

# Applicability and Sustainability of Disinfection of Medical Consumables through UV-C Radiation

A case study at the intensive care unit of the Leiden University Medical  
Centre

by

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*Master Thesis Research Project*

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# 1. Abstract

Climate change and resource scarcity are putting increasing pressure on healthcare systems, making it essential to reduce the sector's environmental impact. In Dutch hospitals, particularly Intensive Care Units (ICUs), large volumes of unused but contaminated medical consumables are routinely disposed of as a precaution against the transmission of infections. This linear, single-use approach generates significant waste and emissions, challenging long-term sustainability goals. This thesis investigates whether ultraviolet germicidal irradiation (UVGI), specifically using UV-C radiation, can serve as a sustainable alternative to the disposal of unused medical consumables in the ICU of the Leiden University Medical Centre. The research assesses both the applicability and sustainability of UV-C disinfection. Applicability was evaluated through an inventory analysis of ICU bedside carts and a workflow analysis comparing current practices with the implementation of UV-C disinfection. The sustainability was assessed using a Life Cycle Assessment (LCA) to compare the environmental impacts between UV-C disinfection and disposal.

A bedside cart inventory contains medical consumables of which approximately 75% are considered manufacturer-proven or literature-supported suitable for UV-C disinfection with a value of €323. The operational disinfection costs are €23 per bedside cart. Assuming 30-50% inventory levels combined with the patient data of 2023 and 2024 (22 and 33 bedside carts), the total avoided costs are estimated to be between €680-2,000 and €1,670-3,650 respectively, including capital expenditure. The disinfection time of a bedside cart including preparatory steps is estimated to be 65 minutes but may be shortened by, for instance, colour-coding the bedside cart compartments. No previous LCA study on UV-C disinfection of medical consumables had been conducted. The results indicate that UV-C disinfection as an infection prevention method has fewer environmental impacts compared to disposal. Across all assessed impact categories, including climate change, water use, and material use, reductions of 46% to 50% were observed.

Integrating UVGI within hospital settings can reduce environmental burdens and support circularity in healthcare supply chains. UV-C disinfection of medical consumables is best suited for hospitals with large ICU departments, as smaller ICU departments may not generate enough contaminated medical consumables to justify the investments, making financial factors critical to its feasibility. This study contributes to ongoing efforts within the Dutch Green Deal for Sustainable Healthcare and provides actionable insights for hospitals, UV-C device manufacturers, medical consumable manufacturers, and policymakers seeking to improve environmental performance in clinical settings.

## 2. Introduction

Climate change has profound consequences for both health and the environment (Romanello et al., 2023). Moreover, additional pressure has been put on the healthcare system due to challenges such as resource scarcity, reduced supply security, and the COVID-19 pandemic (Mughal et al., 2021). Taking action to combat and prevent climate and environmental impact enhances public health and living conditions, both in the short and long term (Zijp et al., 2020). This highlights the need to address the environmental impact of the healthcare sector, which is both a contributor to and a potential catalyst for solutions to climate-related challenges.

Therefore, to reduce the impact of the healthcare sector and improve collaboration and knowledge sharing between care institutions, the first Dutch Green Deal for Sustainable Healthcare was drafted in 2015, followed by a second version in 2018 (Rijksoverheid, 2015, 2018). Currently, a third deal drafted in 2022 is active from 2023 to 2026 (Rijksoverheid, 2022). The third Green Deal for Sustainable Healthcare is divided into five different themes: health-promoting care environment, climate impact awareness, carbon-neutrality, circularity, and reduction of the environmental burden of pharmaceuticals.

The total waste produced by the Dutch healthcare sector is estimated to be 4,803 kton (Steenmeijer et al., 2022). Additionally, the healthcare sector in the Netherlands is responsible for 4% of the country's total waste and 13% of the country's resource use (Steenmeijer et al., 2022). With the size of the national climate footprint of the Dutch healthcare sector, it has the opportunity to play a pivotal role in achieving national climate goals (Rijksoverheid, 2024) and advancing circular economy objectives.

According to the protocols of the Intensive Care Unit (ICU) of the Leiden University Medical Centre (LUMC), complete or strict isolation is imposed when a patient carries a microorganism that can spread through air or (in)direct contact. Patients are transferred to isolation rooms with a pressure hierarchy and visible signalling. The isolation rooms have negative air pressure, which means that the air cannot flow from the isolation room to the hallway or other rooms. Inside the room, all supplies for nursing and physical examination of the patient are present. This includes a 24-hour supply of medical consumables stored in a bedside cart (LUMC, 2023). If more medical consumables are required, the bedside cart can be filled up again. Once the patient leaves the isolation room, all disposable medical consumables, such as syringes, monitor lines, and wound dressings, are disposed of.

The healthcare providers take adequate measures to avoid pathogen transmission by, for instance, practicing hand hygiene and wearing personal protective equipment such as facemasks or gloves. The patient only leaves the room when necessary and additional rules are imposed on visitors. When providing care to patients, it is not possible for healthcare providers to constantly disinfect their hands before grabbing something out of the bedside carts. Even though the medical consumables may be sterile, the packaging material could be contaminated. Therefore, the disposable medical consumables must currently be disposed of to avoid transmission.

Disposing of unused medical consumables is a form of infection prevention, but it produces a lot of waste. Infection prevention is a major challenge in emergency care, as acutely ill and injured patients receiving treatment can transmit infectious diseases to healthcare professionals or other patients and are also at risk of acquiring new infections (Liang et al., 2014). Other examples of infection prevention are hand hygiene, the use of personal protective equipment, and the sterilisation of medical equipment.

The disposal of medical consumables in hospitals has a large contribution to the waste footprint of the Dutch healthcare sector and must be reduced (Noort et al., 2024). ICU departments in particular contribute significantly to the environmental footprint of the healthcare sector (d'Aranda et al., 2025; Klasen et al., 2025). The majority of sustainability issues within hospitals originate from the linear design of their supply chains which heavily rely on the procurement and use of single-use disposable consumables (MacNeill et al., 2020). Such a throw-away system is not sustainable in the long run as it depletes finite resources and generates excessive waste and emissions (Chartier, 2014; Rizan et al., 2020).

An alternative infection prevention method would be disinfection of the medical consumables (Rutala et al., 2023). By doing so, an unused medical consumable may still be used to provide care to patients and is not required to be replaced by a new medical consumable. Therefore, the circularity of the healthcare sector would be increased. One such disinfection technique is ultraviolet germicidal irradiation (UVGI). UVGI uses ultraviolet C (UV-C) radiation to kill or inactivate microorganisms, thus, preventing the transmission of infectious diseases.

Within healthcare settings, UVGI has been shown to effectively disinfect handheld electronic devices (Cremers-Pijpers et al., 2021; Mathew et al., 2016), portable medical equipment (Reid et al., 2020), and filtering facepiece respirators (Hamzavi et al., 2020; Lindsley et al., 2015; O'Hearn et al., 2020; Romanello et al., 2023; H. Yang et al., 2020). During the COVID-19 pandemic, the LUMC decided to temporarily use UVGI to disinfect face masks as a result of scarcity. This experience raised the question of whether UVGI could also be applied to disinfect medical consumables.

The aim of this thesis is to investigate the applicability and sustainability of UV-C radiation for the disinfection of unused medical consumables. The research is conducted specifically for the ICU of the LUMC. The research focusses on using UV-C radiation to disinfect the medical consumables as opposed to disposal. Therefore, it tries to improve circularity and lower the footprint of the Dutch healthcare sector.

This thesis report starts with the introduction of the research questions and objectives followed by a literature review on UVGI within hospital settings and the investigated UV-C device. Hereafter, the thesis is separated into two chapters: applicability and sustainability. These chapters have their own methods, results, and discussion sections. Finally, the thesis ends with a general conclusion with recommendations based on the findings from both chapters.

The applicability chapter of this research focuses on the suitability of medical consumables to UV-C exposure and the integration of UV-C disinfection in the ICU. To understand which medical consumables and packaging are suitable for disinfection, an inventory analysis of the ICU bedside carts was conducted and combined with previous studies from the manufacturer of the UV-C device and existing literature. The integration of UV-C disinfection was further explored through a workflow analysis to map the current workflow and identify pain points. A comparison was made between the time and cost requirements of disposal and disinfection of the medical consumables.

To assess the sustainability of UV-C radiation for disinfection purposes, a Life Cycle Assessment (LCA) was performed. LCA, a core method in Industrial Ecology, is a well-established method used to evaluate and compare potential environmental impacts and identify hotspots throughout the life cycle of products, technologies, and systems (Guinée et al., 2011). No previous LCA studies on UVGI of medical consumables were identified in the literature. LCA is a suitable

method to compare the potential environmental impacts of disposal and UVGI of unused medical consumables.

## 3. Research questions & objectives

### 3.1. Research objective

The research objective was to explore and investigate the applicability and sustainability of using UV-C radiation for the disinfection of medical consumables. The research aimed to inform Dutch hospitals about the possible implementation of UVGI. While the conducted study focussed on the ICU of the LUMC, the findings were also considered for broader relevance to other Dutch hospitals and the healthcare sector as a whole. This approach allowed for an assessment of UVGI supporting an informed decision on whether further research and potential implementation in Dutch hospitals would be justified. These insights might contribute to the development of sustainability guidelines in Dutch hospitals.

The research also aimed to inform manufacturers of medical consumables and UV-C devices. For manufacturers of medical consumables, a recommendation was made regarding the suitability of different materials and how materials sourcing and product design might influence the suitability. For manufacturers of UV-C devices, the potential of disinfection of (unused) medical consumables was assessed as an additional application of the device.

### 3.2. Main research question and sub-research questions

This study investigated the following main research question:

*What are the applicability and sustainability of UVGI as a disinfection method for unused medical consumables at the ICU of the LUMC?*

This main research question can be broken down into the following sub-research questions with (1) & (2) focussing on the applicability and (3) on the sustainability aspects of this study:

1. Which medical consumables (packaging) are suitable for UVGI?
2. How should UVGI be potentially implemented at the ICU of the LUMC?
3. What are the potential environmental impacts of disposal and UVGI of unused medical consumables at the ICU of the LUMC?

## 4. Literature review

UV-C light or radiation typically has a wavelength ranging between 200 and 280 nm and possesses strong disinfecting properties (Yin et al., 2013). UV-C radiation from the sun does not reach the surface of the earth because it is blocked and absorbed by the atmospheric ozone layer. UV-C radiation can be generated from artificial sources such as low-pressure mercury lamps and pulsed xenon lamps. At particular wavelengths such as 254 nm, UV-C radiation is strongly and mainly absorbed by the nucleic acids of microbial cells and is able to destroy the molecular bonds. This results in the formation of pyrimidine dimers leading to the deformation of DNA or RNA molecules which causes cell death in a variety of microorganisms (Cutler & Zimmerman, 2011).

UVGI is a disinfection technique using UV-C radiation to kill or inactivate microorganisms. UVGI technologies have been utilised for decades and can be used to disinfect air, water, and surfaces (Reed, 2010). It is commonly chosen as a disinfection method because of its high efficiency and relatively low costs (Reed, 2010). The COVID-19 pandemic has revived interest in UVGI technologies (Bergman, 2021). Since 2010, the clinical use of UVGI technologies has been growing steadily with a steep increase since the start of the pandemic (Scott et al., 2022). The effectiveness of inactivation achieved by UV-C radiation is influenced by various factors, including wavelength, dose, relative humidity, and temperature. The wavelengths emitted are determined by the light source, with each type of light source possessing unique properties and a specific spectral range (Demeersseman et al., 2023).

### 4.1. Use of UVGI and previous studies

Microbial contamination is a key factor in healthcare-associated infections. Healthcare-associated infections caused by multidrug-resistant pathogens are strongly linked to higher mortality and morbidity rates, as well as substantial increases in healthcare costs (Magill et al., 2014). UV-C disinfection has been used as a complementary method alongside standard cleaning protocols, such as manual cleaning, chemical disinfection by hydrogen peroxide, or neutralising detergent, to eliminate microbial contamination from the environment (Hosein et al., 2016; Liscynsky et al., 2017).

