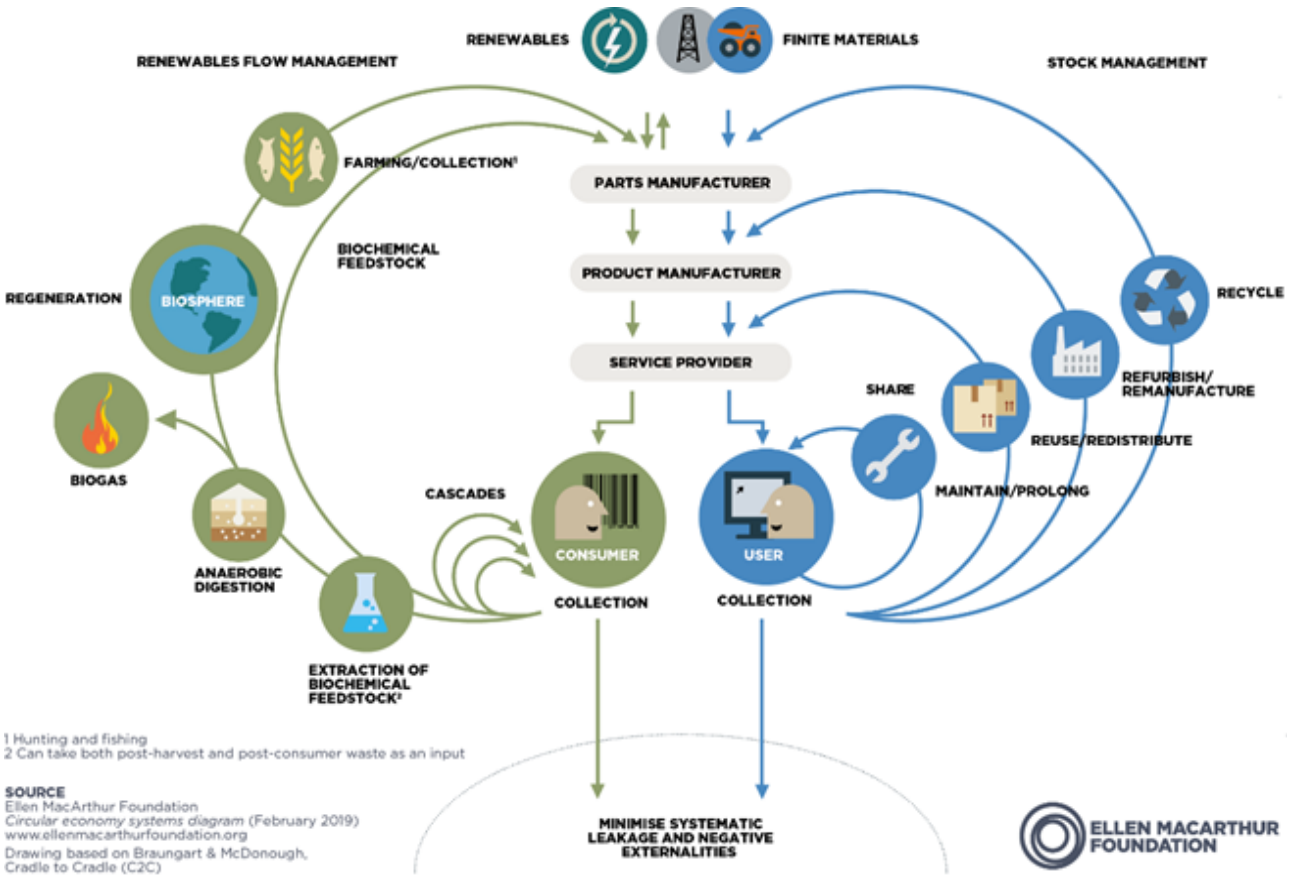


Figure C4: The butterfly diagram of a circular economy (Ellen McArthur Foundation, 2022).

AN OVERVIEW OF CIRCULAR STRATEGIES (FOR HEALTHCARE)

Healthcare is a complex system, therefore it is not always possible to predict changes or the effects of interventions on these systems (Ratnapalan & Lang, 2019). Thus, exploring combinations of multiple approaches simultaneously might be more effective than focusing solely on one.

First, different frameworks for circularity and sustainability are explored below.

The butterfly diagram

A 'circular' product could be defined as a product that is able to go through repeated cycles of obsolescence and recovery while maintaining the highest level of integrity possible (Kane et al., 2018).

The inner loops are where the most embedded value is retained by keeping it whole. Note that recycling is located in the outmost loop and is therefore the stage of last resort in a circular economy (Ellen McArthur Foundation, 2022). This butterfly diagram shows an extensive overview of different types of recovery loops.

The literature research of Kane et al. (2018) identified different recovery strategies that currently do exist in the medical world, which are:

- Refurbishment and remanufacturing: medical device refurbishment is a mature and well-regulated practice in most of the world. The driving reason for the refurbishment/remanufacture of medical equipment is reduced cost for the end-user but with equal or better standard than the original product.
- Repair and maintenance: since medicine is a high-risk field, repair is highly costly

and potentially dangerous. Maintenance, in which parts are changed and systems cleaned and checked at regular intervals, is preferred.

- Recycling: Up to 20–25% of medical waste is estimated to be composed of recyclable plastics (Lee et al., 2002). A major barrier to recycling of this plastic is the presence of infectious waste and hygienic obsolescence. There is evidence of some success in increasing recycling of non-infectious waste by encouraging behavioural change in the way that products are disposed of.
- Sterilization/reprocessing: experimental studies undertaken into the resterilization of SUDs found two main areas of risk – mechanical or chemical damage to the product through repeated sterilization, and inadequate sterilization. High-criticality devices must be hygienically recovered using more aggressive means than low-or -medium criticality devices, and thus in order to be recovered must be designed using materials and forms which can withstand this sterilization and allow it to proceed effectively.

Value hill model

The right side of the Ellen McArthur Foundation (2022) butterfly diagram (technical side) encompasses different strategies for material recovery: repair & maintenance, reuse/redistribution, refurbish/ remanufacture and recycling. The value hill model for circular economy (Figure C655) adds 'refuse', 'rethink', 'redesign' and 'reduce' as strategies and shows their relation to the embedded value of these R-strategies.

Reuse as 'reprocessing'

Reprocessing allows for circularity in the production-consumption process of disposable medical devices (MacNeill et al., 2020). It is currently implemented in medical specialties such as OR, ICU and endoscopy. Establishing a circular supply chain for SUDs would make a significant contribution to reduce health care-generated emissions (Benedettini, 2022). Reprocessing currently occurs within healthcare facilities (in-house) and sometimes it is outsourced. It is nearly impossible to scale up in-house reprocessing short term; it would take enormous investments in terms of budget and specific staff training to achieve this.

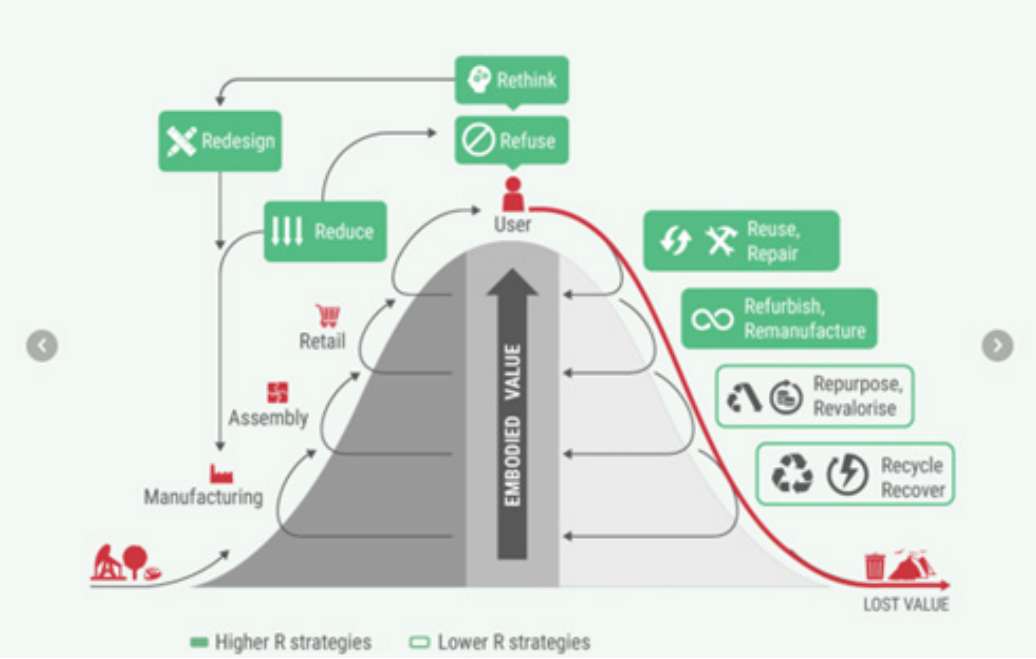


Figure C5: The value hill model (Metabolic, 2023).

Servitization, a strategy where manufacturing firms extend their business into services as a way to develop new revenue streams and improve customer value (Choo et al., 2021), could potentially be used as an effective green strategy in healthcare in the form of OEM reprocessing (Benedettini, 2022).

Decarbonization strategies such as more efficient purchasing of supplies through reprocessing and pack reformulation, result in cost-saving over time, as demonstrated by several hospitals (Kaplan et al., 2012). These can be effective strategies in materials-saving and cost-saving, as over 70% of carbon emissions from healthcare come from the supply chain (Campbell-Lendrum et al., 2023).

Setoguchi et al. (2022) critically emphasises how the majority of the commonly implemented strategies will not be enough to limit the global warming to the target of 1.5 °C, and that health care professionals must also take important steps to reduce overuse of health care services, including medical products, diagnostic procedures, and therapeutic interventions.

This literature review covers multiple models and their strategies that mostly refer to the technical and business aspect of a circular economy. However, it is important to take into account the sociological and organizational aspects of transition for complex systems such as healthcare.

The Triple C-Model

The Triple C model offers a new approach for healthcare clinicians to support sustainability of organizational change (Khalil & Kynoch, 2021). The model consists of three stages of implementation: consultation, collaboration and consolidation.

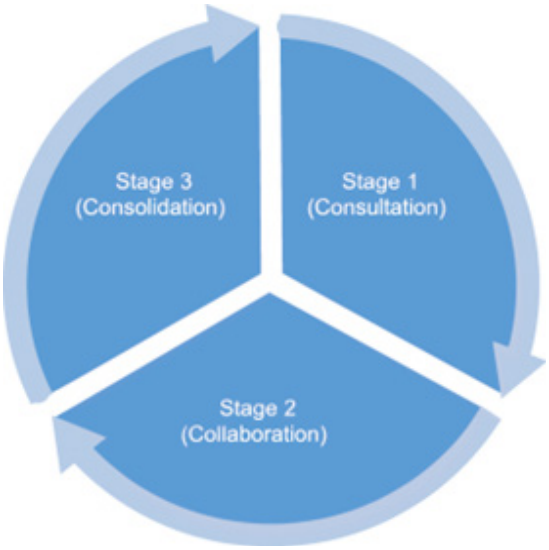


Figure C6: The Triple C-model (Khalil & Kynoch, 2021)

This study identified barriers and facilitators for the implementation of sustainable complex interventions in healthcare, summarized below.

Barriers for interventions included:

- Organisational barriers: organisational culture, support from leadership and the availability of resources
- Other: Education and training needs of staff, time constraints, complexity of intervention, lack of staff engagement and poor management and communication

Facilitators for interventions included:

- Sufficient resources, engagement of stakeholders, staff involvement and support from leaders and staff

One limitation of this model is that it is designed for long-term planning. However, the triple-C model mostly highlights the importance of multidisciplinary stakeholder engagement in all the stages of implementation, which is consistent with the aforementioned literature findings, and can be taken into account by expanding research to meet later horizons.

Research on climate impact of endoscopy practice

A large part of this review was provided before the kick-off in the form of a summary of the most important findings of relevant papers. This review was then used to dive deeper into the research of the presented papers to link the proposed research directions into relevant opportunities for EMC. A vast majority of the literature was based in the United States and even if the results of these studies are highly relevant for endoscopy practices in the Netherlands, it is important to take into account both countries' procedural scale (18 million in US vs. 625.000 in NL) and the diverging infrastructures, and to be critical on how these results translate into the EMC's healthcare system, specifically for activities such as waste management and transportation.

GI endoscopy is a resource-intensive specialty with a large carbon footprint: high throughput caseloads, repeated travel for patients and relatives, multiple nonrenewable waste streams, heavy reliance on single-use consumables, and resource-heavy decontamination processes (Baddeley et al., 2022; Siau et al. 2021). The high-throughput of endoscopy procedures in the Netherlands is related to the focus on cancer prevention (BVO). Since 2014, patients between 50 and 75 years of age are required to undertake screening colonoscopy procedures to prevent late diagnosis of colorectal cancer. This screening plan prevents 2.250 annual deaths (Maag Lever Darm Stichting, 2023). With an ever aging population the health demand in GI endoscopy is expected to rise and so are the environmental effects related to endoscopy.
Several studies have focused on estimating and mapping these environmental effects within varying research scopes.

CALCULATION OF CARBON EMISSIONS OF GI ENDOSCOPY

Carbon footprint for one GIE procedure in the US was calculated total to 28.4 kg CO2e (Lacroute et al., 2023). 45% Of total emissions was from travel by patients and center staff to and from the center. Other emission sources, in rank order, were medical and nonmedical equipment (32%), energy consumption (12 %), consumables (7%), waste (3%), freight (0.4%), and medical gases (0.005 %) (Lacroute et al., 2023).

Henniger, Windsheimer, et al., (2023) developed a tool for calculating the yearly emissions of a middle sized GI endoscopy unit. The total amount of emitted carbon dioxide equivalents in 2022 was 62.72 tons. Based on their data, a further reduction in emissions can be achieved primarily by reduction of the heating power and switching to alternative products for endoscopic accessories while avoiding long delivery routes by plane.