UVGI is most commonly applied in individual rooms after patient discharge and in operating rooms, serving as a supplementary part of routine disinfection protocols (Scott et al., 2022). Around 60% of all UVGI air disinfection systems are installed in healthcare facilities (Memarzadeh et al., 2010) with 41% being in hospitals and 19% in clinics (Kowalski & Bahnfleth, 2000).

Several studies have demonstrated the benefits of using UVGI as an additional disinfection procedure. These studies investigated rooms previously admitted by patients who were infected with gram-positive high-concern microorganisms, methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant *enterococci*, multidrug-resistant *Acinetobacter baumannii*, and multidrug-resistant *Acinetobacter*. Following the standard cleaning protocol, the microorganisms were still detectable in approximately 11-63% of the surface areas. By using UVGI as an additional disinfection procedure, the presence of gram-positive bacteria was reduced to 0-10% (Casini et al., 2019; Hosein et al., 2016; Liscynsky et al., 2017; Nerandzic et al., 2010; Wong et al., 2016). When UVGI was used as the sole disinfection method, it efficiently reduced gram-positive bacteria from surface areas around 90-100% of the time (Mahida et al., 2013; Rutala et al., 2010;

J.-H. Yang et al., 2019). However, no widely accepted criteria for the level of pathogen reduction by UV-C devices exist, as it is unknown to what extent pathogens need to be reduced to prevent transmission (Boyce & Donskey, 2019).

Various studies have been conducted on the disinfection of handheld electronic devices in healthcare settings (Cremers-Pijpers et al., 2021; Mathew et al., 2016). Handheld electronic devices are a potential source of infection with up to 96% of healthcare workers not routinely cleaning and disinfecting them and pathogenic microorganisms being found on 9-27% of these devices (Brady et al., 2009; Huffman et al., 2020; Khan et al., 2015). Cremers-Pijpers et al. (2021) measured the effect of bacterial contamination of these devices by counting colony-forming units (CFU) on RODAC (Replicate Organism Detection And Counting) plates. The overall mean CFU reduction was 97.9% with 87% of the measurements having a complete CFU reduction.

Additionally, UVGI has been investigated for portable medical equipment (Reid et al., 2020) and filtering facepiece respirators (Hamzavi et al., 2020; Lindsley et al., 2015; O’Hearn et al., 2020; H. Yang et al., 2020). However, no studies have been conducted on UV-C disinfection of (packed) medical consumables. Examples of these medical consumables are syringes, tubes, and swabs.

## 4.2. UV-C device

The UV Smart D25<sup>+</sup> (UV Smart Company, Delft, The Netherlands) was investigated for this research since the LUMC currently owns the device. The D25<sup>+</sup> is a mobile UV-C device designed for disinfection of invasive and non-invasive medical devices in healthcare settings (UV Smart, 2023). The D25<sup>+</sup> is capable of disinfecting multiple medical devices simultaneously given that they are not shadowed or covered during the disinfection process. The chamber dimensions of the D25<sup>+</sup> are 420(w)x265(d)x160(h)mm, and the maximum sizes of medical devices to be placed inside the chamber are 380x225x150 mm. The D25<sup>+</sup> gives an average UV radiation of 1718 J/m<sup>2</sup> during the complete disinfection cycle of 25 seconds with a wavelength of 253.7 nm (UV Smart, 2020). Spare parts are available for 7 years after the delivery of a D25<sup>+</sup> device (UV Smart, 2024).

The D25<sup>+</sup> allows for a microorganism count reduction of at least log-4 (99.99%) on non-porous outer surfaces of (non-)invasive medical devices without working channels or other (medical) equipment (UV Smart, 2023). The most commonly used alternative for disinfection of non-invasive medical devices is through the use of chemical disinfectants and antiseptic wipes. The state-of-the-art methodology for disinfection testing refers to the EN 14885:2022 or the previous EN 14855:2018. Therefore, these standards were used for the clinical evaluation of the D25<sup>+</sup>. The performance of the D25<sup>+</sup> has been clinically evaluated by independent research institutes and accredited medical microbiological laboratories (Eurofins, 2022; Streeklaboratorium voor de Volksgezondheid Kennemerland, 2019). As a result of the laboratory tests, the following microbial reductions were determined and claimed by UV Smart (*Table 4.1*). The investigated microorganisms include the most clinically relevant microorganisms.

**Table 4.1:** Claimed performance of microbial reductions of the D25<sup>+</sup> based on EN 14885:2018 for comparison to state of the art disinfection methods (UV Smart, 2021).

| Claim                             | Microorganism to be tested                | Sort and type                              | Log reduction |
|-----------------------------------|---|--|---------------|
| Bactericidal                      | <i>Staphylococcus aureus</i>              | Gram-positive bacteria, vegetative         | ≥ 6.0         |
|                                   | <i>Pseudomonas aeruginosa</i>             | Gram-positive bacteria, vegetative         | ≥ 6.0         |
|                                   | <i>Enterococcus hirae</i>                 | Gram-positive bacteria                     | ≥ 6.0         |
|                                   | <i>Escherichia coli</i>                   | Gram-negative bacteria, Enterobacteriaceae | ≥ 7.0         |
| Sporicidal                        | <i>Bacillus cereus</i>                    | Gram-positive bacteria, endospore          | ≥ 6.0         |
| Fungicidal                        | <i>Aspergillus brasiliensis</i>           | Fungus, spore                              | ≥ 6.0         |
| Yeasticidal                       | <i>Candida auris</i>                      | Fungus, yeast                              | ≥ 7.0         |
| Fungicidal & Yeasticidal          | <i>Candida albicans</i>                   | Fungus, vegetative yeast,                  | ≥ 7.0         |
| Mycobactericidal                  | <i>Mycobacterium avium</i>                | Gram-positive mycobacteria, vegetative     | ≥ 7.0         |
| Mycobactericidal & Tuberculocidal | <i>Mycobacterium terrae</i>               | Gram-positive mycobacteria, vegetative     | ≥ 7.0         |
| Viricidal                         | Adenovirus type 5, strain Adenoid 75      | Adenoviridae                               | ≥ 4.0         |
|                                   | Bovine coronavirus type 1                 | Coronaviridae                              | ≥ 4.0         |
|                                   | Poliovirus type 1; LSc-2ab (picornavirus) | Enterovirus                                | ≥ 4,0         |
|                                   | Murine norovirus, strain s99 Berlin       | Caliciviridae                              | ≥ 4,0         |
|                                   | Polyomavirus SV40, strain 777             | Incertae sedis                             | ≥ 4,0         |

Moreover, the D25<sup>+</sup> has been tested in hospital environments to demonstrate the effectiveness of UV-C radiation in disinfecting the outer surfaces of channel-less invasive medical devices in the intended environment. At the University Hospital of Giessen and Marburg, the D25<sup>+</sup> seemed to be an effective device for reprocessing rigid otorhinolaryngological (ORL) endoscopes, thus, it might be suitable for the usage in clinical practice on-site (UV Smart, 2023). At the Radboud University Medical Centre Nijmegen, the D25<sup>+</sup> was concluded to be effective for the disinfection of non-critical handheld electronic devices in clinical healthcare (Cremers-Pijpers et al., 2021).

All in all, the results from the laboratory and hospital tests confirm that D25<sup>+</sup> effectively disinfects the outer surfaces of non-invasive medical devices, meeting the requirements of EN 14885:2018, and aligning with existing literature (UV Smart, 2023). The D25<sup>+</sup> holds the CE marking handed out by the European Union and is commercially available on the market.

The intended use of the D25<sup>+</sup> currently only mentions medical devices but not medical consumables. However, recent and ongoing studies suggest that the D25<sup>+</sup> is also suitable for medical consumables. As of November 2024, the design of a new Dutch standard NEN 8281:2024 exists, describing the disinfection of non-critical and semi-critical medical consumables with non-porous surfaces. The new standard is not finished yet. However, the NEN 8281:2024 refers to a previous guideline (R2540:2023) to which the D25<sup>+</sup> corresponds. Therefore, it is assumed that the D25<sup>+</sup> falls under the NEN 8281:2024 norm once it is finished.

When switching the use of the D25<sup>+</sup> from disinfecting medical devices to medical consumables, a few aspects change. The main difference is the material composition with medical consumables commonly consisting of both non-porous (e.g. plastic) and porous (e.g. paper) materials. The microbial efficacy of the D25<sup>+</sup> in disinfecting medical consumables and the effect on the mechanical properties of packaging materials are important to consider.

The UV-C radiation of the D25<sup>+</sup> is 6872  $\mu\text{W}/\text{cm}^2$  and the disinfection chamber has an area of 855  $\text{cm}^2$ . Therefore, the D25<sup>+</sup> has a total UV-C radiation of 5.88 W. Boronat et al. (2024) observed no degradation of polypropylene healthcare items after 1 hour of UV-C radiation of 6 W. Jiménez-Reyes et al. (2020) studied the effect of UV-C radiation on kraft, filter, bond, rice, and amate paper. They found that neither the structure of the fibres, pH, nor elemental chemical composition was affected by the exposure of the studied papers to up to 9 W of UV-C radiation. Since the UV-C radiation of the D25<sup>+</sup> is lower than that of these studies, it is expected that these findings are applicable meaning that the paper and plastic packaging do not degrade as a result of UV-C exposure by the D25<sup>+</sup>.

Exposure to UV-C radiation does not change the structure or functionality of materials but only their appearance with polymers turning yellow and fabrics losing colour intensity (Mitxelena-Iribarren et al., 2022). The medical consumables inside the packaging remain functionally unaffected. Currently, the D25<sup>+</sup> is compatible with the disinfection of the following surface materials (Table 4.2). This list only consists of non-porous surface materials.

**Table 4.2:** The D25<sup>+</sup> material compatibility list (UV Smart, 2025).

| Material Group        | Surface Material                      | Found in  |
|-----------------------|---------------------------------------|---|
| <i>Thermoplastics</i> | Acrylonitrile butadiene styrene (ABS) | Thermometers, surveillance monitoring equipment, communication systems.   |
|                       | Polybutylene terephthalate (PBT)      | Diagnostic devices, light-weight surgical tool components.  |
|                       | Polycarbonate (PC)                    | Infusion pumps, blood pressure monitors, wireless ultrasound transducers.                                       |
|                       | Polymethylpentene (PMP)               | Diagnostic test equipment, sterilisable containers, wireless ultrasound transducers, diagnostic test equipment. |
|                       | Polyolefins                           | Labware (e.g., pipette tips, petri dishes), reflex hammers, diagnostic equipment housing.                       |
|                       | Polyphenylsulfone (PPSU)              | Reusable medical devices, orthopaedic surgical instruments, endoscopic equipment parts.                         |
|                       | Polypropylene (PP)                    | Enteral feeding pumps, blood pressure cuffs, infusion pump components.  |
|                       | Polysulfone (PSU)                     | Diagnostic equipment, surgical handles.   |
|                       | Polyurethane (PU)                     | Wireless ultrasound transducer coating, seals for medical devices.  |
|                       | Polyvinyl chloride (PVC)              | IV bags, oxygen masks, blood storage bags.  |

|                   |   |   |
|-------------------|---|---|
| <i>Elastomers</i> | Latex                                       | Reflex hammer tips, stethoscope ear tips.   |
|                   | RTV (Room Temperature Vulcanizing Silicone) | Seals and gaskets in medical devices, surface of cushioning components in respiratory masks.    |
|                   | Silicone Rubber                             | Seals in infusion pumps, stethoscope tubing, wireless ultrasound transducers.                   |
|                   | Thermoplastic Elastomer (TPE)               | Blood pressure cuffs, cushioning in respiratory masks.  |
| <i>Metals</i>     | Aluminium                                   | Stethoscopes, surgical trays, monitors, communication systems, wireless ultrasound transducers. |
|                   | Aluminium Silicate                          | Instrument trays  |
|                   | Brass                                       | Scalpels, scissors, reflex hammers, communication device components.                            |
|                   | Stainless Steel                             | Forceps, rigid ENT scopes, reflex hammers, infusion pumps.                                      |
| <i>Glass</i>      | Quartz Glass                                | Lenses.   |
|                   | Optical Glass                               | Lenses in ENT scopes, diagnostic devices.   |

At the University Medical Centre Groningen, studies have been performed to evaluate the microbial efficacy of the D25<sup>+</sup> and its potential implementation at the ICU for disinfecting medical consumables. Lokate & Brühwasser (2019) found that the D25<sup>+</sup> was effective in killing microorganisms settled on phones, plastic, paper, metal, glass, velcro, artificial leather, and agar, but not on textile and wood. Visser-Hoekstra (2021) concluded that the disinfection of unused and unopened medical packaging is a safe alternative to the disposal of medical packaging. After 20 disinfection cycles, no microscopic changes were observed, paper discoloured irreversibly yellow, and the adhesive edge strength appeared to be increased.