First author	Methodology and topic	Estimates
Gayam [21]	Cross-sectional study on endoscopy waste and carbon footprint using online calculators. See Supplementary material for methodology. It does not include pre- and post-procedure care. Carbon footprint does not include manufacturing, distribution, disposal, heating, or facility energy needs.	▪ One endoscopic procedure: 1.5 kg of waste (0.3 % kg recyclable). ▪ 1-year endoscopy activity in the United States (18 million procedures): – 13 500 tons of plastic waste, of which 10 800 tons are non-recyclable. – CO2 emissions equivalent to more than 3 995 448 gallons of gasoline consumed. ▪ Energy consumption per day in a GI endoscopy unit located in the United States that averages 40 procedures per day: – Wash machines 24.67 kWh – Endoscopy machines 27.00 kWh – Anesthesia machine 12.00 kWh – Room lighting 47.88 kWh – Total 111.55 kWh.
Namburar [22]	Cross-sectional study of endoscopy waste at 2 academic centers in the United States, including pre- and post-procedure care.	▪ One endoscopic procedure: 2.1 kg of disposable waste (46 L); 64 % of waste went to landfill, 28 % was biohazard waste, and 9 % was recycled. Personal protective equipment accounted for 8 % of waste. ▪ 1-year endoscopy activity in the United States: 38 000 metric tons of waste (equivalent to 25 000 passenger cars). ▪ Universal single-use endoscopes would increase the net waste mass by 40 %.
Siau [6]	Narrative review on endoscopic procedure and transport	▪ 1-year endoscopy activity in the United States (18 million procedures): 85 768 tonnes of CO2 → 4.8 kg of CO2 per endoscopy. This calculation includes CO2 related to waste and basic energy needs. ▪ The carbon footprint of a GI scientist using an electric vehicle and accounting for conference travel has been estimated at equivalent to 20.8 tonnes of CO2 per year.
Gordon [23]	Life cycle assessment of pathology specimen	▪ Equivalent to 0.28 kg CO_2 per GI biopsy when 1 jar is used and 0.79 kg CO_2 when 3 jars are used; emissions equivalent to driving a typical passenger vehicle 0.7 mile and 2.0 miles, respectively. ▪ Production of supplies was the largest contributor to greenhouse gas emissions.
Hernández [24]	Life cycle assessment of single-use duodenoscope Only presented as a conference abstract	▪ Single-use duodenoscope consumes 467 MJ and releases 29.3 kg of CO_2 ▪ Reusable duodenoscope 26.8 MJ and 1.55 kg CO2; 20 times less than single-use model. ▪ Duodenoscope with disposable end caps 23.4 MJ and 1.37 kg CO_2.
Vaccari [19]	Data on per capita health care spent at the national level, as well as a case study of a hospital in Italy	▪ Departments with highest generation of hazardous waste per daily occupied bed were: 1 anesthetics, 2 pediatric and intensive care, and 3 gastroenterology–digestive endoscopy (3.09 kg/day/bed). ▪ Departments with the highest average monthly waste generation rates per clinical procedure were 1 radiology (0.67 kg/procedure), 2 gastroenterology–digestive endoscopy (0.50 kg/procedure), and 3 plastic surgery.

Table C1: Estimates of the environmental impact of gastrointestinal (GI) endoscopy (Rodríguez De Santiago et al., 2022)

Other research by Rodríguez De Santiago et al. (2022) presents an overview of different studies' estimates of environmental impacts of GI endoscopy, each paper focusing on a different part of endoscopy procedures with varying research scopes (Table C1).

Detailed analyses of the sustainability of each step in endoscopy activities would allow the identification of small but cumulative beneficial changes that could decrease our environmental impact (Maurice et al., 2020). Thus presenting the need for further refining and narrowing down scopes for carbon footprint calculations.

Besides calculations of the current endoscopy practice, different research and improvement directions can be identified and divided into categories based on the different time stamps in the endoscopy care pathway: pre-procedure, during procedure post-procedure.

PRE-PROCEDURE: ALTERNATIVE DIAGNOSTICS

Reduction of the carbon footprint of endoscopy must start prior to the procedure itself, by lessening the amount of inadequately performed endoscopies (Cunha Neves et al., 2023). It is estimated that up to 56% of referrals for upper GI endoscopies and between 23% and 52% for colonoscopies may be inappropriate (Sebastian et al., 2023). This further emphasizes the need for sustainable interventions along the whole care pathway.

Maurice et al. (2020) highlights the importance of identifying key drivers for unecessary endoscopies, as well as preferred low-waste alternative solutions for diagnostics and home testing to reduce travel.

DURING PROCEDURE

Pain relief alternatives to harmful medical gas

Insufflation with CO2 and pain relief with nitrous oxide are major contributing factors to environmental impact. CO2 insufflation is proven to reduce post-procedural pain for colonoscopy (Wang et al., 2012), and is related with a shorter examination time (Yamano et al., 2010). On average the volume of insufflated CO2 is estimated at 8.3L per patient (Bretthauer et al., 2003). While in the study of Lacroute et al. (2023) it only acounts for 0.005% of the footprint (in kg CO2e) for a single procedure, Siau et al. (2021) and Donelly et al. (2022) critically point out the 300 times more harmful effect of nitrous oxide compared to CO2. This emphasizes the need to look beyond total carbon footprint calculations and to look into toxicity and other, more indirect environmental consequences of medical gases.

Reducing sterile water use

Water-assisted colonoscopy uses approximately 700mL of sterile water per procedure and for intraprocedural activities (Siau et al., 2021). This procedure is the most common in EMC as well. During a visit to the peripheral hospital Reinier de Graaf Gasthuis (RDGG), I learned that the use of sterile water is not mandatory by the WIP (RIVM), but is a standard set by endoscope manufacturers. RDGG implements the use of drinking water instead of sterile water based on their own initiative and agreement with Olympus and Fujifilm (OEMs). Reducing sterile water use has a high actionability potential and should be considered as something that could be applied in the short-term.

Disposable vs. reusable endoscopes

The major components of GI reusable endoscopes are metal (70% of total mass) and plastic (25%–30 %), with a remaining small proportion of electronic components. In contrast, single-use GI endoscopes consist primarily of plastic and a lesser proportion of metal (Rodríguez De Santiago et al., 2022). Rising concerns of cross-contamination infection risk have pushed the industry to use single-use endoscopes, without taking into account the expected increase in environmental impact, i.e. a total 40% increase in waste mass (Namburar et al., 2021; Baddeley et al., 2022), and 24–47 times larger CO2 emissions than that of reusable scopes, with manufacturing accounting for over 90% of the greenhouse gas emissions (Sebastian et al., 2023).

Single use consumables & accessories

Quantifying the waste generated by a single diagnostic endoscopic procedure will be useful (Siddhi et al., 2021; Sebastian et sebastial., 2023). Single-use consumables are generally plastic-predominant, individually wrapped, and are not recycled. OEMs often label reusable products as single-use (Benedettini, 2022). The following GI endoscopy accessories have been marketed as reusable:

- bougie dilators
- biopsy forceps
- band ligation devices
- sphincterotomes
- baskets for stone retrieval
- reloadable clip applicators
- suction and air valves
- snares, guidewires, and balloon expanders
- personal protective equipment

Waste quantification and impact assessment has been done before in the ICU units in EMC (Hunfeld et al., 2022) and presents an extensive approach to material mapping as well as environmental impact assessment of these SUD materials specific to EMC. The in- and outflows of materials might be very similar to the ones to be identified in the EMCs endoscopy department.

A study by Henniger, Lux, et al., (2023) explored the effects of switching to alternative products to the SUDs, as well as the reduction of amount of instruments used per procedure and recycling of packaging material. This is an example of a multiple intervention approach within one workflow, which resulted in a decrease in carbon emissions (tCO2e) by 18.4%.

Packaging

Manufacturers of endoscopy equipment also have an important role to play in terms of reducing packaging volume and using recycled materials (Clough et al., 2022). Complexity of managing packages and their disposal is becoming an important issue (de Melo et al., 2021).

POST-PROCEDURE: WASTE MANAGEMENT AND REPROCESSING

Disposal and waste processing

In a survey performed with endoscopists, GI nurses, and technicians, 58% of staff and 65% of gastroenterologists disposed of endoscopic accessories incorrectly as RMW (NRMA) instead of regular trash. Disposal of RMW and sharps are more energy consuming and often produce toxic gases during the process (Incineration) (de Melo et al., 2021). This is partly because of the material composition of the incinerated waste. See Figure C7).

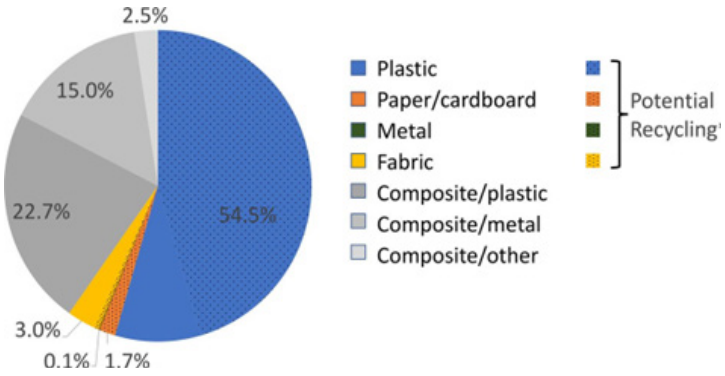


Figure C7: Material composition of endoscopy waste and its recycling potential (Namburar et al., 2021)

Reprocessing of reusable endoscopes and accessories

Reprocessing may be broken down to include: precleaning, cleaning, disinfection, rinsing, drying, and cleaning of reusable components.

In the Netherlands, guidelines for endoscope reprocessing are set by SFERD (2022). The reprocessing of reusable endoscopes is a resource-heavy process involving large volumes of water (approximately 113,6 L per cycle), disinfectants, detergents, and electricity (24.67 kWh per day) (Baddeley et al., 2022). It is acknowledged that reprocessing of reusable scopes is resource-heavy, including water, disinfectants, detergents and costs up to 25 kW electricity per day (Shaji et al., 2023).

The reprocessing turnover of endoscopes in EMC is 60 per day. The reprocessing is done by a separate sterilization department (SD) inside the endoscopy center.

Further research on the energy consumption of the EMC's current endoscope reprocessing is advised.

Regarding the energy transition it is highly advised to conduct further research in the reprocessing of endoscopes. Energy use in endoscopy and reprocessing is as much

Item	Per endoscope	Daily	Weekly	Monthly	Annual
Reprocessing personnel					
Pair extended cuff glove	1	12	60	240	2880
Gown	1	12	60	240	2880
Face shield	1	1	5	20	240
Mask	1	1	5	20	240
Hair covering	1	1	5	20	240
Precleaning					
Precleaning kit Sponge/Wipe Plastic bowel	1	12	60	240	2880
Transport					
Container/Liner	1	12	60	240	480
Leak testing Manual cleaning					
Sponge/Wiper	1	12	60	240	480
Channel brush	1	12	60	240	480
Valve cylinder brush	1	12	60	240	480
Flushing tubing	1	1	5	20	240
Inspection					
Residual soil test	1	12	60	24	480
Post HLD drying					
Pair exam gloves	1	12	60	240	2880
Drying clothe	1	12	60	240	2880
Additional supplies					
Germicidal wipe transport container	1	12	60	240	2880
Germicidal wipe sink	1	12	60	240	2880

Table C2: Estimated materials consumed to reprocess an endoscope with the presumption 12 endoscopes daily for a year (Collins, 2021).

important as other factors (e.g. SUDs) since the energy comes from non-renewable sources. With an increase in reusable devices in the future, the demand on reprocessing will rise and will cause an increase on SUDs used for reprocessing. Collins (2021) estimated the number of materials consumed to reprocess an endoscope (Table C2).

Multiple research directions and priorities for intervention were stated by Sebastian et al. (2022) and Siddhi et al. (2021) and present a relevant summary for possible interventions at EMC.

ORGANIZATIONAL: PROCUREMENT

Research into procurement practices including products purchased with a mandate for green credentials as a criterion is urgently needed. Current procurement policies do not include sustainability as an integral element of the procurement procedure (Internal communication with Maarten Timmermann, 2023).

Pre procedure	
	Large multicentre prospective trials to further evaluate the performance of non-endoscopic technologies
	Determine the environmental impacts of non-endoscopic diagnostic pathways (colon capsule endoscopy, Cytosponge, CT colonography)
Procedural	
	Comprehensive environmental impact assessment of an endoscopic procedure. Identify the 'hotspot' areas within the process which contribute most to this impact
	Engineer and design of effective accessories, consumables and packaging to minimise waste and maximise recyclability and biodegradability
	Comparative life cycle assessment of single use versus reusable endoscopes
	Determine the net effect of artificial intelligence systems on histopathology demand
Postprocedure	
	Determine the environmental impacts of the endoscope decontamination processes
	Innovate improvements to the endoscope decontamination process which reduce per-cycle water, energy and plastic use.
	Develop effective wash cycle chemicals with optimal pH neutrality, biodegradability, and which meet marine life safety certification requirements
	Develop solutions to drying and prolonged storage of endoscopes which replace the need for energy-intensive drying cabinets
	Determine the incidence of clinically significant infection arising from contaminated endoscopes in the context of gastroscopy, duodenoscopy and colonoscopy.
	Determine the effect of endoscope modification (eg, disposable elevator caps) on endoscope contamination rate
General	
	Evaluate the efficacy and environmental impact of strategies for site-based production of 'sterile' water for example local reverse-osmosis, ultrafiltration or autoclave-sterilisation systems.
	Determine the optimal level and materials for an effective PPE policy to minimise overuse and environmental impacts
	Stakeholder review (clinicians, patients, policy makers) to understand barriers to change and how to best integrate environmental impact data into decision making
	Evaluation of educational interventions to improve environmentally sustainable practices
	Define environmental key performance measures for a sustainable endoscopy unit

Table C3: Summary of research directions and interventinos (Sebastian et al., 2022)

Table 1. Table of Priorities

Easy wins – low cost and easy to implement	Intermediate targets – higher cost and more difficult to implement	Long term targets – expensive and global, strategic
1 Recycling waste – waste segregation, raising awareness amongst endoscopy staff	Reducing the need for plastic bottled water by implementing a RO Water plant for filtered clean water to be used for endoscopy	Use of new technologies to reduce the demand for endoscope based diagnostic procedures in Gastroenterology (e.g. colon capsule endoscopy, cytosponge, artificial intelligence enabled radiology, ultrasound)
2 Reducing paper use – electronic reporting and dissemination by email	Reducing plastic containers for water and cleaning agents and moving over to recyclable cardboard containers	Reducing single use consumables in endoscopy, especially high volume low end items like biopsy forceps by re-usable items where feasible
3 Reduce cost of lighting, heating by installing motion Sensor lights, timers on heating controls	Minimise the workforce and travel needs for endoscopy – more community endoscopy where appropriate rather than hospital based diagnostic endoscopy	A global perspective on the most cost effective landscape for diagnostic and therapeutic endoscopy

Table C4. Priorities in sustainable endoscopy (Siddhi et al., 2021).

Challenges to sustainable endoscopy

Figure C8: Challenges to sustainable endoscopy, adapted from Siddhi et al. (2021)to fit the layout of this document.

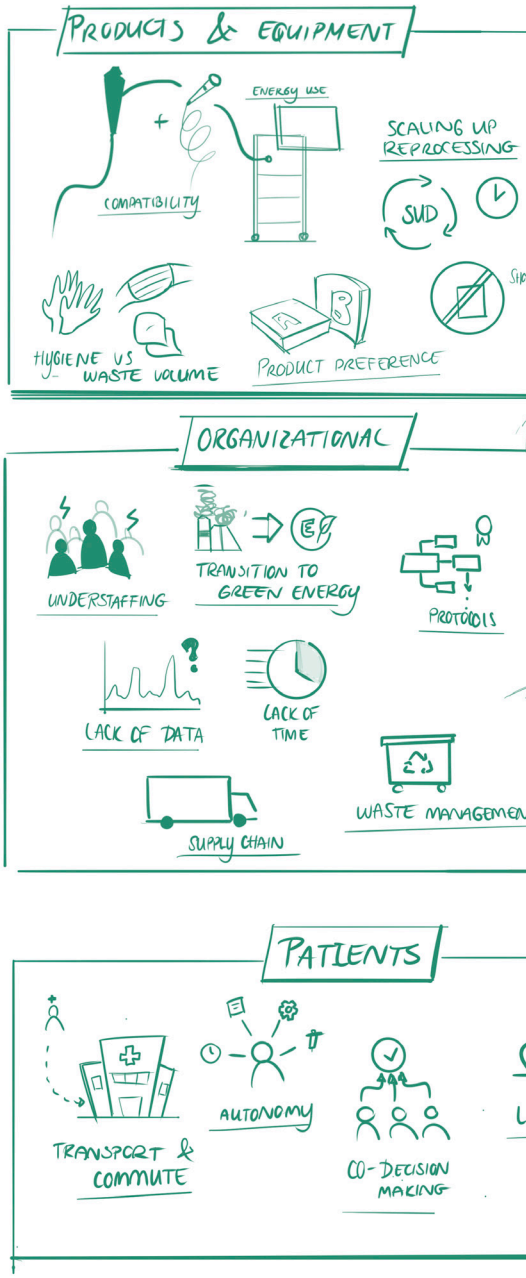
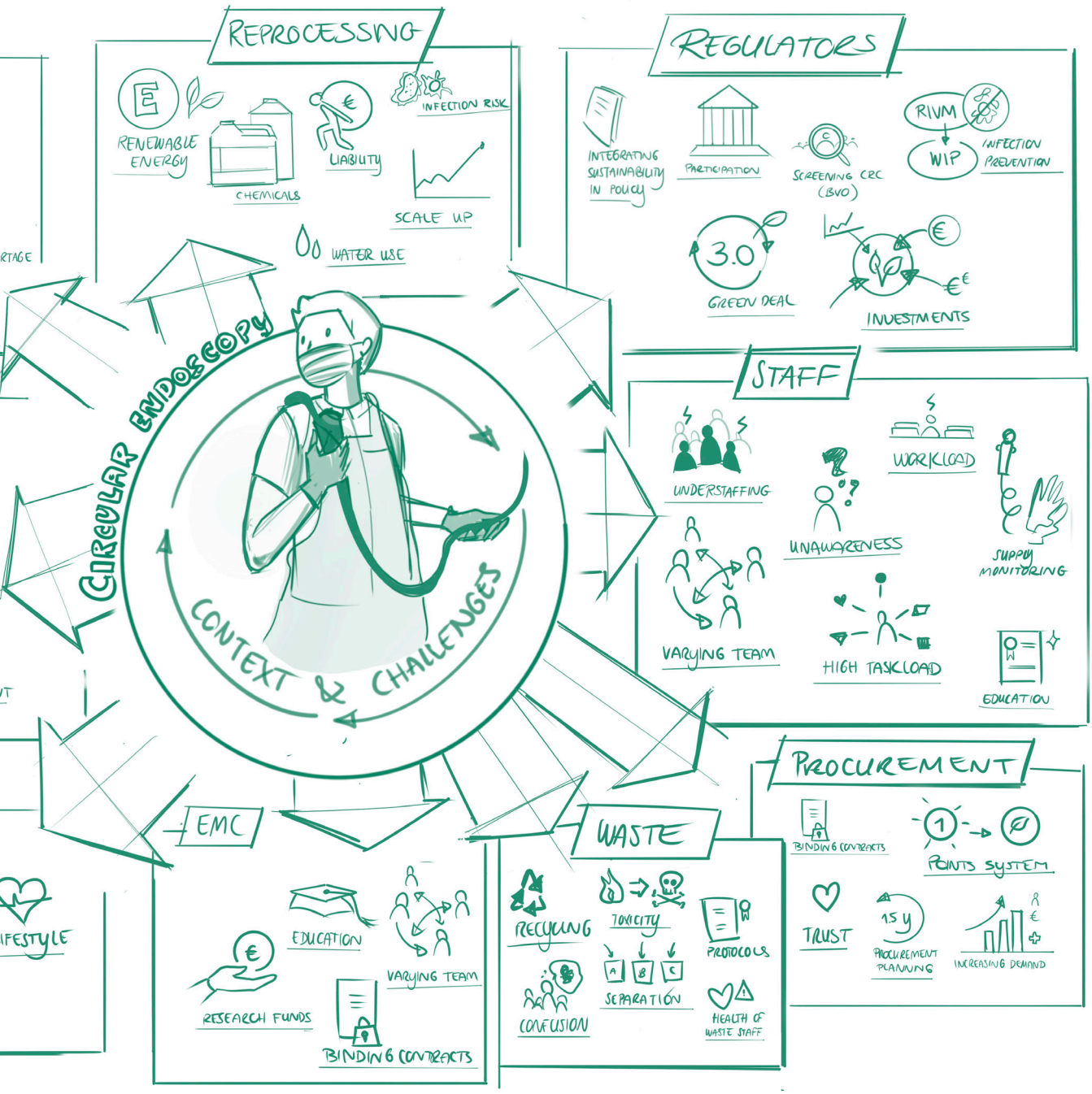


Figure C9: A summa

Following the topics depicted in the previous section, challenges in sustainable endoscopy are in line with general challenges of implementing interventions in healthcare, see Figure C8.

Leadership, sustainable pathways, buildings and procurement are more on the organizational level, but designers play a major role in achieving the goals of sustainable equipment & accessories, staff behaviour and waste recycling.



arizing context map of the challenges to circular endoscopy based on the literature review as well as EMC context research.

By implementing R-strategies (see Section 2.3) designers can help develop sustainable interventions across multiple system levels.

These literature findings helped shape a more streamlined research direction for this project, because there is no homogeneous distribution of existing research on sustainable endoscopy. Moreover, the different literature 'clusters' helped me gain insight in relevant keywords to look for. It also made clear that research into sustainable endoscopy is still at an early stage and that closing the knowledge gap requires a multidisciplinary approach. The role of design in this transition to sustainable endoscopy is for this reason a crucial one, and it is important to keep in mind the circular design models in in designing sustainable interventions.

Appendix D

Waste audit report

WASTE STREAM IDENTIFICATION FOR THE ENDOSCOPY CENTRE

Waste room in the endoscopy unit

The identified waste categories were:

- Bed linen -> this is rewashed but it creates waste in terms of water and energy and detergents elsewhere in the system
- Non-hazardous medical waste (niet risico-houdend medisch afval, NRMA -> PreZero)
- Hazardous medical waste (SZA -> TONTO Pharmafilter)
- Sharps and meds (needles and glass ampoules)
- Non-confidential paper (e.g. multipack boxes)
- Confidential paper
- Chemical waste (black containers)
- Glass (medication pots)
- Company waste (e.g. single use food plates, cups, etc.)
- (Clean) Plastic bottles, sterile water bottles
- “Confusion container” -> confusion items, needle containers and metal
- Other, not included in the waste room: medical liquids, contrast liquids, sterile water, body fluids (suction bags)


NG / TEXTILE
REST/MEDICAL WASTE
NON-CONFIDENTIAL PAPER WASTE
CHEMICAL CONTAINERS
NS-421K
VULL
NOT REALLY SURE IF USED OR NOT
CONFIDENTIAL PAPER
STERILE WATER BOTTLES - to recycle
This was an initiative of the head of endoscopy nursing, Sandra
TONTO
SPECIFIC MEDICAL WASTE (SZA)

WASTE MANAGEMENT IN EMC

There are two actors in the waste management of Erasmus MC.

Pharmafilter

Pharmafilter enables the system around the TONTO and filtration of the EMC sewage. Because there is an increased amount of pharmaceutical discharge in the water compared to regular sewage, filtration is necessary to prevent toxic chemicals and residual medication from entering the ecosystem.

There is at least one TONTO in every department. The TONTO is a special machine that grinds waste into smaller pieces, so they can enter the EMC sewage system and directed to Pharmafilter, which is on-site installation on EMC.

Solid waste is separated from water through a sieve. The solid waste enters an anaerobic reactor, which converts (bio) solid waste into bio-gas, eliminating viruses and bacteria. This bio-gas is then used to power the Pharmafilter installation (efficacy unknown). The residual solid waste (around 10%) is transported to PreZero for SZA incineration (higher temperature). This is used for energy (e.g. heat).

The water stream enters a purification process using porous charcoal filters, that only permeate water. The water can then re-enter the sewage system, creating a closed loop (R-strategy reuse/reprocess).

Specifieke EURAL-afvalstoffencodes:

18 01 01	niet infectueuze scherpe voorwerpen (spuiten zonder naald, scalpels, ...);
18 01 03*	afval waarvan de inzameling en verwijdering zijn onderworpen aan speciale richtlijnen teneinde infectie te voorkomen (divers afval van patiënten met specifieke infectieziekten, incl. naalden, bloedstalen en organen);
18 01 04	afval waarvan de inzameling en verwijdering niet zijn onderworpen aan speciale richtlijnen teneinde infectie te voorkomen (bv. verband, gipsverband, linnengoed, wegwerpkleding, luiers van niet specifiek besmette patiënten);
18 01 06*	chemicaliën die uit gevaarlijke stoffen bestaan of deze bevatten;
18 01 07	ongevaarlijke chemicaliën;
16 05 06*	labchemicaliën die uit gevaarlijke stoffen bestaan of deze bevatten, inclusief mengsels van labchemicaliën.

PreZero

Waste types are determined by EURAL-codes, which is a European standard for the disposal of waste:

18 01 03 refers to hazardous medical waste (i.e. SZA, sharps and chemical), and 18 01 04 refers to non-hazardous medical waste (PPE, diapers, gauzes, etc.).

Residual waste generated in hospital is different from company and household waste and is not allowed to get in contact with the municipal waste management streams. Therefore, all medical residual waste (hazardous + non-hazardous) is incinerated with energy recovery. It is interesting that household waste generated in hospitals ends up in the same waste stream as medical waste and is incinerated, even though it is not hazardous nor medical.

Currently only around 20% of the hospital's waste is recycled by PreZero.
The EMC's ambitions to become circular are described in sub-goals to improve their environmental, social and governance sustainability. (Duurzaamheidsdoelstellingen EMC).

There is a set of steep waste management goals for 2023-2024:

- 25% decrease in unsorted residual waste compared to 2018. Keeping in mind the goal of 2030 only 25% unsorted residual waste.
- In 2025 the amount of recyclable waste will have increased from 20% to 40%
- In 2026 at least 20% or medical instruments /equipment is reusable

PRODUCT QUANTIFICATION AND MATERIAL IDENTIFICATION

Research aim

Reduction and recycling of waste was described by Siddhi et.al (2021) as one of the priority actions to create more sustainable interventions in the endoscopy unit. Therefore, a waste audit was needed to start mapping more detailed material flows in the department and identifying opportunities to increase recyclable materials and furthermore increase the number of reusable materials.

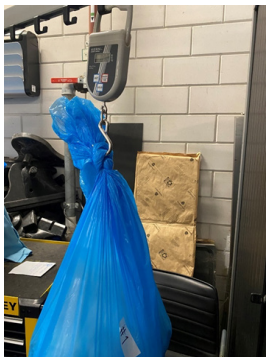
In order to successfully implement greener strategies in endoscopy departments, support from all staff groups is required (Donnelly, 2022). This can also be seen in Appendix B, where organisation, departments and staff are all included in the sustainability plan as actors. Therefore, the waste audit also included contextual factors such as the endoscopy staff's workflow and their behaviour surrounding the disposal of used products, done by observations during procedures.