At the TU Delft, the mechanical properties of medical packaging materials were studied after extensive UV-C exposure and continuous disinfection cycles (Verhaar et al., 2023). The study assessed adhesive edge strength and permeability in plastic-plastic, plastic-paper, and paper-paper packaging. Plastic-plastic packaging showed no change in adhesive strength after 100 cycles, while plastic-paper and paper-paper combinations showed increased strength after 25 and 3 cycles, respectively. No significant changes in paper permeability were observed after 50 and 100 cycles. Despite the stable permeability of the paper packaging, subtle material degradation or polar group formation may have occurred. The study did not investigate potential damage to the medical consumables inside the packaging. Additionally, the effects of UV-C exposure on various glue types used across different packaging were not explored, potentially affecting adhesive integrity over time. The permeability of plastic packaging was also not measured, as the applied methodology failed to produce significant results.

All in all, the previous studies and laboratory tests showed promising results for the disinfection of medical consumables with the D25<sup>+</sup>. Packaging materials of the medical consumables are mainly plastic and paper. Plastic packaging is made out of commodity plastics such as polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), or polystyrene (PS) (Joseph et al.,

2021). These plastics are widely used in packaging due to their strength, lightweight nature, clarity, gas barrier properties, and shatter resistance (Amobonye et al., 2023; Gahleitner & Paulik, 2017; McKeen, 2012; Ronca, 2017). These types of plastic fall under the plastics mentioned in the compatibility statement and are suitable for disinfection with the D25<sup>+</sup> (*Table 4.2*). The paper used is of medical grade to maintain sterile storage of the contained medical consumable but does not fall within the material compatibility of the D25<sup>+</sup>. However, the aforementioned studies indicate that this medical-grade paper is suitable for disinfection with UV-C radiation but the appearance is affected meaning that careful practices are required.

# Part I - Applicability

The first part of this thesis will consider the applicability of UV-C disinfection of medical consumables at the ICU of the LUMC. It focuses on the suitability of the medical consumables and their packaging material to UV-C exposure. It also focuses on the implementation of UV-C disinfection in the ICU department and the costs related to it.

## 5. Methods

To achieve the goals of the applicability section of this thesis, two methods have been used: inventory analysis and workflow analysis.

### 5.1. Inventory analysis

The inventory analysis aimed to determine which medical consumables are suitable for disinfection with the D25+. To select these medical consumables, it is essential to understand what kind of medical consumables are stored in the bedside carts. The bedside carts in the ICU consist of a cabinet and several drawers with different compartments. The inventory of the bedside carts is standardised meaning that medical consumables are consistently stored in the same compartment and quantity.

By consulting the ICU, data regarding the medical consumables, quantity, and purchasing costs were obtained (*Figure 5.1 & Appendix I*). Patient data covering the number of patients admitted to isolation rooms in 2023 and 2024 was also obtained. Additional data was collected by inspecting the medical consumables stored in the bedside carts and pantries of the ICU. For each medical consumable, the manufacturer, reference number, and packaging materials (front & back) were collected.

For medical consumables to be considered suitable for UV-C disinfection with the D25+, three criteria were set up. The medical consumables had to be sterile storage, size compatible, and material compatible. Sterile stored means that a medical consumable is stored under sterile conditions with the packaging hermetically sealing the contents. Size compatibility indicates that the medical consumable fits in the disinfection chamber of the D25+ without being folded or shaded. Material compatibility is based on the compatibility statement of the D25+ (*Table 4.2*) and previous studies (Lokate & Brühwasser, 2019; Verhaar et al., 2023; Visser-Hoekstra, 2021). Medical consumables were deemed 'manufacturer-proven suitable' if the packaging materials were mentioned in the compatibility statement by the manufacturer. Medical consumables were deemed 'literature-supported suitable' if the packaging materials were reported by literature to be suitable for UVGI. All other medical consumables were considered unsuitable for UVGI with the D25+.





## 5.2. Workflow analysis

A workflow is a sequence of physical and mental tasks performed by various people within and between work environments. A workflow analysis is a process of examining and evaluating a workflow within an organisation to identify inefficiencies, bottlenecks, redundancies, or areas for improvement. It involves breaking down a workflow into its individual steps, analysing how tasks are completed, and looking for ways to optimise the process to improve efficiency, productivity, and overall performance (Ozkaynak et al., 2022). The aim was to investigate possible ways to implement UVGI in the ICU department.

A small-scale workflow analysis was conducted and the following steps were performed:

- (1) Mapping of the current workflow
- (2) Identification of pain points
- (3) Proposal of improvements

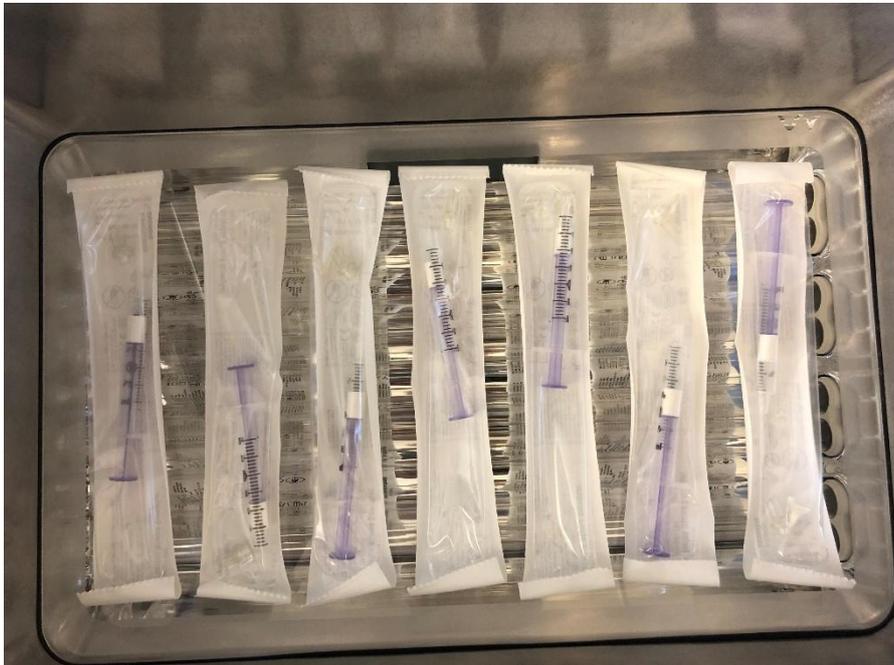
Since this study aims to investigate the applicability of UV-C disinfection of medical consumables and the D25<sup>+</sup> is not yet in use, a potential workflow was designed for step (1). This proposed workflow is a combination of the existing ICU protocol and procedures outlined in the user manual of the D25<sup>+</sup>.

In order to map the designed workflow disinfection of medical consumables, the different steps were documented and timed. To determine the consequences for the healthcare professionals, it is important to have an estimation of the amount of time it takes to disinfect the inventory of a bedside cart including preparatory and additional tasks. The disinfection itself can be divided into three steps; loading, disinfection, and unloading. Loading refers to transferring the medical consumables from the bedside cart to the disinfection chamber of the D25<sup>+</sup>. Disinfection refers to running a 25-second disinfection cycle of the D25<sup>+</sup>. Unloading refers to transferring the disinfected medical consumables to a clean bedside cart.

These steps have been simulated and timed for all suitable medical consumables of a fully stocked bedside cart with the following set-up (*Figures 5.2 & 5.3*). A full bedside cart was placed next to the D25<sup>+</sup>. A bedside cart consists of a cabinet and six drawers. For the simulation of the workflow, medical consumables were taken from the cabinets and drawers. The cabinets and drawers contain various compartments in which the medical consumables are stored. The medical consumables were taken from their compartments and placed in the disinfection chamber. Only medical consumables found in the same drawer or cabinet were disinfected simultaneously. For each disinfection cycle, the disinfection chamber was fully filled. Afterwards, the medical consumables were transferred back from the disinfection chamber of the D25<sup>+</sup> into the bedside cart. All medical consumables have a fixed quantity and designated location within the bedside carts of the ICU. The disinfection of the bedside carts itself was not included since it is current practice at the ICU and will remain so regardless of the UVGI implementation.



**Figure 5.2:** The set-up of the workflow analysis with the D25+ (left) and fully stocked bedside cart (right) in an ICU room. This set-up was used to estimate the disinfection time of the medical consumables.



**Figure 5.3:** Example of medical consumables (blood gas syringes) placed in the disinfection chamber of the D25+.

## 6. Results

### 6.1. Inventory analysis

According to the consultation from the ICU, in 2023, 18 patients required complete isolation, occupying 14 single rooms and 4 double rooms. This led to the disposal of medical consumables from at least 22 bedside carts. In 2024, 22 patients required complete isolation, occupying 11 single rooms and 11 double rooms, leading to the disposal of medical consumables in 33 bedside carts. The actual number may even be higher since patients in complete isolation may be transferred to new isolation rooms during their stay. Moreover, the reported patient data only covers patients in complete isolation whereas the contents of a bedside cart may also be disposed of due to other reasons.

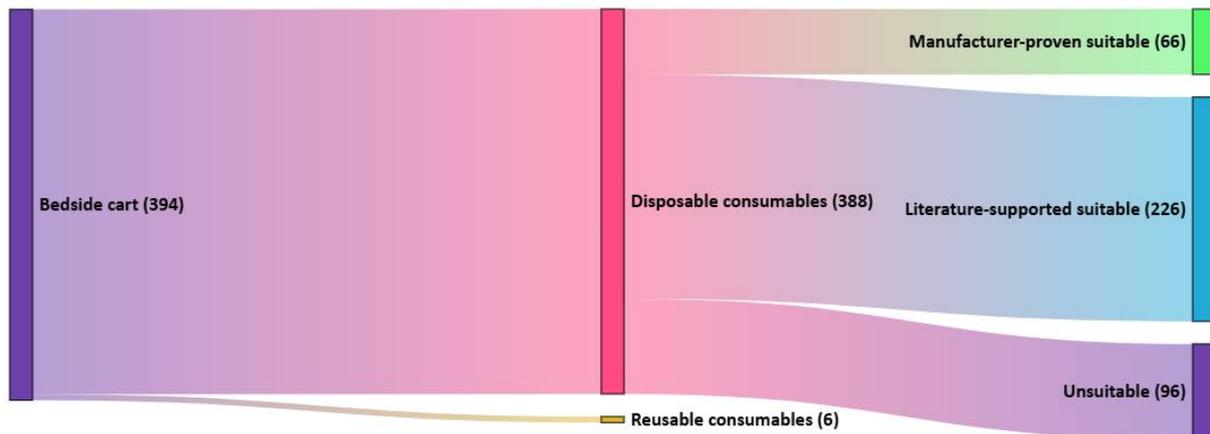
The full inventory of a bedside cart contains 109 kinds of medical consumables with a combined total of 394 medical consumables. All unused and packaged medical consumables except the scissors and artery clamps are disposed of once a patient leaves the isolation room. The scissors and artery clamps are disinfected elsewhere in the hospital and reused. The total price of disposable medical consumables in a full bedside cart is €476.88.