The waste audit was conducted as described in Appendix C. Please note that the method was adapted and improved along the way, which will be discussed and evaluated in the following sections. Evaluation and improvement of this method is highly recommended and valuable for future research.

The method consisted of the observation of 15 colonoscopy procedures conducted during 5 afternoon programs, of which 3 procedures were used as an observation pilot. Each individual observation was followed by waste sorting of the waste bags specific to the observation room the next day. During both observations and the waste audit the process was documented with photographs (excluding critical data, i.e. patient documents, etc.).

Set-up in EMC logistics hallway

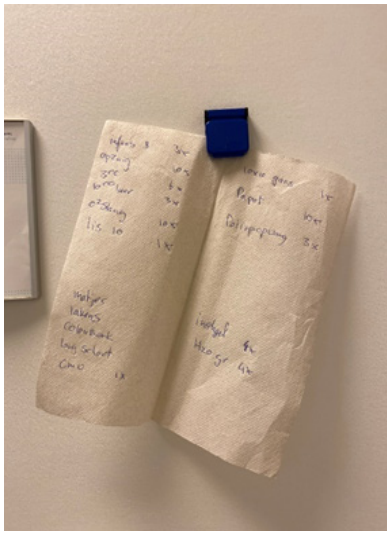
Scales	Description	Accuracy
Kern CH-15K20	Hanging scale	0,1 g
Kitchenwell KN353	Regular kitchen scale	1g
Kitchenwell KN350	Precision scale	0,01g

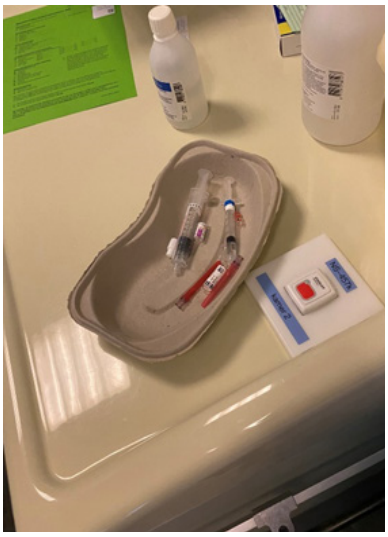


The waste was divided into **7 product categories:**

1. Paper
2. Textile & tissue
3. Hard plastic products
4. Medical instruments (metal + plastic)
5. Packaging
6. PPE
7. Other

Each of the waste bags was weighed in their totality, and then the different product categories were weighed separately. As mentioned before, there were lots of adaptations in the method, which resulted in some irregularities. The product categories of Day 2 (day after pilot) were not weighed because of inconsistent documentation. Therefore it is highly recommended that the waste audit is performed with **at least two people!**





KEY INSIGHTS

Kidney dishes are used mostly for collecting stuff around the room like
- gloves
- Syringes
- Meds

The doctor always grabs 3 gloves, 1 is only used for applying lube to the patient.

Lube is put on gauze pad first for doctor to grab it, but a lot of it is absorbed by the gauze.

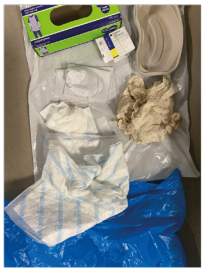
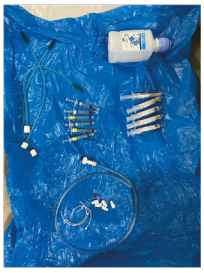
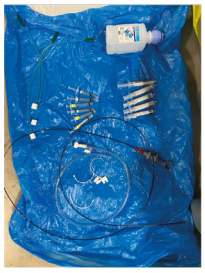
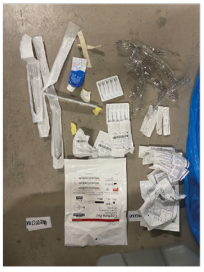
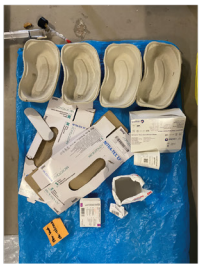
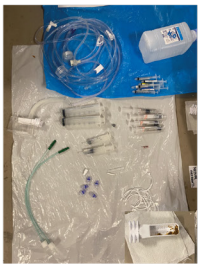
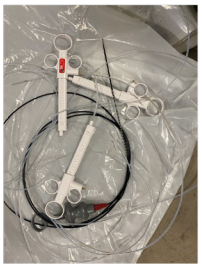
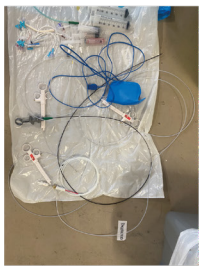
Carepath
The patient has the final say in the carepath, which can influence the impact of a colonoscopy procedure. A specific patient did not agree on the preparation terms and therefore the endoscopy procedure had no effect: there was no usable screening data obtained during the procedure and has to be redone with clinical preparation

Results and analysis

In this section, a bit of background information is provided for context, followed by pictures and tables of the results of that day. Day 0 started on Monday afternoon. Day 4 ended on Monday afternoon the week after.

Day #0: Observation pilot and set-up

Due to a logistics complication, the waste bags of that afternoon could not yet be collected. However, observation was used to test the observation templates (score sheets) and to identify all the different products in the preparation of the room. These were adapted to include more detailed descriptions of the SUDs per procedure phase (room prep, patient prep, procedure, surgical intervention, and cleaning). This pilot was also useful to understand how some products fulfil different functions than expected.

	CARDBOARD	TISSUES & TEXTILE	PLASTIC CONSUMABLES	MEDICAL INSTRUMENTS	PLASTIC PACKAGING	PERSONAL PROTECTIVE EQUIPMENT
DAY 1						
	10	39	34	2	28	39
DAY 2						
	10	23	28	1	40	36
DAY 3						
	13	35	42	4	58	53
DAY 4						
	11	57	42	6	50	52

Product categories	mber of produ
Blue bags	
White bag	
Paper	8
Textile & tissues	38
Hard plastic products	26
Medical instruments	2
non-paper Packaging	23
Protective clothing	40
Other (excluded from sorting)	4,5
Total number of products:	141,5

Observation #1	Patients 1-3	1 patient with biopsy	Total waste weight (kg)
Product categories	**Number of products**	**Notes**	1,7400
Blue bags		1 piece of gum	0,70
		Medicine residue of 1,5 ampoule. I decided that it would be excluded from the waste audit, might be hazardous	0,94
White bag			0,10
Paper	10	3 boxes, 6 kidney dish, 1 bijsluiter	
Textile & tissues	39	4 sterile, 6 paper tissues, 4 mini gauze, 2 paper wash cloths, 23 gauze pads	
Hard plastic products	34	4 equipment tubes, 7 biospy container seals, 1 sterile water bottle, 2 oxyegn tubes, 9 syringes, 3 valves, 1 needleness connector, 2 needle protectors, 1 suction tube (white), 4 connecting pieces	
Medical instruments	2	biopsy forceps	
non-paper Packaging	28	1 forceps, 3 waterjet connectors, 2 IV catheter (sterile pack, paper & thermoform plastic), 2 tegaderm sticker pack, 2 oxygen tube pack, 4 large syringe pack (non-sterile), 4 sterile syringe pack, 4 needles sterile pack, 1 ampoule holder (5x), 1 needleness connector, 4 biopsy valves, 1 biopsy ziplock (unused)	
Protective clothing	39	12 aprons (2 was stuck in gloves), 27 gloves	
Other (excluded from sorting)	3	gum, 1.5 ampoule, 2 hard plastic pieces with blood	
Total number of products:	155		

Day #1

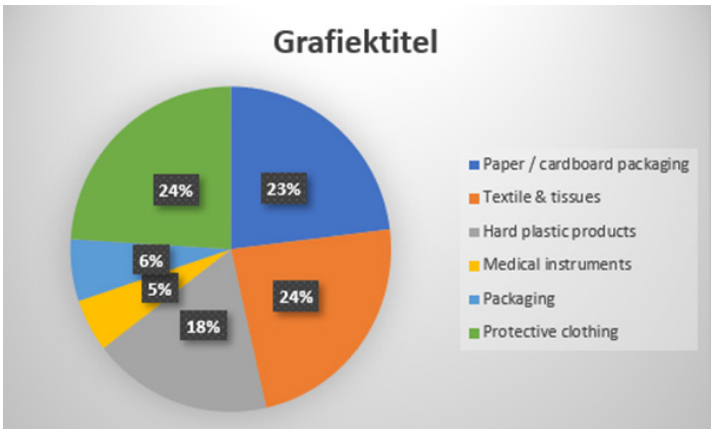
The total weight of the waste amounted to 1,74 kg for one afternoon. Total products used during a single observation: 155. On average that is 51,7 products and 0,58 kg of general medical waste (GMW) per patient.

After each afternoon, the sterile water bottles were empty or emptied, thus 3-4 sterile water bottles were wasted. This is pretty much constant during all afternoons and also in line with (Siau et al., 2021), were it was estimated that a single procedure uses 0,7L of water. One bottle ended up in the blue waste bag instead of in the PD recycle bin.

Key insights day 1:

- Even though the three patients had the exact same procedure, a lot of variations can occur even between biopsies and polypectomies
- Incorrect disposal of glass ampoules
- Better preparation of the documentation sheets was necessary. Inadequate preparation of the different product categories beforehand resulted in messy documentation, were the different product categories were not weighed separately
- Apprentice staff confused about proper disposal of the sterile water bottles

Product categories	Number of products
Blue bags	
White bag	
Paper	8
Textile & tissues	25
Hard plastic products	23
Medical instruments	2
non-paper Packaging	31
Protective clothing	37
Other (excluded from sorting)	1
Total number of products:	127

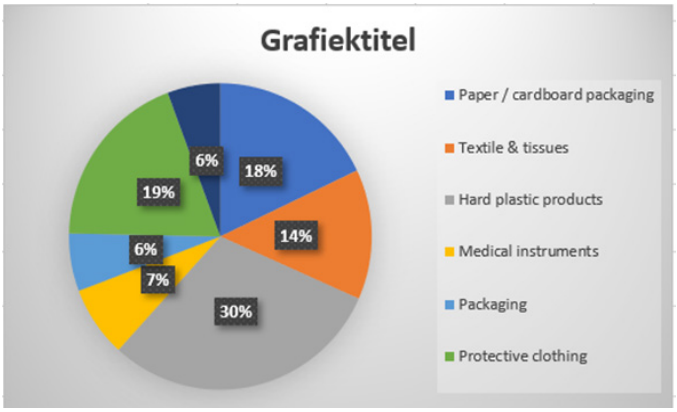


Observation #2	Patients 1-2		Total waste weight (kg)
Product categories	Number of products	Notes	1,1400
Blue bags			0,62
			0,46
White bag			0,06
Paper / cardboard packaging	10	8 kidney, 1 schortendoos, 1 fentanyl doosje	0,263
Textile & tissues	23	9 paper tissues, 4 washandjes, 9 gaasjes, 1 celstofmatje	0,267
Hard plastic products	28	1 steriele fles, 5 grote spuiten, 6 kleine spuiten, 3 zuurstof tubes, 3 waterjet connecter, 1 afzuigbuis, 5 opzetstukjes, 3 biops seals	0,207
Medical instruments	1	1 biopteur	0,06
Packaging	40	3 zuurstofslangen, 3 waterjet connectors, 1 biopteur, 2 biopy valves, 6 kleine spuitjes, 6 naaldverpakkingen, 5 niet steiele spuiten, 1 gel tube, 2	0,07
Protective clothing	36	28 handschoene, 8 schorten	0,274
Other (excluded from sorting)	1	1 kauwgum	
Total number of products	139		

Day #2

The total weight amounted to 1,14 kg of GMW. The total number of products was 139. Only two patients were treated that afternoon, hence on average 69,5 products were used per patient and the total waste mass per patient was 0,57 kg. The highest number of products lie in the categories packaging and PPE.

Product categories	Number of produ
Blue bags	
White bag	
Paper	9
Textile & tissues	45
Hard plastic products	38
Medical instruments	4
non-paper Packaging	48
Protective clothing	36
Other (excluded from sorting	1
Total number of products:	181

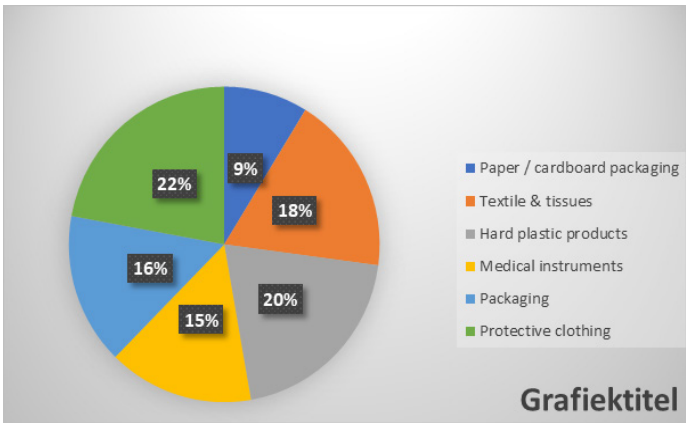


Observation #3	Patients 1-4	Polyp removal, biopsies and more complications	Total waste weight (kg)
Product categories	**Number of products**	**Notes**	2,3500
Blue bags			1,21
			1,06
White bag			0,08
Paper / cardboard packaging	13	8 nierbekken, 2 handschoennen dozen, 1 post it, 1 doosje midazolam, 1 spray nozzle verpakking, 1 bekertje, 1 verpakking gaasjes	0,421
Textile & tissues	35	1 celstofmatje, 2 steriele tussues, 1 washandje, 22 gaasjes, 2 mini gaasjes, 7 papieren doekjes,	0,323
Hard plastic products	42	4 afzuigslangen, 1 polyptrap bakjee met 2 witte insteekbakjes, 12 seal strips, 1 sterile waterfles, 2 grote waterspuiten, 2 gelspuiten, 4 grote spuiten, 6 kleine spuitjes, 1 plastic buisje, 5 waterinjectors , 2 zuurstofslangen	0,707
Medical instruments	4	3 captivators, 1 biopteur	0,176
Packaging	58	1 verpakking polip trap, 1 ampulhouder, 1 cathether, 1 biopteur, 3 captivator, 2 grote waterspuiten, 3 zuurstofslangen, 2 verdovende gel, 8 kleine spuitjes, 9 naaldenverpakkingen, 6 waterjet connectors, 4 biopsy valves, 1 deagdermtransparant sticker, 5 niet steriele spuitverpakking, 10 achterkant sticker, 1 plastic zakje,	0,143
Protective clothing	53	9 schorten, 44 handschoentje	0,447
Other (excluded from sorting	1	waterpomp	0,133
Total number of products	206		

Day #3

The total weight amounted to 2,35 kg of GMW. The total number of products that afternoon was 206 units. On average per patient, there were 51,6 products and 0,58 kg of waste. The highest number of products were again, in packaging and in PPE.

Product categories	Number of products
Blue bags	
White bag	
Paper	5
Textile & tissues	40
Hard plastic products	30
Medical instruments	4
non-paper Packaging	38
Protective clothing	47
Other (excluded from sorting	50
Total number of products:	214

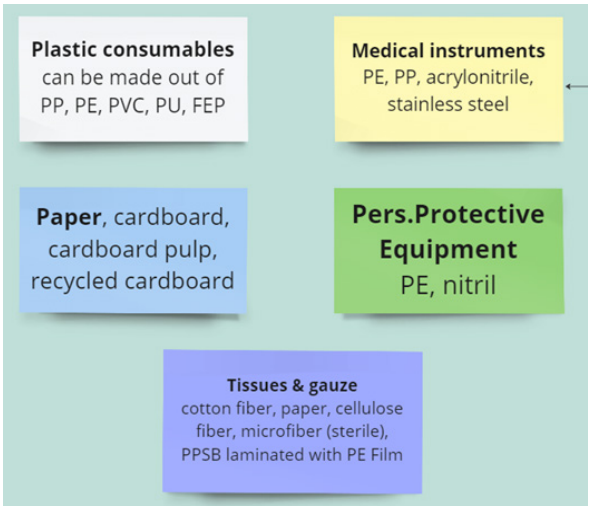


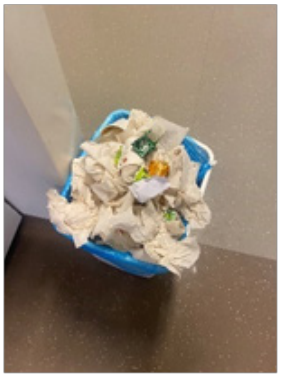
Observation #4	Patients 1-2	2 patients, 1 patient with double gastro+colo	Total waste weight (kg)
Product categories	**Number of products**	**Notes**	1,7600
Blue bags			0,66
			0,76
White bag			0,34
Paper / cardboard packaging	11	5 kidney dish, 1 box infacol, 2 boxes midazolan, 2 bijsluiters	0,154
Textile & tissues	57	2 fiber mats, 1 sterile tissue, 2 washcloths, 13 paper tissues, 30 gauze, 9 mini gauze	0,323
Hard plastic products	42	2 polyp traps, 2 grote spuiten, 1 mondstukje, 2 waterdoppen, 1 plastic cupje, 1 infacol, 1 zuiger, 2 IV catheters, 7 biopteur seals, 2 kleine spuiten, 4 normale spuiten, 1 O2 tube, 3 opzetstukjes wit, 5 buisjes, 2 water jet connector, 2 bloedbuisjes, 1 catheteter aansluiting, 3 catheter dopjes	0,354
Medical instruments	6	1 koude sticker, 1 biopteur, 3 clips, 1 electrische clip	0,266
Packaging	50	1 bite block, 1 biopsy ventiel, 1 instilla gel, 4 catheters, 4 naalden, 5 niet steriele spuiten, 1 indignity shorts, 4 steriele spuit, 2 grote spuit, 2 poliep, 2 O2 slang, 2 water jet connector, 1 ampul houder, 3 catheter stickers, 1 kartonnen houder, 1 biopteur, 1 elektrode, 3 clips, 2 water tubing, 1 variable injection needle (kartonnen houder hoort erbij), 8 stickers	0,273
Protective clothing	52	42 handschoenen, 9 schorten, 1 mondkapje	0,389
Other (excluded from sorting)	1	1 ijzerdraadje	0,00048
Total number of products	219		

Day #4

The total number of products amounts to 219 and the total waste to 1,76 kg. Per patient it is an average of 109,5 number of products and 0,88kg of NHMW. Technically not only 2 but 3 procedures were performed for two patients, since one patient had to undergo upper GI and colonoscopy in one treatment. The highest number of products were in the categories textile and tissues followed by PPE.

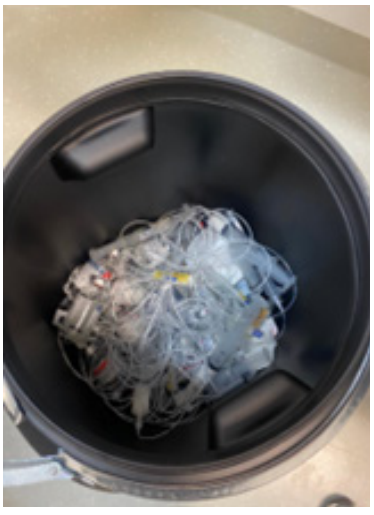
Common material types within the categories were identified using the information on the packaging, as well as literature for the materials in biopsy forceps and snares (López-Muñoz et al., 2023), leading to these material groups:





Other waste streams

While the waste audit was focused on the composition of the GMW bags, I tried to keep track of other waste streams as well. However, within the timeframe and the nature of this waste audit including observations, it was not possible to perform a quantification analysis. With a larger waste audit team, e.g. endoscopy green team, different team members can be assigned different waste streams. It is especially difficult because not all containers are emptied daily; some containers are emptied on weekly or monthly basis.



Discussion & conclusions

Variations in colonoscopy procedures between patients

Even though every patient had a 'routine' colonoscopy treatment, it became clear that there are numerous variations within this procedure, making it more complex than expected. Variations include multiple biopsies and polypectomies needing a different number of biopsy containers (pots), ranging from 1 pot to 8 pots per patient. Also there can be a lot of variation in sedation doses. All patients except two, were administered sedation. Out of 12 patients, 4 were administered a second dose of sedation and 2 needed additional local numbing (with numbing gel), which increases the number of products and packaging units per procedure. Moreover, for 2 patients the staff used two types of endoscopes in one procedure. For one patient it was because of the level of discomfort, the staff switched to a scope with a smaller diameter hoping it would relieve some pain. For the other patient it was for the double procedure of upper GI and colonoscopy. Using two scopes for one patient doubles the resources needed for reprocessing.

Ratio of used versus unused products

Interestingly, almost all products were used, meaning there is only a very small percentage of unused products like gloves or gauze that ends up in the waste bag. This may be due to the fact that there is a very clear structure to this type of colonoscopy procedure. In contrast to e.g. ERCP procedures, where the visibility is very different and one approach for placing stents or balloons is not always effective, colonoscopy procedures are predictable enough resulting in a quite efficient used/unused ratio of SUDs and consumables per patient.

Number of products

In each observation, the number of products scored during the observations was always lower than the number of discarded products, ranging from 5 to 25 product units. This discrepancy could be explained by multiple factors:

- Some tubing and connecting pieces come packed together and fell apart during the waste sorting, resulting in more products.
- Some of the products including IV catheter systems require a couple of elements, such as needles, adhesive gauze, butterfly clips. They are packaged separately but were only noted as a single catheter system on the scoring sheet.
- Some waste bags contained discarded materials prior to the start of the observation.

The largest number of products per category was quite consistently in PPE and packaging. This raises the question if these are potentially the largest hotspots. A point for further research is to identify the amount of uncontaminated gloves that could theoretically be recycled. Even though the number of medical instruments was really low compared to the amount of gloves and aprons, medical instruments contain critical materials such as stainless steel which are being incinerated. However deeper impact analyses like LCAs are needed to calculate the impact of the different consumables and their impact keeping in mind incineration and potential toxicity.

Limitations

The number of unexpected variations in a single colonoscopy procedure requires a new approach where the number of procedures observed can be statistically analysed. This waste audit provided a clear distinction between different colonoscopy procedures but is not fit for conclusions about frequency of procedures and frequency of use of the SUDs and consumables.
The first day of the waste audit was conducted poorly and therefore the weight distribution could not be analysed for 3 patient procedures.

Appendix E

Material composition of routinely used products

Endoscopy

Table 1 Material composition, weight and thermochemical properties of analysed biopsy forceps, polypectomy snares and haemostatic clips

	Forceps	Snares	Haemoclips
Total weight (g) (range)	57.08 (64.46–46.39)	57.05 (64.58–52.92)	71.29 (85.63–56.93)
Device weight (g) (range)	45.82 (54.60–33.75)	42.96 (47.46–40.28)	54.60 (65.60–43.58)
Packaging weight (g) (range)	11.31 (12.63–9.86)	14.10 (17.12–11.8)	16.69 (20.03–13.35)
Composition (%)			
Polyethylenes	32.00 (17–51)	45.33 (36–50)	53.50 (24–30)
Polypropylene	19.33 (0–34)	11.66 (0–35)	–
Acrylonitrile butadiene styrene	–	28.00 (0–50)	14.50 (23–53)
Stainless steel	45.00 (38–59)	14.33 (14–15)	35.00 (13–53)

López-Muñoz et al. (2023)

Material distribution of plastics vs. metals averages as derived from Table >

Biopsy forceps:
Polymers 51,33 %
SS 45,00%

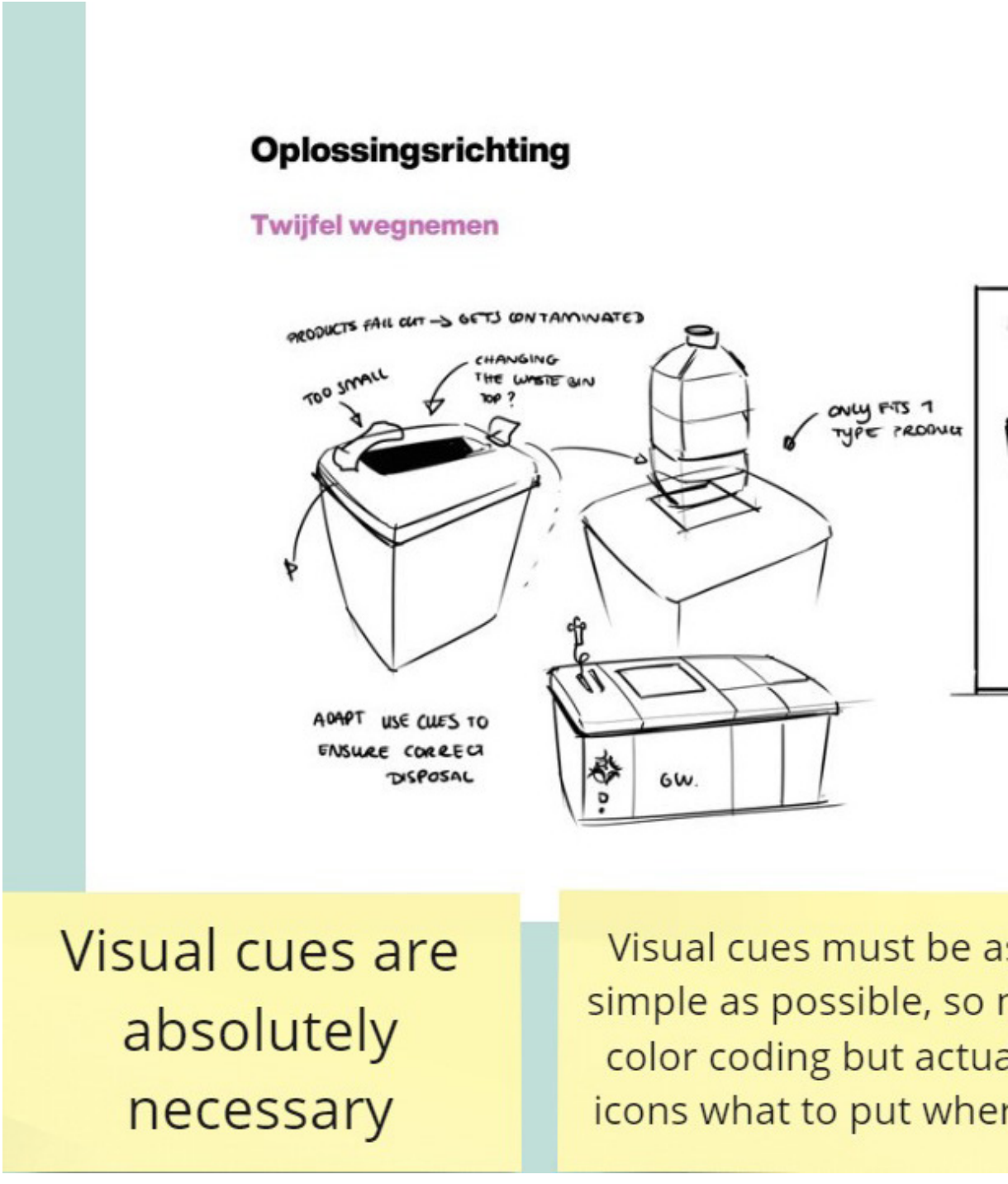
Snares
Polymers 84,93%
SS 14,33%

Clips
Polymers 68,00%
SS 35,00%

Assumption: in the category medical instruments, at least 51,33% of the weight distribution is polymer-based.