The inventory of the bedside carts has been fully documented (*Appendix I*). The documentation covers prices, quantities, manufacturers, reference numbers, and packaging materials. All medical consumables fit inside the disinfection chamber of the D25<sup>+</sup>. A qualitative estimation was also made to determine the maximum number of medical consumables that can be disinfected at once. To do so, each type of medical consumable was placed in different orientations inside the disinfection chamber to assess how many could be disinfected simultaneously.

The packaging material of the medical consumables is an important criterion to determine the suitability for UVGI. Based on the material compatibility statement of the D25<sup>+</sup>, plastic packaging is suitable (*Table 4.2*). Additionally, paper and velcro packaging are presumed suitable for UVGI based on previous studies but not claimed by the manufacturer (Jiménez-Reyes et al., 2020; Lokate & Brühwasser, 2019; Visser-Hoekstra, 2021).

The majority of the packaged medical consumables are sterile stored. If the packaging material is suitable for UVGI and the disposable medical consumable is unused and unopened, it may be disinfected with the D25<sup>+</sup>. In some cases, the medical consumables are not sterile stored or packaged meaning that not only the packaging material but also the medical consumable itself may be contaminated. Examples are fixation bandages, roller bandages, pH indicator strips, wooden tongue depressors, and cotton tips. The fixation and roller bandages are stored inside paper boxes that are unsuitable for disinfection with the D25<sup>+</sup> since the boxes are not hermetically closed. Therefore, the interior of the box may be contaminated but unreachable by the UV-C radiation. Alternatively, these bandages are stored in the bedside cart without their packaging. The textile of these bandages is ineffective for UVGI so these bandages are unsuitable for disinfection with the D25<sup>+</sup>. Wooden tongue depressors, pH indicator strips, and cotton tips are stored in plastic containers or zip-lock bags. Healthcare providers may open these containers or zip-lock bags during the provision of care which means that the medical consumables may be contaminated. UVGI of these containers and zip-lock bags is unsuitable and direct disinfection of these medical consumables is inconvenient.

A list was made of medical consumables suitable for disinfection with the D25<sup>+</sup> (Table 6.1) based on the following three criteria: sterile storage, size compatibility, and material compatibility. All medical consumables shown fit in the disinfection chamber and are sterile stored. Suitable medical consumables were either considered manufacturer-proven or literature-supported. All suitable medical consumables of a full bedside cart have a combined price of €322.76. For a full bedside cart inventory, 66 medical consumables are manufacturer-proven suitable and 226 medical consumables are literature-supported suitable (Figure 6.1).



**Figure 6.1:** Sankey diagram of a full bedside cart at the ICU of the LUMC.

**Table 6.1:** List of suitable medical consumables for disinfection with the D25<sup>+</sup>. These medical consumables are sterile stored and are size and material compatible with the D25<sup>+</sup>. Manufacturer-proven suitable indicates that the packaging material falls under the material compatibility statement of the manufacturer. Literature-supported suitable means that the packaging material was found to be suitable by previous studies (Lokate & Brühwasser, 2019; Verhaar et al., 2023; Visser-Hoekstra, 2021).

|                                     | Name   | Price (€) | Quantity | Total price (€) |
|-------------------------------------|--|-----------|----------|-----------------|
| <b>Manufacturer-proven suitable</b> | Oral care swab   | 0.16      | 10       | 1.6             |
|                                     | Elastic bandage 6 cm                                   | 0.16      | 1        | 0.16            |
|                                     | Elastic bandage 8 cm                                   | 0.16      | 1        | 0.16            |
|                                     | Adult-paediatric intubated CO <sub>2</sub> filter line | 20.88     | 2        | 41.76           |
|                                     | Filta-guard bacterial filter                           | 1.67      | 1        | 1.67            |
|                                     | Microbiological swab                                   | 0.47      | 5        | 2.35            |
|                                     | Urine bag  | 0.65      | 2        | 1.3             |
|                                     | Adult SpO <sub>2</sub> sensor                          | 14.68     | 2        | 27.36           |
|                                     | Disinfecting cap for needleless connectors             | 0.41      | 20       | 8.2             |
|                                     | Syringe NaCl 0.9% 10 ml                                | ?         | 8        | ?               |
|                                     | Stitch cutter  | 0.16      | 3        | 0.48            |
|                                     | Tipstop compression dressing                           | 0.86      | 2        | 1.72            |
|                                     | Transafix fixation strip                               | 2.23      | 5        | 11.15           |
|                                     | Endotracheal tube holder                               | 8.46      | 2        | 16.92           |
|                                     | Adult nasal cannula with curved prongs and tube        | 0.59      | 1        | 0.59            |
|                                     | Oxygen tube  | 0.85      | 1        | 0.85            |

|                                      |   |      |      |       |
|--------------------------------------|---|------|------|-------|
| <b>Literature-supported suitable</b> | Needleless shielded cannula                 | 0.49 | 15   | 7.35  |
|                                      | Arterial cannula                            | 3.91 | 3    | 11.73 |
|                                      | Enfit female                                | 2.75 | 2    | 5.5   |
|                                      | Bionector                                   | 1.44 | 5    | 7.2   |
|                                      | Venipuncture blood collection set           | 1.4  | 2    | 2.8   |
|                                      | Blood gas syringe                           | 1.28 | 15   | 19.2  |
|                                      | Blood culture syringe                       | 0.2  | 2    | 0.4   |
|                                      | Cavilon stick                               | 1.64 | 2    | 3.28  |
|                                      | Klinion compress 10 x 10 cm 2 pcs           | 0.09 | 4    | 0.36  |
|                                      | Klinion compress 10 x 10 cm 5 pcs           | 0.36 | 10   | 3.6   |
|                                      | Klinion compress 5 x 5 cm                   | 0.05 | 5    | 0.25  |
|                                      | Klinion drain compress 10 x 10 cm           | 0.09 | 5    | 0.45  |
|                                      | Klinion absorbent wound dressing 9 x 12 cm  | 0.58 | 2    | 1.16  |
|                                      | Klinion absorbent wound dressing 10 x 20 cm | 0.47 | 2    | 0.94  |
|                                      | Klinion absorbent wound dressing 20 x 20 cm | 0.76 | 2    | 1.52  |
|                                      | Enteral syringe cap                         | 0.34 | 5    | 1.7   |
|                                      | 3-way stopcock                              | 0.59 | 6    | 3.54  |
|                                      | 3-way stopcock with extension line 14 cm    | 1.3  | 4    | 5.2   |
|                                      | Enfit 3-way stopcock                        | 3.59 | 2    | 7.18  |
|                                      | Flask of distilled water NaCl 0.9% 10 ml    | ?    | 4    | ?     |
|                                      | Pink Venflon needle protected IV cannula    | 2.52 | 2    | 5.04  |
|                                      | Green Venflon needle protected IV cannula   | 2.52 | 2    | 5.04  |
|                                      | Infusion set                                | 4.37 | 2    | 8.74  |
|                                      | Catheter spigot                             | 0.18 | 2    | 0.36  |
|                                      | Secondary line for infusion therapy         | 1.24 | 3    | 3.72  |
|                                      | Climatrach HME filter                       | 1.8  | 2    | 3.6   |
|                                      | Leukomed wound dressing 10 x 25 cm          | 0.47 | 2    | 0.94  |
|                                      | Leukomed wound dressing 10 x 30 cm          | 0.58 | 2    | 1.16  |
|                                      | Leukomed wound dressing 5 x 7,2 cm          | 0.09 | 5    | 0.45  |
|                                      | Leukomed wound dressing 8 x 10 cm           | 0.18 | 5    | 0.9   |
|                                      | Leukomed wound dressing 8 x 15 cm           | 0.27 | 5    | 1.35  |
|                                      | Leukoplast wound closure strip              | 1.01 | 5    | 5.05  |
|                                      | Catheter tip syringe                        | 0.5  | 3    | 1.5   |
|                                      | Mepilex border flex lite                    | 2.07 | 5    | 10.35 |
|                                      | Mepitel one                                 | 0.74 | 5    | 3.7   |
|                                      | Monitoring line                             | 0.99 | 3    | 2.97  |
|                                      | Nasal fix plaster                           | 0.4  | 3    | 1.2   |
|                                      | Eye ointment                                | 1.35 | 1    | 1.35  |
|                                      | Hypodermic needle                           | 0.16 | 5    | 0.8   |
|                                      | Cannula with air filter                     | 0.86 | 3    | 2.58  |
|                                      | Purol lipstick                              | 2.32 | 1    | 2.32  |
|                                      | Rectal temperature probe                    | 3.06 | 2    | 6.12  |
|                                      | Combi-lock                                  | 0.09 | 10   | 0.9   |
| Syringe 10 ml                        | 0.14  | 5    | 0.7  |       |
| Syringe 20 ml                        | 0.02  | 5    | 0.1  |       |
| Syringe 5 ml                         | 0.13  | 5    | 0.65 |       |

|  |       |   |       |
|--|-------|---|-------|
| Syringe 50 ml                            | 0.5   | 2 | 1     |
| Enteral syringe                          | 0.58  | 2 | 1.16  |
| Mucus specimen trap set                  | 3.4   | 2 | 6.8   |
| Stomahesive                              | 2.68  | 2 | 5.36  |
| Tegaderm I.V. securement dressing 1681   | 0.43  | 5 | 2.15  |
| Tegaderm transparant film dressing 1624W | 0.47  | 5 | 2.35  |
| Tegaderm transparant film dressing 1626W | 1.08  | 5 | 5.4   |
| Tegaderm CHG I.V. securement dressing    | 10.17 | 2 | 20.34 |
| Enfit male                               | 0.81  | 2 | 1.62  |
| Connector feeding tube                   | 0.34  | 5 | 1.7   |
| Extension line 30 cm                     | 1.33  | 2 | 2.66  |
| Oxygen catheter                          | 0.5   | 2 | 1     |

## 6.2. Workflow analysis

The first step of the workflow analysis is mapping the designed workflow. The use of the D25<sup>+</sup> for disinfection of medical consumables can be broken down into the following steps that are based on a combination of the current protocol of the ICU and the user manual of the D25<sup>+</sup>:

- 1) Complete isolation ends and the patient leaves the room.
- 2) The room is thoroughly cleaned and disinfected.
- 3) Unused disposable medical consumables suitable for UVGI are collected and sorted.
- 4) The D25<sup>+</sup> and medical consumables to be disinfected are brought together.
- 5) The D25<sup>+</sup> is checked for visible debris on the walls and glass plates of the disinfection chamber and cleaned with an antiseptic wipe.
- 6) Medical consumables are inspected for visible debris, which is removed with an antiseptic wipe if present.
- 7) Medical consumables are placed inside the disinfection chamber of the D25<sup>+</sup> and the D25<sup>+</sup> is fully closed (until the clip clicks in position).
- 8) The disinfection cycle is started, and the indicator lights are checked to confirm operation. If the lights do not turn on, UV Smart or a local distributor should be contacted.
- 9) The 25-second disinfection cycle runs while the operator disinfects their hands.
- 10) The D25<sup>+</sup> opens automatically. A green light confirms successful disinfection; a red light indicates failure, in which case steps 8 and 9 are repeated.
- 11) Disinfected medical consumables are removed from the D25<sup>+</sup> with disinfected hands and placed into a clean bedside cart.
- 12) Steps 6 to 10 are repeated until all medical consumables have been disinfected.