Appendix F

Idea directions including Green Team feedback



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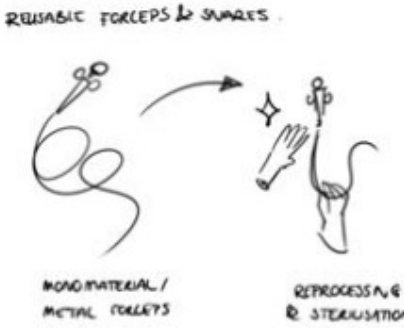
See what can already be used in the room, e.g. small waste bin next to the sink can be used for plastic bottles

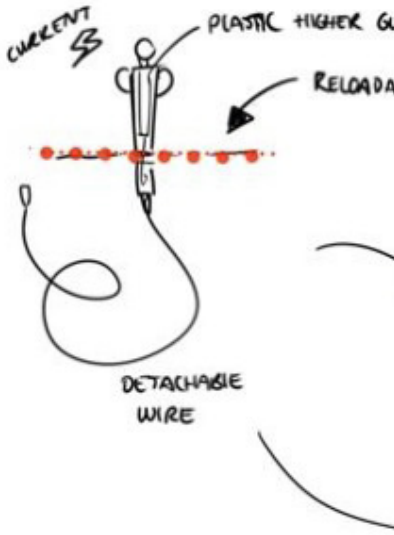
→

Reuse existing components

Oplossingsrichting

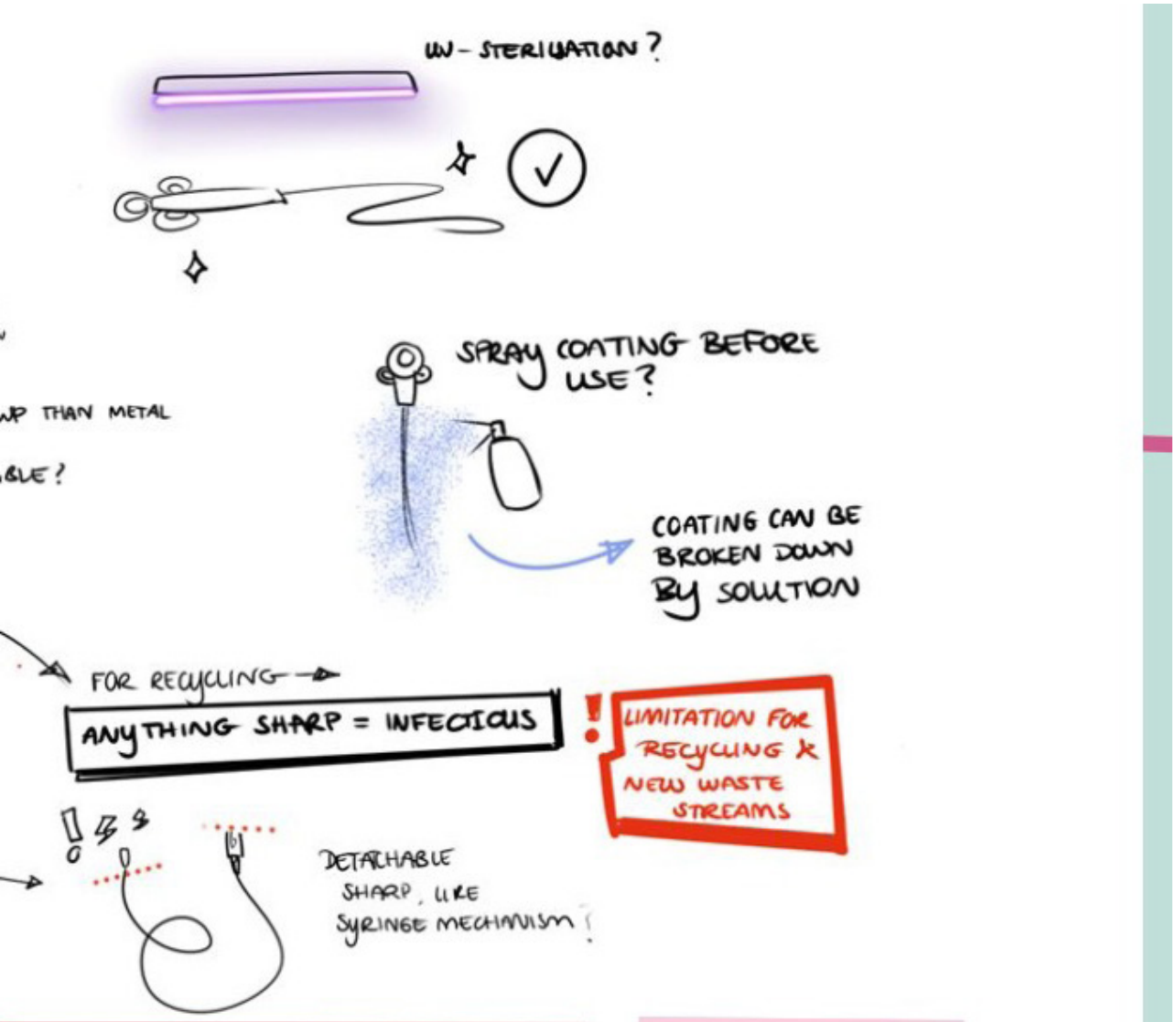
Scheiden van instrumenten





Important to establish a safe way to cut off the wire from the handle

It is mostly the responsibility of the supplier to ensure that the products can be clicked off or modular



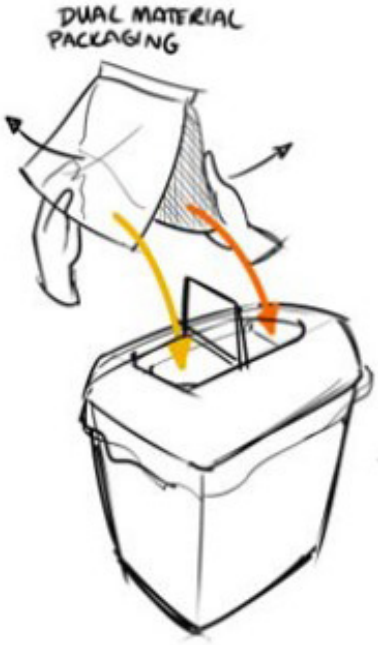
The problem is how the handle can be separated safely

Redesign for recycling

HOW TO: MATERIAL SEPARATION ?

Oplossingsrichting

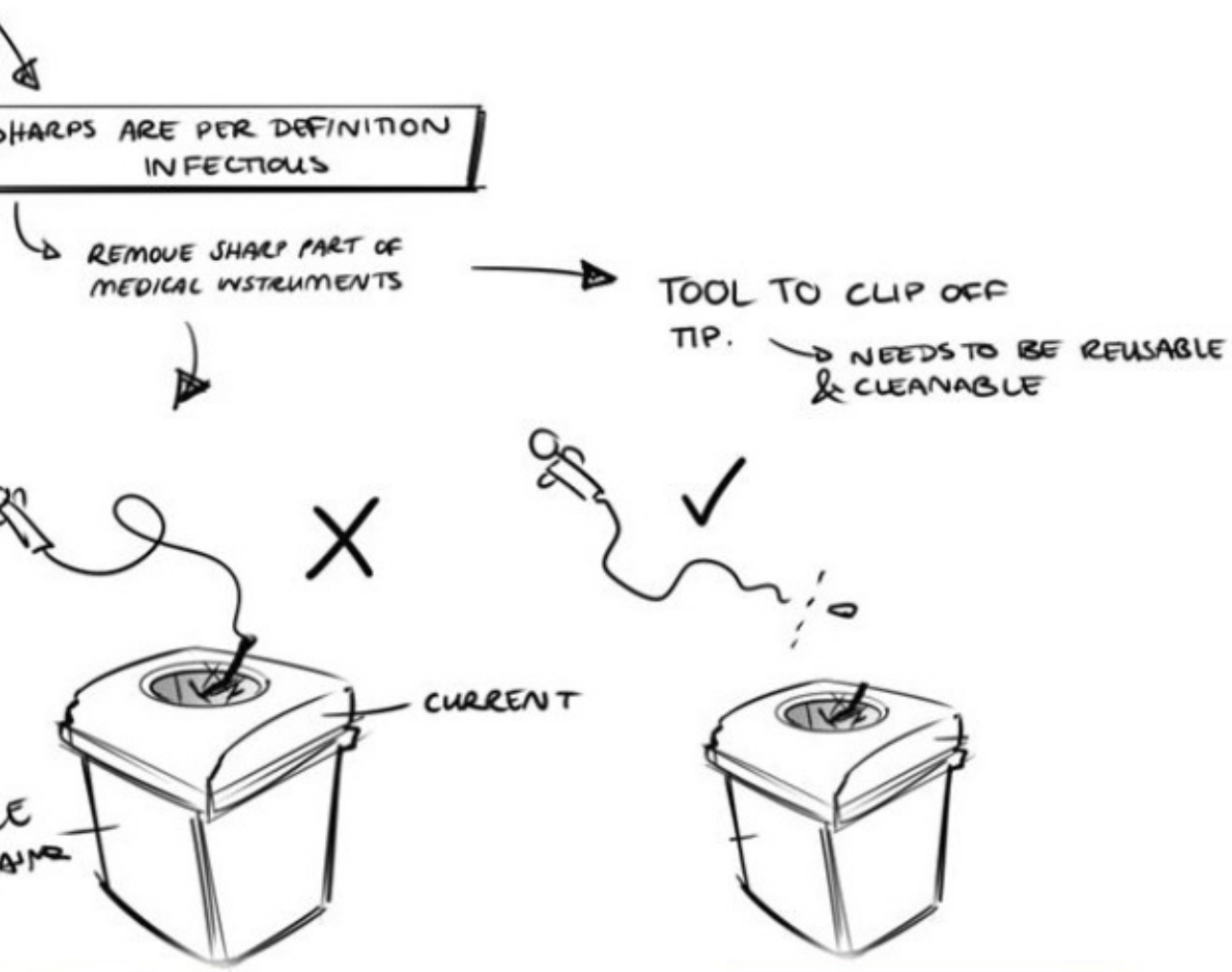
Scheiden van materiaal



The packaging can be separated with hands, does not need to be done with a separate product

→

OK/Radiology is already doing this as well



rating
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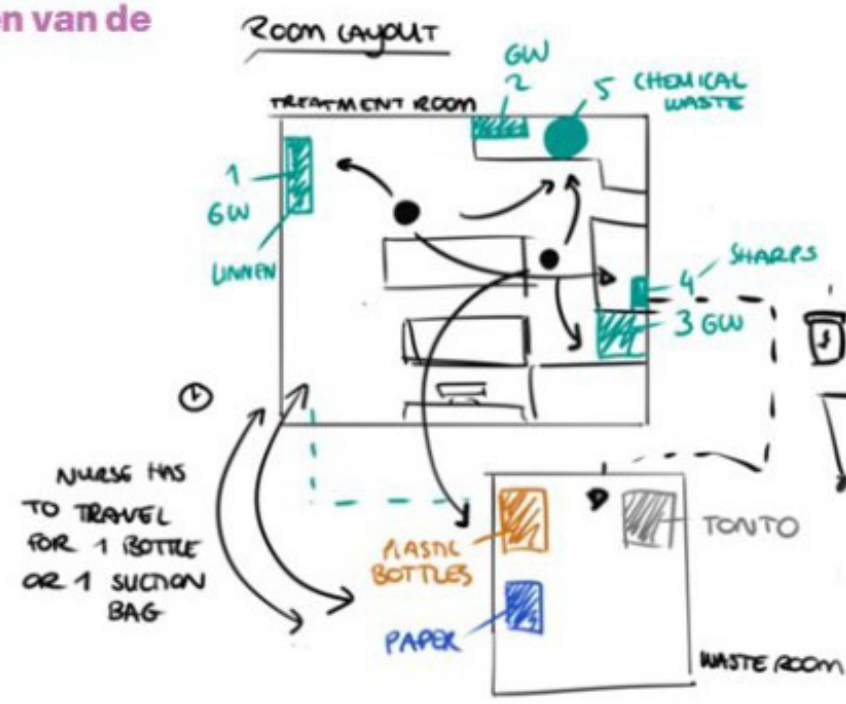
Modularity analogy like an ikea closet

The waste bins should include foot control pedal for hands-free use

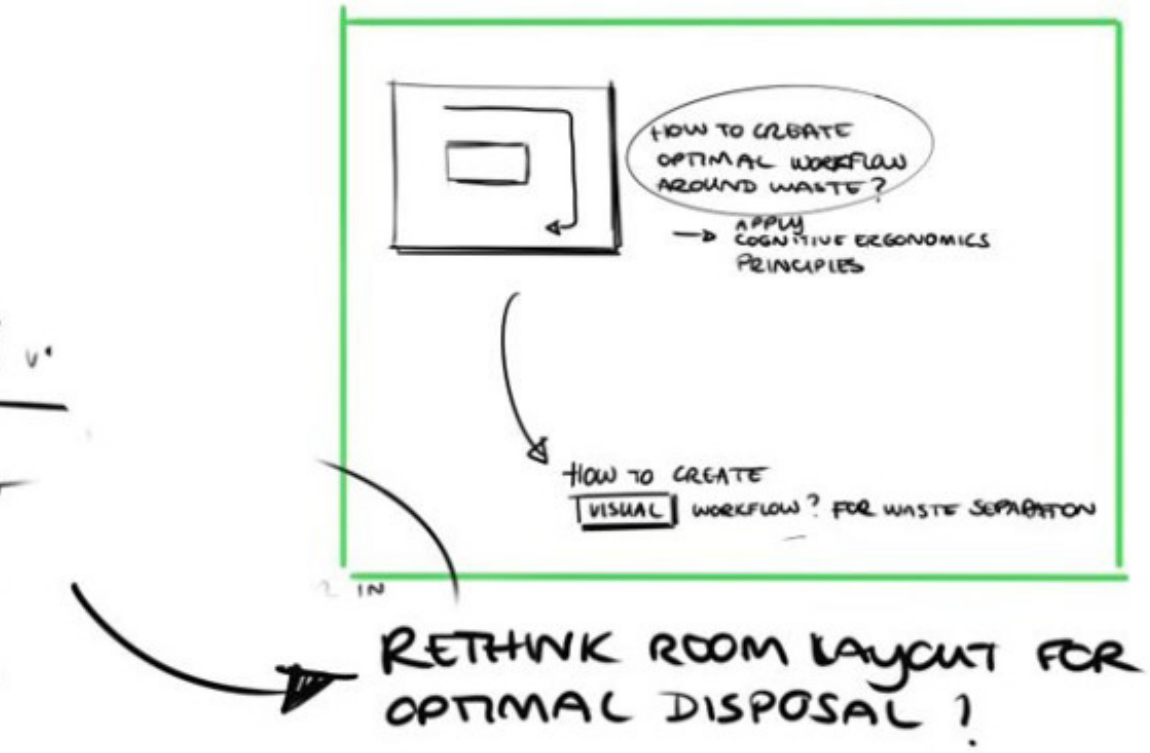
Oplossingsrichting

Optimaliseren van de route



The new intervention should take into account an optimization of the workflow with the waste disposal