The entire workflow of disinfecting all suitable medical consumables from a fully stocked bedside cart was timed (*Table 6.1*). The preparation steps were estimated to take 15 minutes. This includes starting up the D25<sup>+</sup> and cleaning it with antiseptic wipes (~1 minute) but also the selection of suitable medical consumables (~14 minutes). As for this selection, it was assumed that it would take 2 minutes per cabinet or drawer. Disinfection of the full inventory of a bedside cart was measured to be 2,945 seconds or roughly 50 minutes (*Table 6.2*). With 292 suitable medical consumables, the average disinfection time per consumable was 10 seconds. A total of 47 disinfection cycles were required. All in all, the entire workflow is estimated to take 65 minutes.

**Table 6.2:** Disinfection times of the suitable medical consumables of a fully stocked bedside cart. Only medical consumables found in the same cabinet or drawer were disinfected simultaneously. For each disinfection cycle, the disinfection chamber of the D25+ was adequately filled.

|                                   | Medical consumable                         | Quantity | Loading (s) | Disinfection (s) | Unloading (s) |
|-----------------------------------|--|----------|-------------|------------------|---------------|
| <b>Cabinet</b>                    | Syringe 5 ml (5)                           | 5        | 35          | 25               | 20            |
|                                   | Syringe 10 ml (5)                          | 5        |             |                  |               |
|                                   | Syringe 20 ml                              | 5        | 30          | 25               | 15            |
|                                   | Flask of distilled water NaCl 0.9% 10 ml   | 1        |             |                  |               |
|                                   | Syringe 10 ml NaCl 0.9%                    | 3        |             |                  |               |
|                                   | Syringe NaCl 0.9% 10 ml                    | 5        | 30          | 25               | 15            |
|                                   | Oral care swab                             | 6        |             |                  |               |
|                                   | Oral care swab                             | 8        |             |                  |               |
|                                   | Klinion compress 10 x 10 cm                | 2        | 40          | 25               | 15            |
|                                   | Klinion compress 10 x 10 cm                | 3        | 15          | 25               | 10            |
| <b>Drawer 1</b>                   | Klinion compress 10 x 10 cm                | 3        | 15          | 25               | 10            |
|                                   | Klinion compress 10 x 10 cm                | 3        | 15          | 25               | 10            |
|                                   | Klinion compress 10 x 10 cm                | 3        | 15          | 25               | 10            |
|                                   | Klinion compress 10 x 10 cm                | 3        | 15          | 25               | 10            |
|                                   | Klinion compress 10 x 10 cm                | 1        | 10          | 25               | 10            |
|                                   | Blood gas syringe                          | 7        | 45          | 25               | 10            |
|                                   | Blood gas syringe                          | 7        | 45          | 25               | 10            |
|                                   | Combi-lock                                 | 20       |             |                  |               |
|                                   | Hypodermic needle                          | 10       |             |                  |               |
|                                   | Pink Venflon needle protected IV cannula   | 2        |             |                  |               |
|                                   | Green Venflon needle protected IV cannula  | 2        | 90          | 25               | 40            |
|                                   | Disinfecting cap for needleless connectors | 20       |             |                  |               |
|                                   | Needless shielded cannula                  | 13       |             |                  |               |
|                                   | Bionector                                  | 5        | 110         | 25               | 40            |
| Stitch cutter                     | 3  |          |             |                  |               |
| Venipuncture blood collection set | 2  |          |             |                  |               |
| Catheter spigot                   | 3  |          |             |                  |               |
| Cannula with air filter           | 3  | 45       | 25          | 30               |               |
| <b>Drawer 2</b>                   | Climatrach HME filter                      | 2        |             |                  |               |
|                                   | Arterial cannula                           | 2        |             |                  |               |
|                                   | Tipstop                                    | 2        | 25          | 25               | 20            |
|                                   | Extension line 30 cm                       | 3        |             |                  |               |
|                                   | Catheter tip syringe                       | 2        | 20          | 25               | 10            |
|                                   | Catheter tip syringe                       | 1        |             |                  |               |
|                                   | Syringe 50 ml                              | 1        |             |                  |               |
| Monitor line                      | 3  | 20       | 25          | 15               |               |
| <b>Drawer 3</b>                   | Monitor line                               | 2        |             |                  |               |
|                                   | 3-way stopcock                             | 4        | 20          | 25               | 15            |
|                                   | 3-way stopcock                             | 2        |             |                  |               |
|                                   | 3-way stopcock with extension line 14 cm   | 5        |             |                  |               |
|                                   | Blood culture syringe                      | 2        | 30          | 25               | 20            |
|                                   | Secondary line for infusion therapy        | 3        | 10          | 25               | 10            |
|                                   | Infusion set                               | 2        | 10          | 25               | 10            |
| <b>Drawer 3</b>                   | Leukomed wound dressing 5 x 7,2 cm         | 6        |             |                  |               |
|                                   | Leukoplast wound closure strip             | 2        | 25          | 25               | 15            |
|                                   | Leukoplast wound closure strip             | 1        |             |                  |               |
|                                   | Mepitel one                                | 3        |             |                  |               |
|                                   | Mepilex border flex lite                   | 2        | 20          | 25               | 15            |
|                                   | Mepilex border flex lite                   | 1        |             |                  |               |
|                                   | Klinion compress 5 x 5 cm                  | 3        |             |                  |               |
|                                   | Klinion compress 10 x 10 cm                | 2        | 30          | 25               | 20            |
| Klinion compress 10 x 10 cm       | 2  | 20       | 25          | 10               |               |

|                 |  |   |    |    |    |
|-----------------|--|---|----|----|----|
|                 | Leukomed wound dressing 8 x 15 cm                      | 2 |    |    |    |
|                 | Klinion compress 10 x 10 cm                            | 2 |    |    |    |
|                 | Leukomed wound dressing 8 x 15 cm                      | 2 | 20 | 25 | 10 |
|                 | Klinion compress 10 x 10 cm                            | 1 |    |    |    |
|                 | Leukomed wound dressing 8 x 15 cm                      | 3 | 20 | 25 | 10 |
|                 | Tegaderm transparant film dressing 1624W               | 6 | 20 | 25 | 10 |
|                 | Tegaderm transparant film dressing 1624W               | 1 |    |    |    |
|                 | Tegaderm I.V. securement dressing 1681                 | 3 | 20 | 25 | 10 |
|                 | Tegaderm transparant film dressing 1626W               | 3 | 15 | 25 | 10 |
|                 | Tegaderm CHG I.V. securement dressing                  | 2 | 10 | 25 | 10 |
|                 | Tegaderm CHG I.V. securement dressing                  | 1 | 5  | 25 | 5  |
| <b>Drawer 4</b> | Oxygen catheter  | 1 |    |    |    |
|                 | Mucus specimen trap set                                | 2 | 15 | 25 | 10 |
|                 | Oxygen catheter  | 1 |    |    |    |
|                 | Klinion compress 10 x 10 cm                            | 2 | 15 | 25 | 10 |
|                 | Klinion compress 10 x 10 cm                            | 3 | 15 | 25 | 10 |
|                 | Klinion compress 10 x 10 cm                            | 1 |    |    |    |
|                 | Klinion absorbent wound dressing 20 x 20 cm            | 1 | 15 | 25 | 10 |
|                 | Klinion absorbent wound dressing 20 x 20 cm            | 1 |    |    |    |
|                 | Klinion drain compress 10 x 10 cm                      | 1 | 15 | 25 | 10 |
|                 | Klinion absorbent wound dressing 10 x 20 cm            | 1 |    |    |    |
|                 | Klinion drain compress 10 x 10 cm                      | 1 | 15 | 25 | 10 |
|                 | Klinion absorbent wound dressing 10 x 20 cm            | 1 |    |    |    |
|                 | Klinion drain compress 10 x 10 cm                      | 1 | 15 | 25 | 10 |
|                 | Klinion drain compress 10 x 10 cm                      | 2 | 10 | 25 | 10 |
| <b>Drawer 5</b> | Leukomed wound dressing 10 x 25 cm                     | 2 | 15 | 25 | 10 |
|                 | Leukomed wound dressing 10 x 25 cm                     | 1 |    |    |    |
|                 | Leukomed wound dressing 10 x 30 cm                     | 1 | 15 | 25 | 10 |
|                 | Leukomed wound dressing 10 x 30 cm                     | 2 | 15 | 25 | 10 |
|                 | Adult SpO <sub>2</sub> sensor                          | 2 |    |    |    |
|                 | Rectal temperature probe                               | 1 | 20 | 25 | 10 |
|                 | Rectal temperature probe                               | 1 |    |    |    |
|                 | Microbiological swab                                   | 6 | 25 | 25 | 10 |
|                 | Cavilon stick  | 2 |    |    |    |
|                 | Enteral syringe  | 2 |    |    |    |
|                 | Filta-guard bacterial filter                           | 1 |    |    |    |
|                 | Connector feeding tube                                 | 4 | 30 | 25 | 20 |
|                 | Adult-paediatric intubated CO <sub>2</sub> filter line | 2 | 10 | 25 | 10 |
|                 | Enfit female   | 3 |    |    |    |
| Enfit male      | 3  |   |    |    |    |
|                 | Enfit 3-way stopcock                                   | 2 | 25 | 25 | 15 |

Based on the workflow above, the following pain points were identified: time, hand hygiene, and costs. The main pain point is the amount of time it takes to disinfect all medical consumables hence strategies are required to lower the total time. This includes the disinfection itself but also the additional steps required for the operation of the D25<sup>+</sup>.

To reduce the preparation time, specifically the selection of suitable medical consumables and the disposal of unsuitable consumables, colour coding of bedside cart compartments could be implemented. Since the bedside cart inventory is standardised, medical consumables are always stored in the same drawers and compartments. The operator requires a list of suitable medical consumables for the selection process. Colour coding the compartments gives a clear visual guide and would speed up the selection process. Compartments containing suitable medical

consumables can be marked with green stickers whereas compartments with unsuitable consumables can be marked with red stickers.

Moreover, the positioning of the equipment plays a crucial role in ensuring a smooth and efficient workflow for the operator. Ideally, the D25<sup>+</sup>, a contaminated bedside cart, and a clean bedside cart are positioned side by side. This setup enables the operator to transfer medical consumables from a contaminated bedside cart to the D25<sup>+</sup> for disinfection and then directly into a clean bedside cart. A clean bedside cart is required because the medical consumables are not allowed to be transferred back into a contaminated bedside cart. For the operator, it minimises unnecessary movement and allows for a clear overview of the disinfection process.

Another pain point is the fact that the operator must disinfect their hands for every disinfection cycle of the D25<sup>+</sup>. Medical consumables taken from the bedside cart are considered contaminated. When the operator touches these medical consumables, their hands should also be considered contaminated. To avoid cross-contamination, the operator must disinfect their hands after touching contaminated medical consumables. Many disinfection cycles result in many hand-washing cycles which can become inconvenient for the operator.

The last pain point is the costs related to UV-C disinfection. An overview of the costs is provided in *Table 6.3*. If the D25<sup>+</sup> were implemented at the ICU, it would be operated by a care assistant. In 2024, a care assistant working 36 hours a week, earned a maximum of €3255 per month or €20.87 per hour (NFU, 2024). The D25<sup>+</sup> consumes 0.011 kWh per disinfection cycle with an average electricity cost (including taxes) of €0.30 per kWh in 2024 (CBS, 2025). To disinfect the entire inventory of a bedside cart with the D25<sup>+</sup>, 65 minutes and 47 disinfection cycles are required. The purchase of the D25<sup>+</sup> costs €7800. The device has a guaranteed lifespan of 7 years. The maintenance costs of the D25<sup>+</sup> are estimated to be €1300 (UV Smart, personal communication, June 17, 2025). This includes annual maintenance and repairs by the distributor. Replacement costs of components within two years of use are covered by the D25<sup>+</sup> warranty. After those two years, the hospital has to pay for the replacement costs. The disposal costs of €0.09 per kilogram of waste are neglected and the transportation costs are unknown.