An input
creation s
what the o
the new wa
a



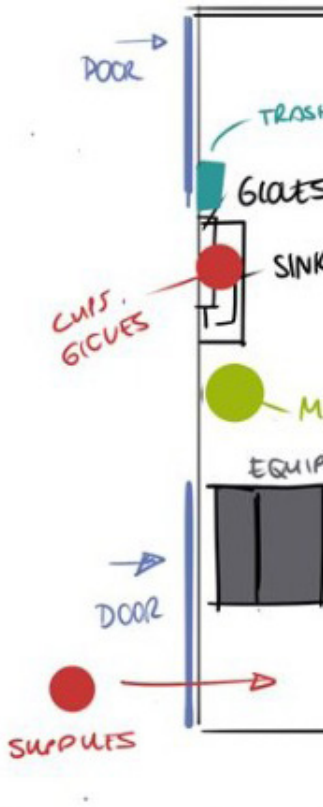
to the third co-
ession should be
ptimal position of
aste bins could be
and why

→

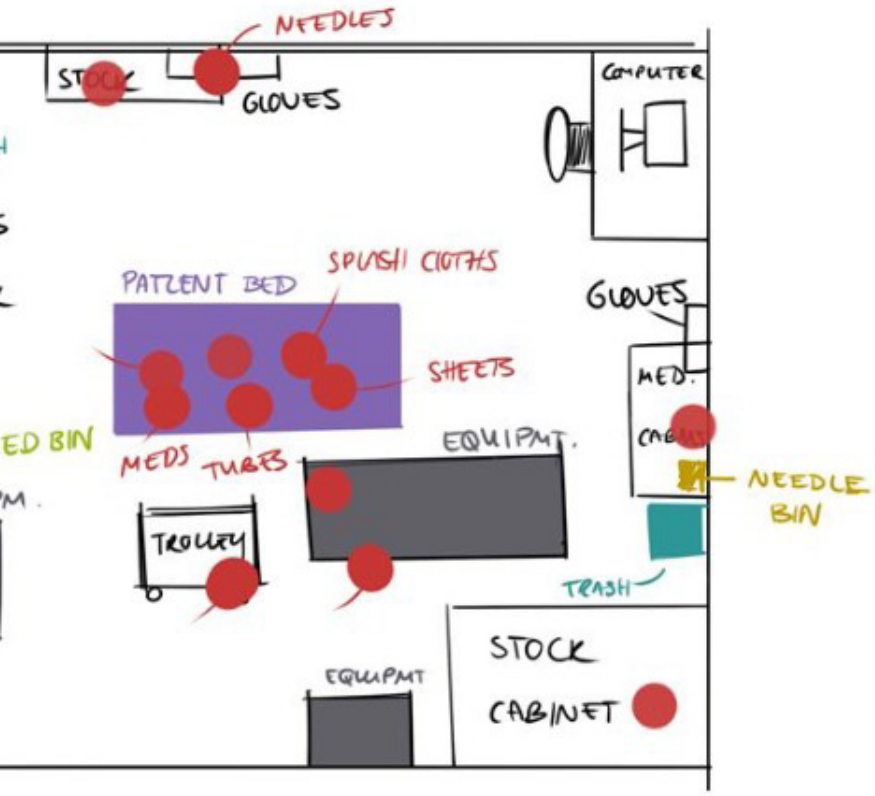
Rethink
the waste
route

Oplossingsrichting

Optimaliseren van de route



There is a lot of points in the room where waste is created. Nurses Really believe that a re-design of the workflow and room elements is in place.



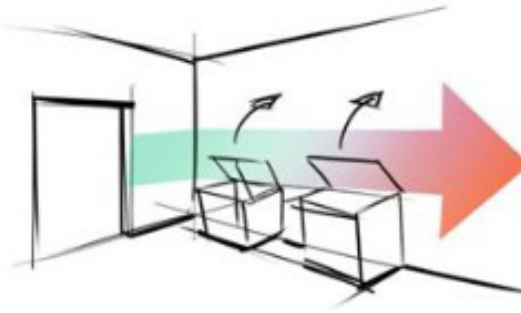
e elements
and
sthesiology
ipment is
dly used in
s 1, 2, and 3.

The system is always turned on but is not used

design
the
terior

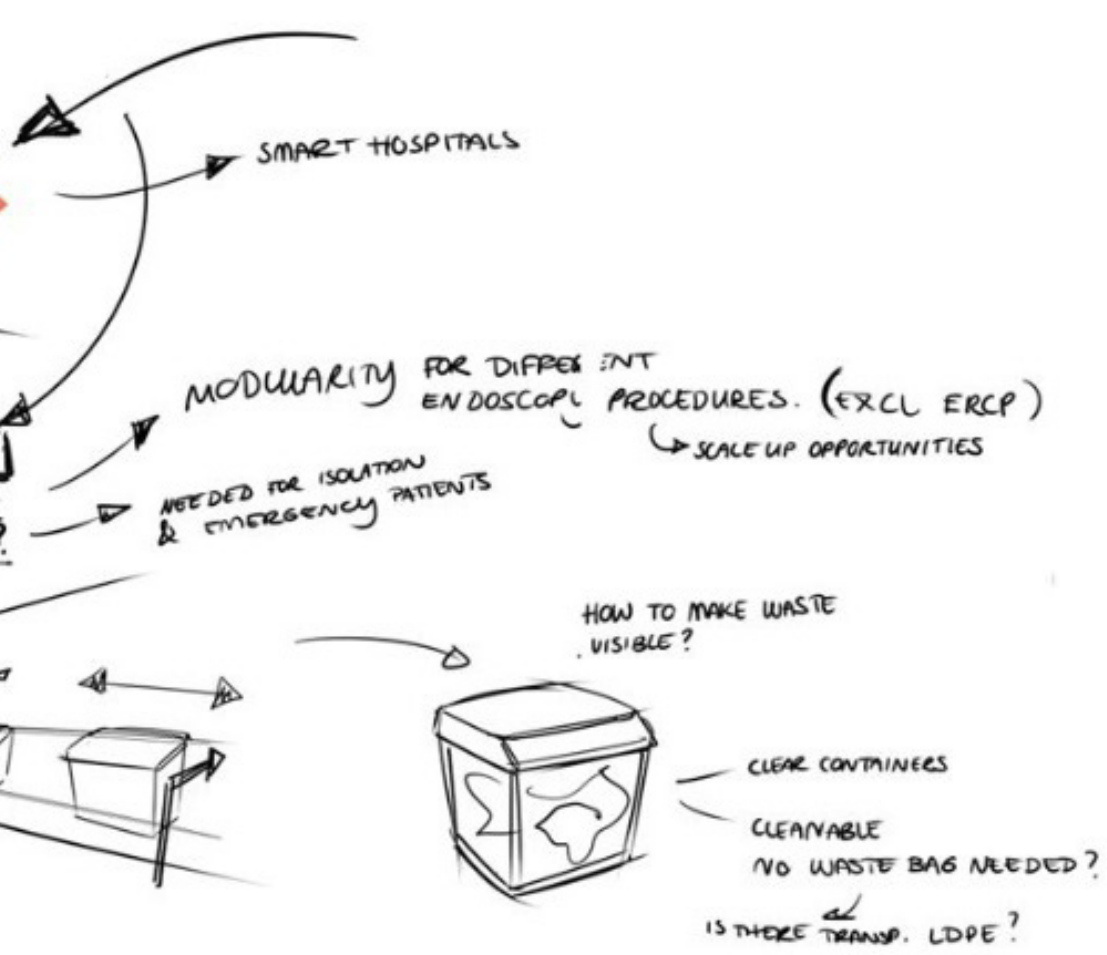
Oplossingsrichting

Optimaliseren van de route



Visual cues for the workflow should not interfere with the patient

The room should still look serene > visually appealing modular system



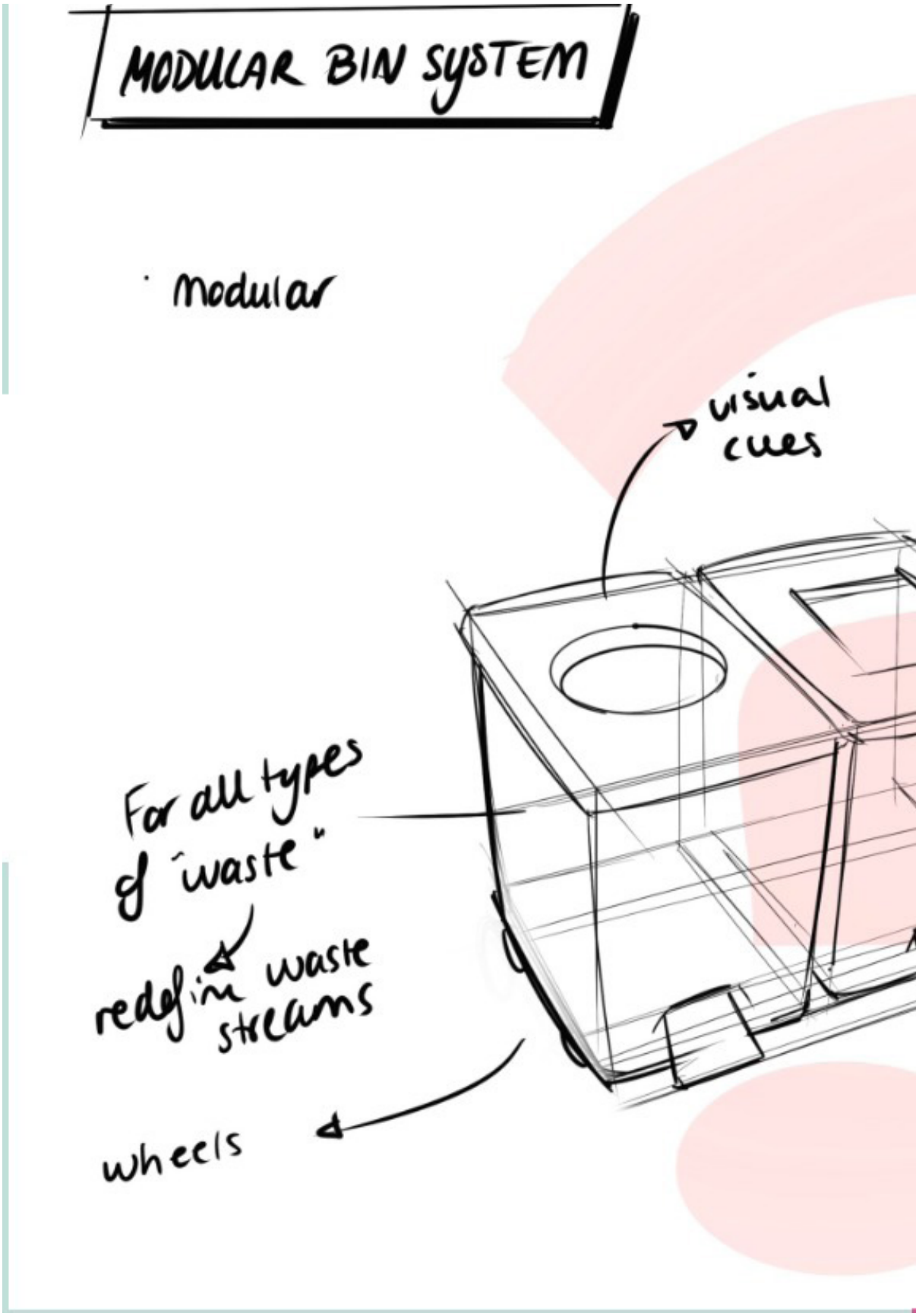
System should be modular

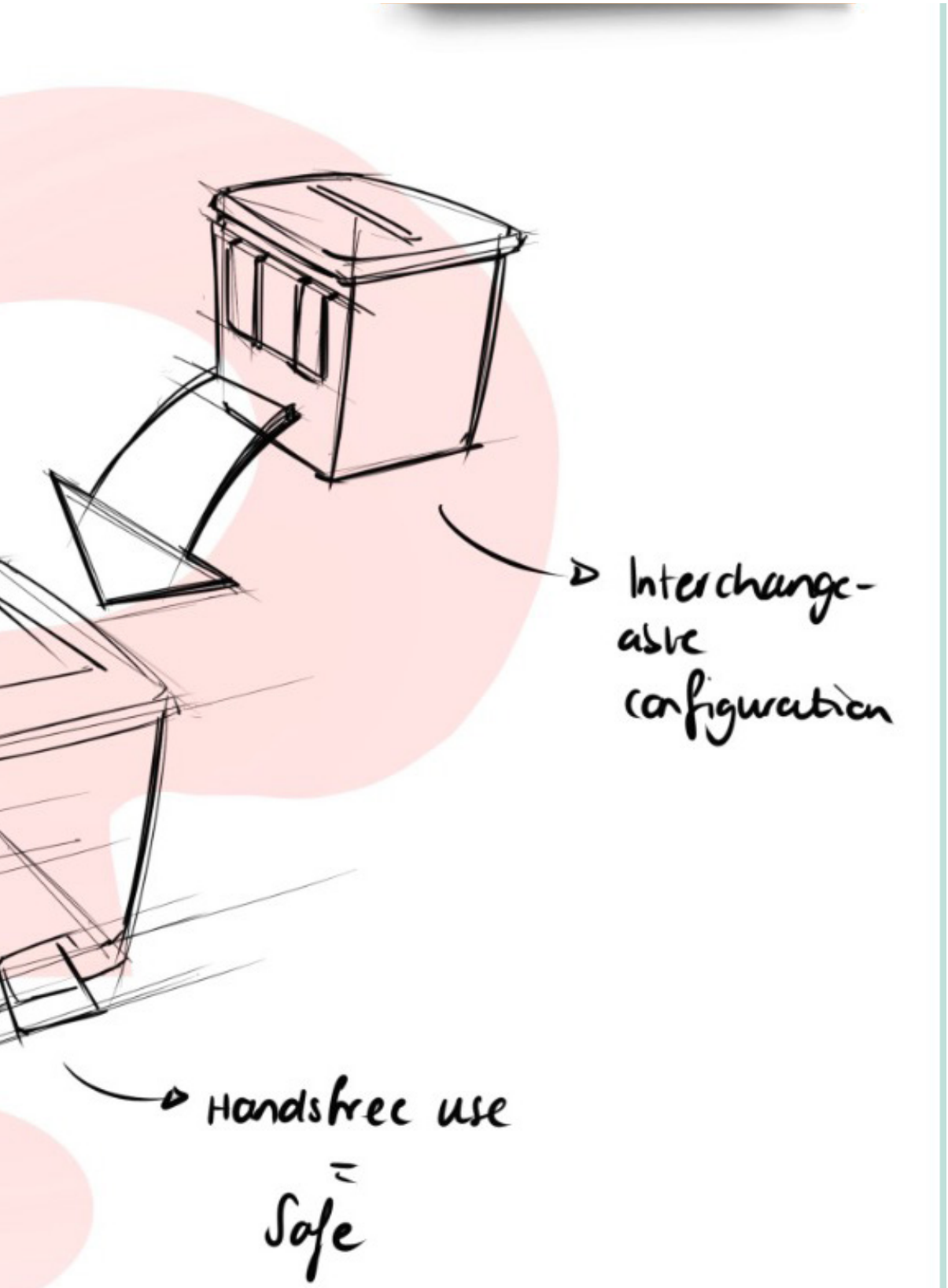
First focus is to try to gather all **non-infectuous plastics**

↓

Redefine the waste streams

CONCLUDING PRODUCT IDEA DIRECTION




Interchange-
able
configuration
Handsfree use
=
Safe

Appendix G

Creating new waste streams: Observation and visit with PreZero to operating theatre (OT) in EMC

This visit was enabled by the head of the Zero Waste from PreZero project in EMC.

The EMC has a standard separation protocol for all departments of EMC regarding hazardous and non-hazardous medical waste. While this is controlled by protocols and guidelines set by healthcare authorities, that does not imply that there is no room for direct implementation of new recyclable waste streams. In fact, other departments such as the OT and Sophia Children's Hospital have implemented an increased amount of waste segregation compared to other departments because they created their own departmental protocol together with PreZero. As mentioned before, these are initiatives taken by the department, like the sterile water bottle container in the endoscopy unit.

Operating Room as an example

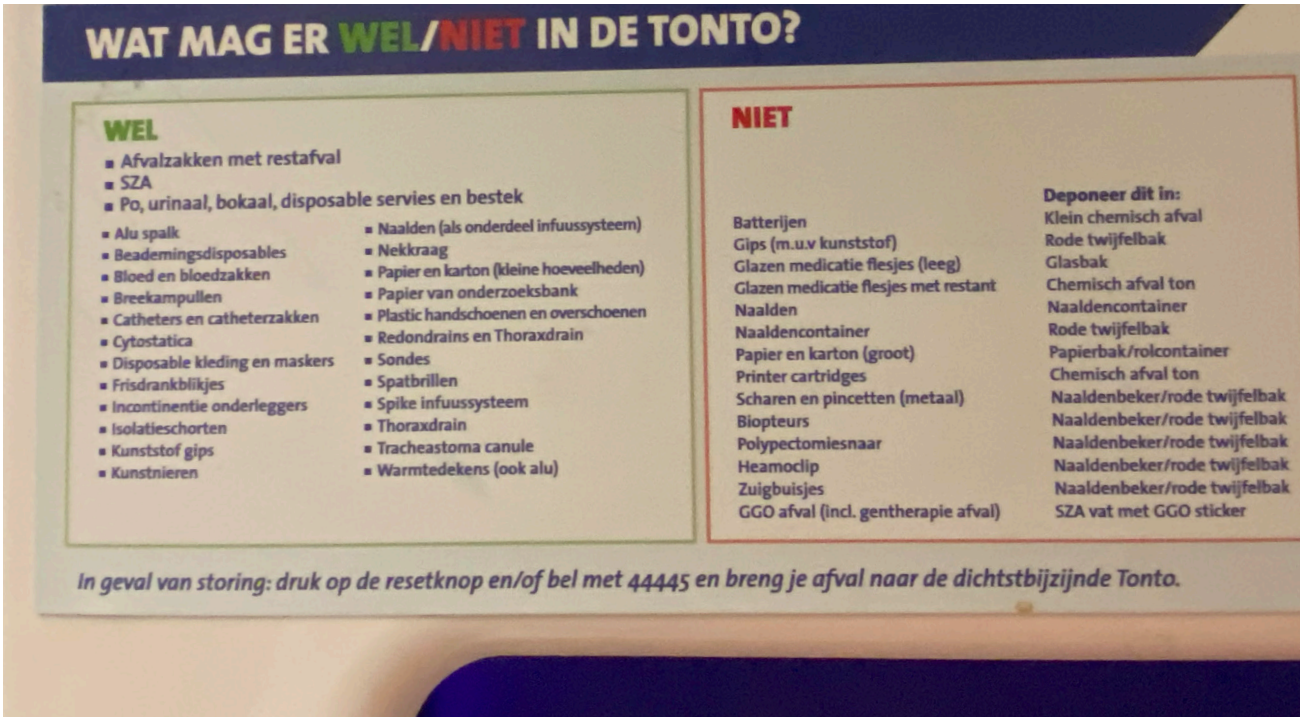
Head of Zero Waste management from PreZero showed the waste separation in the operating room (OR). The OR is a highly complex environment with the most strict sterility requirements of all hospital departments. In short, every product (packed or unpacked) brought into the OR is per definition infectious, leading to enormous amounts of unnecessary waste, which discarded as hazardous waste for high level incineration. Within its complexity, the EMC's OR has found an easy way to reduce their ratio of used/unused products as well as create new recyclable waste flows.
(Clean) Plastics can be disposed of together, since material recovery techniques can separate the types of plastic after it has been shredded. Plastic packaging materials such as PET, PE, HDPE and LDPE can be recycled.

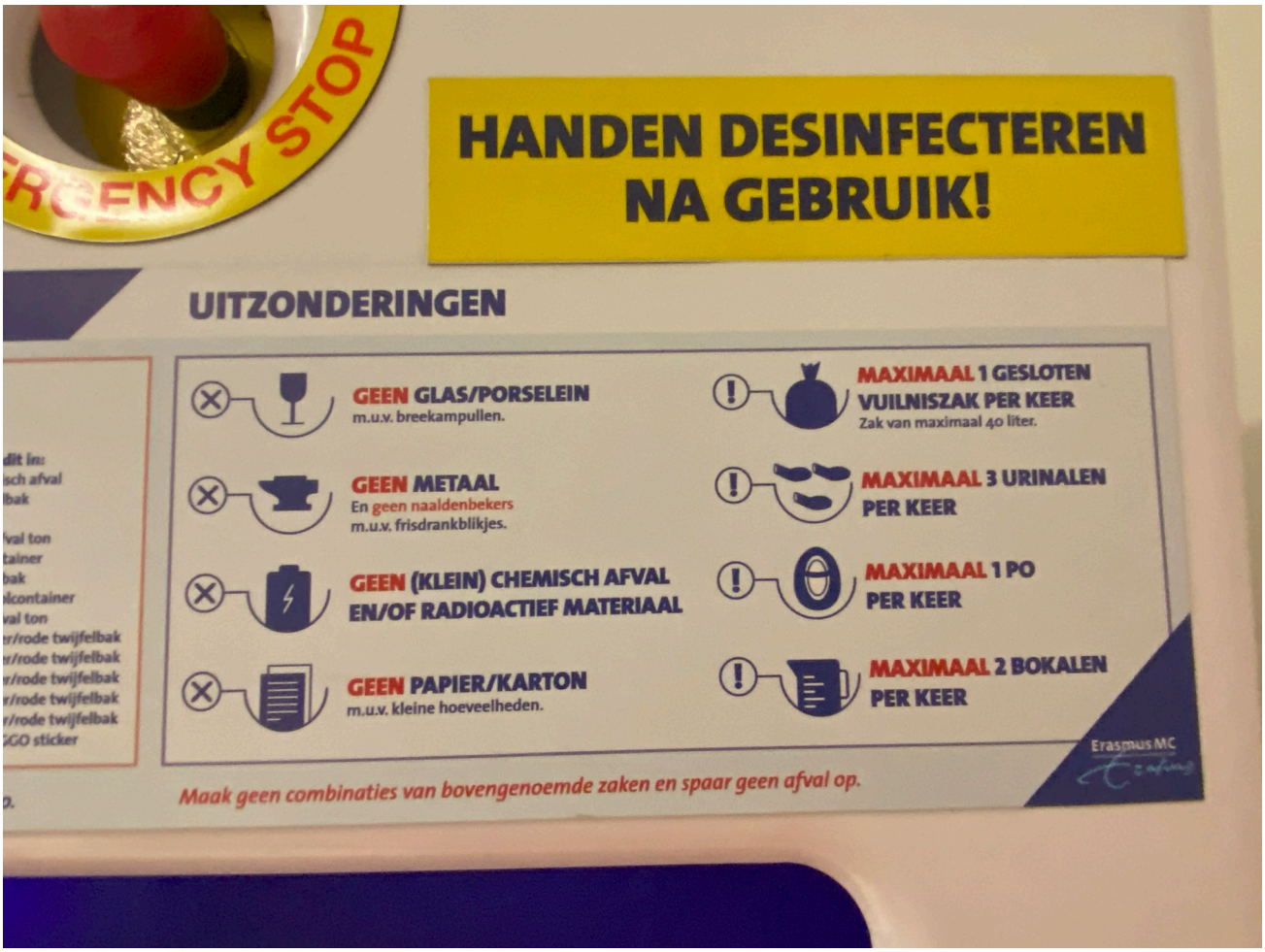
Sterile sheets from the SD are also currently gathered separately for recycling. These sheets have been sterilised and are therefore clean. Instead of discarding them inside the OT, they are discarded outside during the preparation phase.

Agreements with PreZero were made by the OT and discussed that clean plastics can be disposed together for recycling, since the mechanical process can separate the different types of plastics. Therefore the size of the plastic container in endoscopy unit should be enlarged.

Appendix H

TONTO instructions


WAT MAG ER WEL/NIET IN DE TONTO?
WEL
Afvalzakken met restafval
SZA
Po, urinaal, bokaal, disposable servies en bestek
Alu spalk
Beademingsdisposables
Bloed en bloedzakken
Breekampullen
Catheters en catheterzakken
Cytostatica
Disposable kleding en maskers
Frisdrankblikjes
Incontinentie onderleggers
Isolatieschorten
Kunststof gips
Kunstnieren
Naalden (als onderdeel infuussysteem)
Nekkraag
Papier en karton (kleine hoeveelheden)
Papier van onderzoeksbank
Plastic handschoenen en overschoenen
Redondrains en Thoraxdrain
Sondes
Spatbrillen
Spike infuussysteem
Thoraxdrain
Tracheastoma canule
Warmtedekens (ook alu)
NIET
Deponeer dit in:
Batterijen — Klein chemisch afval
Gips (m.u.v kunststof) — Rode twijfelbak
Glazen medicatie flesjes (leeg) — Glasbak
Glazen medicatie flesjes met restant — Chemisch afval ton
Naalden — Naaldencontainer
Naaldencontainer — Rode twijfelbak
Papier en karton (groot) — Papierbak/rolcontainer
Printer cartridges — Chemisch afval ton
Scharen en pincetten (metaal) — Naaldenbeker/rode twijfelbak
Biopteurs — Naaldenbeker/rode twijfelbak
Polypectomiesnaar — Naaldenbeker/rode twijfelbak
Heamoclip — Naaldenbeker/rode twijfelbak
Zuigbuisjes — Naaldenbeker/rode twijfelbak
GGO afval (incl. gentherapie afval) — SZA vat met GGO sticker
In geval van storing: druk op de resetknop en/of bel met 44445 en breng je afval naar de dichtstbijzijnde Tonto.


HANDEN DESINFECTEREN NA GEBRUIK!
UITZONDERINGEN
GEEN GLAS/PORSELEIN
m.u.v. breekampullen.
GEEN METAAL
En geen naaldenbekers
m.u.v. frisdrankblikjes.
GEEN (KLEIN) CHEMISCH AFVAL EN/OF RADIOACTIEF MATERIAAL
GEEN PAPIER/KARTON
m.u.v. kleine hoeveelheden.
MAXIMAAL 1 GESLOTEN VUILNISZAK PER KEER
Zak van maximaal 40 liter.
MAXIMAAL 3 URINALEN PER KEER
MAXIMAAL 1 PO PER KEER
MAXIMAAL 2 BOKALEN PER KEER
Maak geen combinaties van bovengenoemde zaken en spaar geen afval op.
Erasmus MC

Appendix I

CONTAINER


ARGE
OPENING
SMOOTH
CLEANABLE
SURFACE


BBER HOLDER
=
E GRIP ON