**Table 6.3:** Disposal and disinfection costs of all suitable medical consumables in a bedside cart at the ICU of the LUMC.

| Disposal                                  |        | Disinfection  |      |  |       |
|---|--------|---------------|------|--|-------|
| Bedside cart costs (€)                    |        | D25 costs (€) |      | Operational costs per bedside cart (€) |       |
| Manufacturer-proven suitable consumables  | 116.27 | Purchase      | 7800 | Wages                                  | 22.61 |
| Literature-supported suitable consumables | 206.49 | Maintenance   | 1300 | Electricity                            | 0.16  |
| All suitable consumables                  | 322.76 | Total         | 9100 | Total                                  | 22.76 |

## 7. Discussion

The results of the inventory analysis and workflow analysis of UVGI of unused medical consumables at the ICU of the LUMC show great potential for implementation and possible upscaling to other departments and hospitals. UVGI may also be more widely implemented to disinfect reusable medical consumables or medical devices.

Disinfection of unused and contaminated medical consumables is only applicable at hospital departments that deal with patients requiring complete isolation or other forms of isolation that use disposal as infection prevention method. Taking into account patient isolation needs and financial factors, implementation is deemed most suitable for ICU departments comparable in size or larger than the LUMC. In 2023, the LUMC had the seventh-largest ICU department in the Netherlands (NVIC, 2023). All university teaching hospitals and some regional hospitals have similar or larger ICU departments compared to the LUMC (*Appendix II*). For these hospitals and larger hospitals outside of the Netherlands, UV-C disinfection of unused medical consumables is deemed applicable. For smaller hospitals, the supply of unused and contaminated medical consumables may be insufficient to implement UVGI.

### 7.1. Inventory analysis

When implemented in the ICU, clear work protocols must be formed. These should define which types of packaging are suitable for disinfection and specify the allowed number of disinfection and reuse cycles per medical consumable. Repeated disinfection is unlikely to pose an issue in the current setting, provided that previously disinfected medical consumables are used before new ones. There is potential to scale up the number of disinfected consumables at the ICU or to expand the practice to other departments. However, it should be noted that the exact effects of multiple disinfection cycles of literature-supported suitable medical consumables are unknown. The D25<sup>+</sup> would be used outside of the intended use so a prospective risk analysis may be used to identify potential risks for upscaling within the LUMC.

A maximum number of disinfection cycles should be established for a medical consumable, as some consumables may be repeatedly contaminated and require multiple cycles. Regardless, the aim of the ICU should be to avoid repeated contamination of medical consumables. Given the current case where only medical consumables exposed to patients during complete isolation require disinfection, the number of disinfected medical consumables is expected to be low. In 2023 and 2024, 22 and 33 bedside cart inventories would have been eligible for UVGI respectively. Since each inventory holds a 24-hour supply and the overall number of disposed carts was limited, the likelihood of repeated contamination and disinfection would be minimal. Medical consumables inside the ICU bedside carts have a high turnover rate and are typically used or discarded within six months at the latest.

During this research, the suitability of medical consumables were categorised into two groups: manufacturer-proven and literature-supported. This distinction was necessary for medical consumables containing paper packaging since the manufacturer of the D25<sup>+</sup> does not claim paper compatibility despite previous studies suggesting potential compatibility. Given the limited manufacturer guidance and variability in packaging materials, further research is necessary to systematically evaluate the efficacy and safety of UV-C disinfection across a broader spectrum of packaging types.

The responsibility for ensuring safe and effective UV-C disinfection extends beyond the UV-C device manufacturer. Producers of packaging materials and medical devices should actively collaborate with UV-C device manufacturers to test and validate the compatibility of their products with UV-C technology. This includes providing detailed information on material properties relevant to UV-C transmission and resistance, as well as supporting the development of standardised testing protocols. Currently, a new Dutch standard (NEN 8281:2024) is being designed that describes the disinfection of non-critical and semi-critical medical consumables with non-porous surfaces. This standard could ultimately be used by the manufacturers of packaging materials and medical consumables to test if their products are compatible with UV-C technologies.

The European Union's Safe and Sustainable by Design (SSbD) framework emphasises the importance of developing products and processes that are both safe for human health and environmentally sustainable (Caldeira et al., 2022). In the context of UV-C disinfection, this framework highlights the need for transparent communication of material compatibility, robust safety standards, and the minimisation of environmental impact. Medical consumable and packaging manufacturers should prioritise material innovation that ensures both safety during UV-C exposure and end-of-life sustainability. The packaging material should be compatible with UV-C disinfection and favour recyclable components. Medical plastic waste has great recycling potential (Apeviyeneku et al., 2024). By doing so, the distinction made in this report between manufacturer-proven and literature-supported suitability disappears. To lower the waste footprint of the healthcare sector, hospitals should prioritise medical consumable manufacturers that use UV-C compatible and recyclable packaging.

## 7.2. Workflow analysis

The main identified pain points of the workflow analysis were time, hand disinfection, and costs. By positioning the D25<sup>+</sup>, a contaminated bedside cart, and a clean bedside cart side by side, a smooth workflow can be created for the operator minimising unnecessary movement and allowing for more clarity of the disinfection process. One of the preparation steps involves the selection of suitable medical consumables for disinfection and the disposal of unsuitable medical consumables. By providing a list of suitable medical consumables and colour coding the compartments of the bedside cart, the timed selection and disposal process of 14 minutes is expected to be shortened by around 5 to 10 minutes.

The workflow for disinfecting medical consumables with the D25<sup>+</sup> includes several repeated hand disinfection steps. The operator should disinfect their hands when the D25<sup>+</sup> disinfects the medical consumables during its 25-second disinfection cycle to avoid cross-contamination. This hand disinfection appears to be unavoidable. It is possible to use one hand to handle contaminated medical consumables with the other hand only handling disinfected medical consumables. However, this would require more coordination, does not save time, and increases the risk of cross-contamination.

Even if the ICU is looking for a more sustainable alternative to the disposal of unused medical consumables, the financial aspects are also important to consider. By only considering the purchasing costs, a bedside cart inventory contains up to €322.76 of suitable medical consumables. The D25<sup>+</sup> is warranted for a lifespan of 7 years, which will be used for the calculations in this report. However, a lifespan of 10 years is also regularly observed by the manufacturer of the D25<sup>+</sup>. The annual cost of the D25<sup>+</sup> is estimated at €1,300 covering the

purchase and maintenance of the device. By including the wages of the operator and electricity costs, the annual costs for disinfection of all bedside carts (at 100% inventory levels) in 2023 and 2024 were €1,801 and € 2,051 respectively (Tables 7.1 & 7.2). However, the actual number would have been lower since medical consumables are taken out of the bedside carts to provide care to patients. By assuming that between 30-50% of the bedside cart inventories remain after the patient leaves complete isolation, for 2023 and 2024, the avoided costs would have been around €680-2,000 and €1,670-3,650 respectively (Tables 7.1 & 7.2).

Alternatively, only the most expensive medical consumables may be disinfected if a balance between costs and time is necessary. The purchasing costs and quantity of the ten or twenty most expensive suitable medical consumables would be €152.45 or €207.46 and 21 or 48 consumables per bedside cart respectively. With an average disinfection time of 10 seconds per medical consumable, disinfecting only the ten and twenty most expensive medical consumables (excluding preparatory steps) would take 210 and 480 seconds, or 3.5 and 8 minutes respectively.

**Table 7.1:** Annual disposal and disinfection costs of suitable medical consumables at different bedside cart levels at the ICU of the LUMC. The costs are based on the 2023 data with annually 22 contaminated bedside carts.

| Bedside cart levels | Disposal (€) | Disinfection (€) | Avoided costs (€) |
|---------------------|--------------|------------------|-------------------|
| 100%                | 7101         | 1801             | 5300              |
| 50%                 | 3550         | 1550             | 2000              |
| 30%                 | 2130         | 1450             | 680               |

**Table 7.2:** Annual disposal and disinfection costs of suitable medical consumables at different bedside cart levels at the ICU of the LUMC. The costs are based on the 2024 data with annually 33 contaminated bedside carts.

| Bedside cart levels | Disposal (€) | Disinfection (€) | Avoided costs (€) |
|---------------------|--------------|------------------|-------------------|
| 100%                | 10651        | 2051             | 8600              |
| 50%                 | 5326         | 1676             | 3650              |
| 30%                 | 3195         | 1525             | 1670              |

A large portion of people working in the healthcare sector experience high levels of work pressure. Since 2019, between 37-50% of healthcare professionals have experienced high levels of work pressure. In 2024, this number was on average 43% (AZW, 2024). Disinfection of unused medical consumables is more time-consuming than disposal. Switching from disposal to disinfection would increase the workload of care assistants and may result in increased work pressure. According to some LUMC healthcare professionals, the disinfection of contaminated medical consumables at the ICU of the LUMC will not increase the work pressure of care assistants since only around two patients per month require complete isolation. With 22 and 33 disposed bedside carts in 2023 and 2024, the additional monthly workload for care assistants at the ICU would have been 2 to 3 hours respectively.

Another optional improvement to the current workflow that was not included in the workflow analysis but may be interesting to further research is the storage of contaminated bedside carts. Currently, the bedside cart inventories are immediately disposed of once a patient leaves the isolation room. If more unused medical consumables require disinfection, it may be more time-efficient to accumulate them before UV-C disinfection. This means that in total fewer preparation

steps are required since the medical consumables are disinfected in one large session instead of several smaller sessions. However, this would mean that storage should be found for contaminated medical consumables or that the contaminated bedside carts cannot be used for longer periods of time. The infection risks should be further investigated.

Effective operation of UV-C devices is dependant on clear work protocols and education for operators. Currently, the D25<sup>+</sup> does not notify the operator if the UV-C device is used incorrectly. It will notify the operator if too little UV-C radiation is emitted but not if the medical consumables are placed incorrectly in the disinfection chamber. Operators should be informed that the medical consumables must not touch the walls or ceiling of the disinfection chamber or that medical consumables are folded or shaded. The manufacturer of the D25<sup>+</sup> addresses these issues in their user manual but might consider design features such as sensors to prevent incorrect use.

## Part II - Sustainability

The second part of this thesis considers the sustainability of UV-C disinfection of medical consumables at the ICU of the LUMC. It focuses on calculating and comparing the environmental impacts of disinfection of medical consumables compared to disposal.

### 8. Methods

The environmental impacts of the disposal and disinfection of medical consumables have been calculated, compared, and evaluated through Life Cycle Assessment (LCA), in accordance with the ISO 14040/44 framework (ISO, 2006a, 2006b). This LCA study followed the four LCA phases: goal and scope definition, inventory analysis, impact assessment, and interpretation.

#### 8.1. Goal and scope definition

The goal of this LCA study was to compare and evaluate the environmental impacts of disposal and UV-C disinfection of unused medical consumables at the ICU of the LUMC. The study was performed in accordance with the ISO 14040/44 framework. The results of this study will provide insights for healthcare professionals and manufacturers interested in reducing the environmental impacts of healthcare practices. The healthcare professionals at the LUMC may use it to reduce the environmental footprint of the ICU department and manufacturers may use it to improve material sourcing and product design.

The scope of this LCA was to cover all life cycle phases (cradle-to-grave) of both disposal and UV-C disinfection of medical consumables at the ICU of the LUMC in 2024. This relatively detailed LCA study adopted an attributional approach. The study was geographically specific to the Netherlands with the use and end-of-life (EOL) stages taking place in this geography. However, the production of the medical consumables is taking place elsewhere. The temporal coverage is connected to the collected data and should not be older than 2019. The technological coverage comprised currently used modern technologies. As for UV-C disinfection, the D25<sup>+</sup> from UV Smart was used. Through expert consultancy, four medical consumables were selected for this LCA study namely, a blood gas syringe, CO<sub>2</sub> filter line, SpO<sub>2</sub> sensor, and vacutainer (*Appendix III*). These medical consumables were used to model an ICU bedside cart. Only the environmental impacts of suitable medical consumables were calculated since unsuitable consumables still require disposal leaving their emissions unchanged. The function, functional unit, alternatives, and reference flows are listed below.

*Function:*

- Use of UV-C compatible medical consumables stored in ICU bedside carts at the LUMC

*Functional unit:*

- Use of UV-C compatible medical consumables stored in ICU bedside carts at the LUMC in 2024

*Alternatives:*

- Disposal as infection prevention method
- UV-C disinfection with the D25<sup>+</sup> as infection prevention method

*Reference flows:*

- Use of UV-C compatible medical consumables stored in ICU bedside carts at the LUMC in 2024 with disposal as infection prevention method
- Use of UV-C compatible medical consumables stored in ICU bedside carts at the LUMC in 2024 with UV-C disinfection with the D25<sup>+</sup> as infection prevention method

## 8.2. Inventory analysis

The life cycle inventory analysis entails the compilation and quantification of inputs and outputs of the defined product systems throughout its life cycle. This section includes the definition of the system boundaries, flowcharts of product systems, and data collection.

### 8.2.1. System boundaries

An appropriate comparison between the disposal and disinfection of medical consumables stored in a bedside cart requires that the system boundary be set to include all relevant differences between the two alternatives. The bedside cart inventory is set to consist only of medical consumables suitable for UV-C exposure. The product system consists of all relevant unit processes that form the full life cycle of medical consumables and UV-C devices. This includes the extraction of raw materials, manufacturing of medical consumables and UV-C devices, transportation, use at the ICU, and end-of-life practices such as incineration and recycling.

All economic flows should be followed until they have been translated into environmental flows. In other words, all economic flows have to be followed from resource extraction up until emission. However, some flows have to be excluded from the system boundary due to various reasons and are considered to be cut-off. For this LCA study, cut-offs were made which will be further elaborated in the next sections.

### 8.2.2. Flowcharts

The (simplified) flowcharts of the disposal and disinfection of bedside cart inventories are shown below (*Figures 8.1 & 8.2*). The flowcharts give a graphic representation of the interlinked unit processes comprising the product system. A more detailed flowchart for both alternatives can be found in *Appendix IV*.

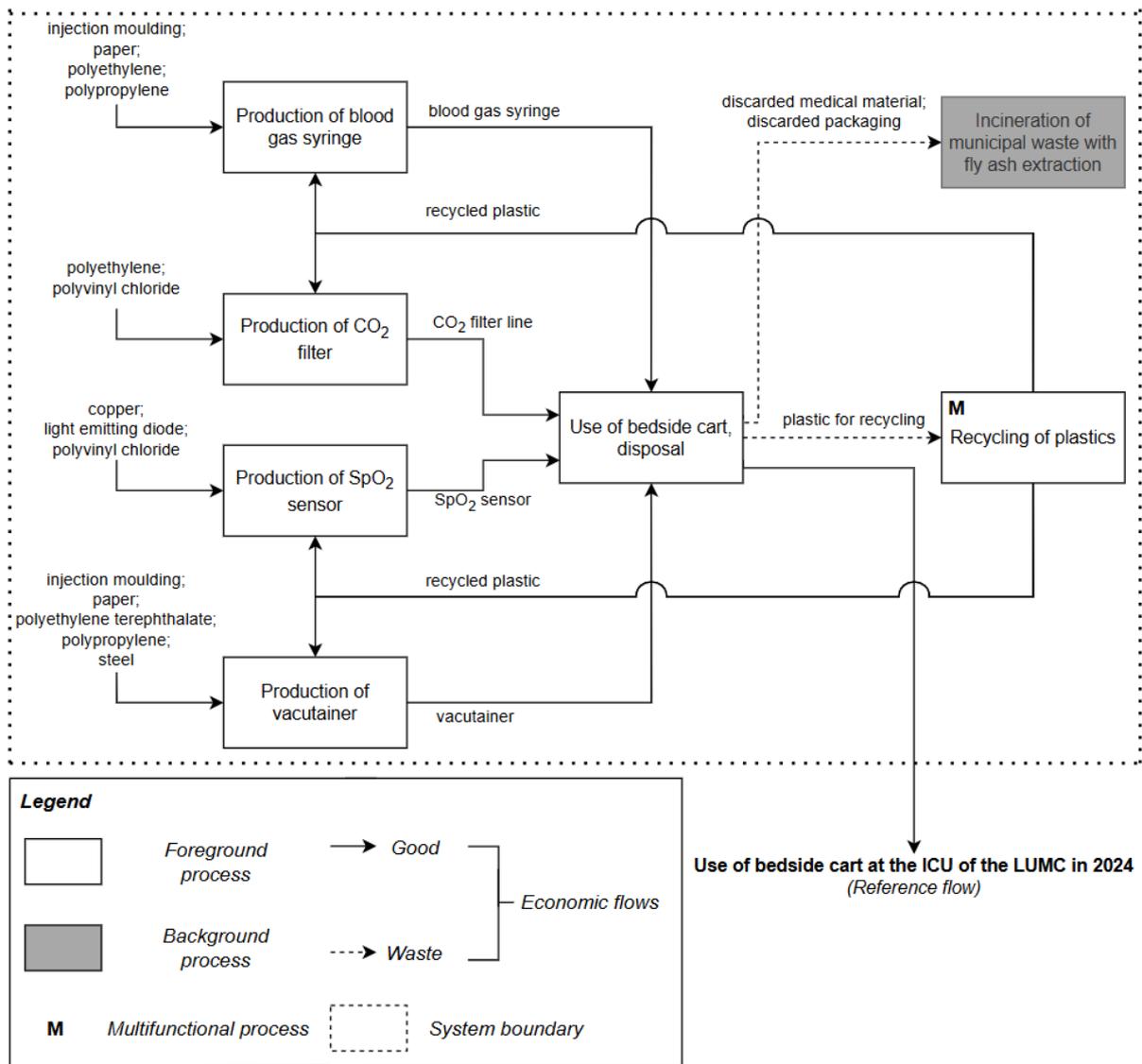


Figure 8.1: Simplified flowchart of the disposal of bedside cart inventories product system.

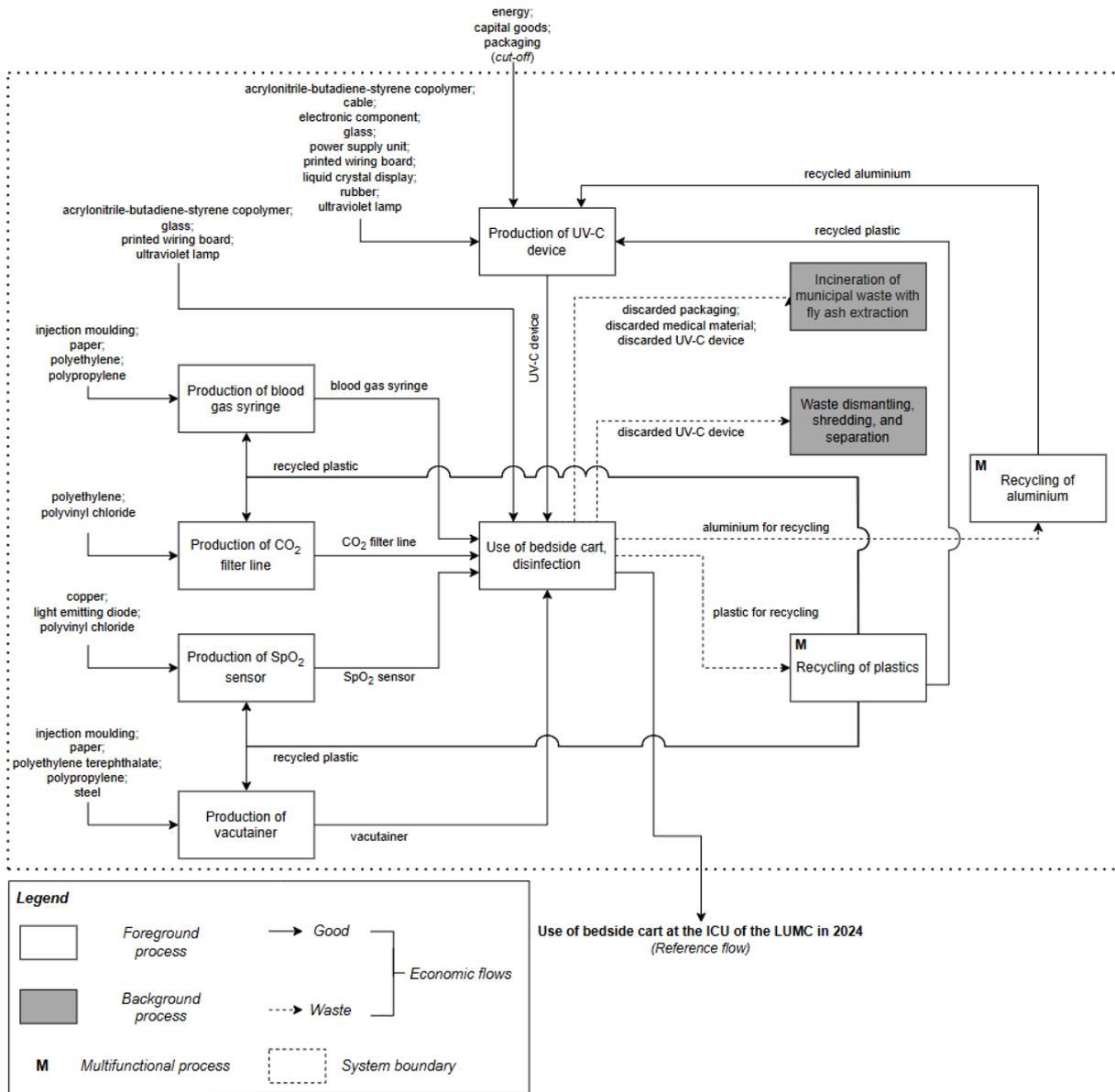


Figure 8.2: Simplified flowchart of the disinfection of bedside cart inventories product system.

### 8.2.3. Data collection

This LCA study was performed using data from the ecoinvent 3.11. database and reports from the UV-C device manufacturer. The masses of the used medical consumables were collected through weighing. The full input/output tables of the foreground unit processes including calculations and data sources are found in *Appendix V*.

#### 8.2.3.1. Production of medical consumables

An overview of the production and manufacturing inputs of the four medical consumables is provided in *Table 8.1*.

The blood gas syringe is made out of PP, has low-density PE and paper packaging, and is manufactured by Westmed in Mexico. The blood gas syringe, PE packaging, and paper packaging have a mass of 4, 2, and 1 grams respectively. The PP is manufactured through injection moulding and the PE packaging through film extrusion.

The CO<sub>2</sub> filter line is made out of PVC, has low-density PE packaging, and is manufactured by Medtronic in Mexico. The CO<sub>2</sub> filter line and PE packaging have a mass of 20 and 4 grams respectively. The PVC is manufactured through suspension polymerisation and the PE packaging through film extrusion. Suspension polymerisation was assumed for PVC manufacturing since 80% of global PVC production uses this manufacturing process (Fischer et al., 2014). Moreover, the PE packaging is manufactured through film extrusion.

The SpO<sub>2</sub> sensor is made out of PVC, has low-density and high-density PE packaging, and is manufactured by Covidien in Mexico. The SpO<sub>2</sub> sensor, low-density PE packaging, and high-density PE packaging have a mass of 18, 2, and 2 grams respectively. It was not possible to obtain the masses of the individual components of the SpO<sub>2</sub> sensor. The main components of the SpO<sub>2</sub> sensor are the cable, connector, and LED sensor. The mass of the LED sensor was estimated based on Duffy et al. (2023) who used a SpO<sub>2</sub> sensor of 17.27 g. Their ratio between cable and a combination of LED sensor, sensor top/bottom, and shield was 15.99 : 1.28. Using this ratio as a proxy, the obtained masses for the cable and LED sensor are 16.7 and 1.3 g respectively. The connector was omitted due to a lack of data. The PVC to copper ratio of the cable was assumed to be 45:55 (Kumar et al., 2024). The PVC is manufactured through suspension polymerisation, copper through wire drawing, and PE packaging through film extrusion.

The vacutainer is made out of PP, contains a 21g stainless steel needle, has PET and paper packaging, and is manufactured by BD in the USA. The vacutainer, PET packaging, and paper packaging have a mass of 6, 7, and 1 grams respectively. The PP is manufactured through injection moulding and the PE packaging through film extrusion.

**Table 8.1:** Production and manufacturing inputs of the blood gas syringe, CO<sub>2</sub> filter line, SpO<sub>2</sub> sensor, and vacutainer.

|                  | <b>Inputs [g]</b>  | <b>Blood gas syringe</b> | <b>CO<sub>2</sub> filter line</b> | <b>SpO<sub>2</sub> sensor</b> | <b>Vacutainer</b> |
|------------------|--------------------|--------------------------|-----------------------------------|-------------------------------|-------------------|
| <i>Materials</i> | Copper             |                          |                                   | 7.50                          |                   |
|                  | Paper              | 1.00                     |                                   |                               | 1.00              |
|                  | LED                |                          |                                   | 1.33                          |                   |
|                  | High-density PE    |                          |                                   | 1.86                          |                   |
|                  | Low-density PE     | 1.86                     | 3.72                              | 1.86                          |                   |
|                  | PET                |                          |                                   |                               | 6.51              |
|                  | PP                 | 3.72                     |                                   |                               | 5.51              |
|                  | PVC                |                          | 18.60                             | 8.52                          |                   |
|                  | Recycled plastic   | 0.42                     | 1.68                              | 0.92                          | 0.90              |
|                  | Steel              |                          |                                   |                               | 0.07              |
| <i>Processes</i> | Injection moulding | 4.00                     |                                   |                               | 14.00             |
|                  | Wire drawing       |                          |                                   | 7.50                          |                   |

### 8.2.3.2. Production of UV-C device

The bill of materials of the UV-C device was obtained from the manufacturer (*Table 8.2*). The UV-C device is manufactured in the Netherlands but the materials are sourced from China. The UV-C device has a mass of 19.13 kg. The framework and sheet metal are made out of aluminium whereas the housing and lid clip hook are made out of acrylonitrile butadiene styrene (ABS). Moreover, the disinfection chamber has a transmissive glass plate and contains eight UV-C lamps. Additionally, to provide electricity to the UV-C device, a cable (0.3 kg) is required. The energy requirements, capital goods, and packaging were omitted due to a lack of available data.

For the LCA model, to make the required materials for the UV-C device correspond to the ecoinvent database, some adaptations were required. The electromagnetic interference (EMI) filter was considered a passive, unspecified electronic component. Surface-mounted printed wiring board was used as a proxy for ballast. The printed wiring board for through-hole mounting was used for the printed circuit board assembly (PCBA). This flow is expressed by area with one m<sup>2</sup> corresponding to 3.08 kg. The power entry module and power supply were assumed to be desktop computer power supply units. The power supply unit and ultraviolet lamp in the ecoinvent database are expressed per item corresponding to 1.47 and 0.382 kg respectively. Lastly, due to a lack of available data, the energy and capital good requirements of the manufacturing processes as well as the packaging of the UV-C device were omitted.

**Table 8.2:** Bill of materials of the D25<sup>+</sup> UV-C device made by UV Smart.

| <b>Material</b>          | <b>Mass (kg)</b> |
|--------------------------|------------------|
| ABS                      | 3.05             |
| Aluminium, cast alloy    | 12.50            |
| Aluminium, wrought alloy | 2.13             |
| Ballast                  | 0.15             |
| Display                  | 0.15             |
| EMI filter               | 0.10             |
| Glass                    | 0.50             |
| PCBA                     | 0.13             |
| Power entry module       | 0.05             |
| Power supply             | 0.25             |
| Rubber                   | 0.02             |
| UV-C lamp                | 0.10             |

#### 8.2.3.3. Use

Based on the results from the inventory analysis, 292 medical consumables stored in a bedside cart at the ICU are suitable for UV-C disinfection. The blood gas syringe, CO<sub>2</sub> filter line, SpO<sub>2</sub> sensor, and vacutainer are stored in a 15:2:2:2 ratio in a bedside cart. This ratio is used to create a proxy of all 292 medical consumables in the bedside cart. In 2024, 33 bedside carts were contaminated as a result of complete isolation.

When disposal is used as an infection prevention method to treat contaminated medical consumables, the full inventory of 33 contaminated bedside carts must be disposed of. To provide care to ICU patients, every disposed of bedside cart has to be replaced, which means that in total 66 bedside carts are required.

When disinfection is used as an infection prevention method to treat contaminated medical consumables, the full inventory of 33 contaminated bedside carts must be disinfected. Based on the results of the workflow analysis, 47 cycles are needed to disinfect the full inventory of a bedside cart. The D25<sup>+</sup> consumes 0.011 kWh per cycle and has a lifespan of 7 years. Annual maintenance of the D25<sup>+</sup> is required. The UV-C lamps are replaced annually and the PCBA once every 3 years. The lid clip hook and transmissive glass plate may also be replaced during the lifespan of the D25<sup>+</sup> but only if they are damaged. The lid clip hook and transmissive glass plate were assumed to be replaced once during the lifespan of the D25<sup>+</sup>.

#### 8.2.3.4. End-of-life

Medical consumables and their packaging are disposed of as residual waste. In the Netherlands, several waste fractions are post-sorted from residual waste including packaging waste, plastics, metals, and composite waste. Post-sorting is forbidden for bio-waste, paper and cardboard, textiles, and glass (European Environment Agency, 2023). All paper and cardboard in the residual waste are sent to incineration plants (Ministerie van Infrastructuur en Waterstaat, 2025). All other

components of the modelled medical consumables, except plastics, are also assumed to be sent to incineration plants.

Overall, 81% of the plastic packaging waste found in residual waste is directly sent to energy recovery, and only 19% is sent to material recovery facilities (Brouwer et al., 2019). Waste incineration is coupled to thermal and electric energy generation and uses fly ash extraction (Ministerie van Infrastructuur en Waterstaat, 2024a, 2024b). Residues rejected from the material recovery facilities are also sent to energy recovery sites. Of all plastic packaging waste collected in residual waste, only 7% is recycled and 93% is incinerated.

For the UV-C device, aluminium and ABS are recycled. The Netherlands has a 95 % recycling rate of aluminium (PBL, 2025). However, aluminium production only partly uses recycled post-consumer aluminium scrap. According to the ecoinvent database, cast alloy and wrought alloy aluminium production consist of 10.1% and 5.7% of recycled post-consumer aluminium scrap respectively. As for ABS, a recycling rate of 49% was used (Stichting Verpact, 2024). Therefore, these recycling rates have been assumed with the remaining fractions going to incineration.

All other components of the UV-C device are assumed to be shredded, separated, and sent to incineration plants as described in the ecoinvent database. The transmissive glass plates of the UV-C device were made out of flat glass. The recycling of this flat glass was not considered since recycling of post-consumer glass cullets recovered from waste flat glass has been low or non-existent (Elstner et al., 2024).

For all recycled flows, system expansion has been applied to credit the system for recycling by subtracting the impacts of the displaced virgin plastics and metals and adding the impacts of the recycling process. All recycling processes are based on processes in the ecoinvent database and have been modelled as closed loops.

#### 8.2.3.5. Transport

The transport data are summarised in *Table 8.3*. The transport details for the UV-C device were provided by the manufacturer. The materials for the UV-C device are sourced from China but the assembly takes place in the Netherlands. In accordance with the ecoinvent database, for land transport outside of Europe, unspecified diesel lorries were assumed. For land transport within Europe, 16-32t EURO6 diesel lorries were assumed to comply with the latest emission standards by the European Union (2022). Transport of materials from the extraction site to the manufacturing plant of the medical consumables and UV-C device was omitted.

**Table 8.3:** Transport data of the UV-C device and medical consumables.

| Transported item            | Transport detail  | Distance (km) | Mass (kg) | Freight transport (tkm) |
|-----------------------------|---|---------------|-----------|-------------------------|
| UV-C device                 | Transport plant China to Shanghai port                  | 5.00E+02      | 1.91E+01  | 9.57E+00                |
|                             | Transport Shanghai port to Rotterdam port               | 1.95E+04      |           | 3.74E+02                |
|                             | Transport Rotterdam port to plant Netherlands           | 2.17E+02      |           | 4.15E+00                |
|                             | Transport plant Netherlands to LUMC                     | 2.20E+02      |           | 4.21E+00                |
| Blood gas syringe           | Transport plant Mexico to Veracruz port                 | 3.08E+03      | 7.00E-03  | 2.15E-02                |
|                             | Transport Veracruz port to Rotterdam port               | 1.00E+04      |           | 7.00E-02                |
|                             | Transport Rotterdam port to LUMC                        | 5.59E+01      |           | 3.91E-04                |
| CO <sub>2</sub> filter line | Transport plant Mexico to Los Angeles/Long Beach port   | 2.23E+02      | 2.40E-02  | 5.35E-03                |
|                             | Transport Los Angeles/Long Beach port to Rotterdam port | 1.44E+04      |           | 3.45E-01                |
|                             | Transport Rotterdam port to LUMC                        | 5.59E+01      |           | 1.34E-03                |
| SpO <sub>2</sub> sensor     | Transport plant Mexico to Los Angeles/Long Beach port   | 2.23E+02      | 2.00E-02  | 4.46E-03                |
|                             | Transport Los Angeles/Long Beach port to Rotterdam port | 1.44E+04      |           | 2.87E-01                |
|                             | Transport Rotterdam port to LUMC                        | 5.59E+01      |           | 1.12E-03                |
| Vacutainer                  | Transport plant USA to New York & New Jersey port       | 2.18E+03      | 1.40E-02  | 3.05E-02                |
|                             | Transport New York & New Jersey port to Rotterdam port  | 6.27E+03      |           | 8.77E-02                |
|                             | Transport Rotterdam port to LUMC                        | 5.59E+01      |           | 7.83E-04                |

### 8.3. Impact assessment

During the life cycle impact assessment (LCIA), the magnitude and significance of the potential environmental impacts of the disposal and disinfection of bedside cart inventories will be assessed and evaluated. Impact categories represent environmental issues of concern to which inventory results can be assigned. Category indicators are used as quantifiable representations of impact categories. Characterisation models are mathematical models that form the basis for converting inventory results into potential environmental impacts. They model the impact of environmental interventions concerning a particular category indicator. Lastly, characterisation factors are derived from these models to express environmental interventions into a common unit of a category indicator such as the global warming potential (Guinée et al., 2002).

The calculations of this LCA study were performed using openLCA 2.4.1. software and the impacts have been estimated according to the EF v3.1. method. This impact assessment method was chosen because it is supported by the European Union (2021).

## 9. Results and interpretation

In this section, the results of the LCIA and the interpretation of the disposal and disinfection of bedside cart inventories at the ICU of the LUMC are presented and compared. The LCIA results of the study are presented followed by sensitivity analyses of the interpretation. The full results of all LCIA results and contributions can be found in *Appendix VI*.

### 9.1. LCIA results of bedside carts

The LCIA results for the disposal and disinfection of bedside carts at the ICU of the LUMC in 2024 indicate that disinfection has lower impacts across all impact categories (*Table 9.1*). For the disinfection alternative's environmental impacts, 46–50% reductions were observed compared to the disposal alternative. The disposal alternative requires the production and end-of-life of twice as many medical consumables compared to the disinfection alternative. Therefore, it is important to investigate what the contributions of the UV-C device and medical consumables are to the total LCIA results of the disinfection alternative.

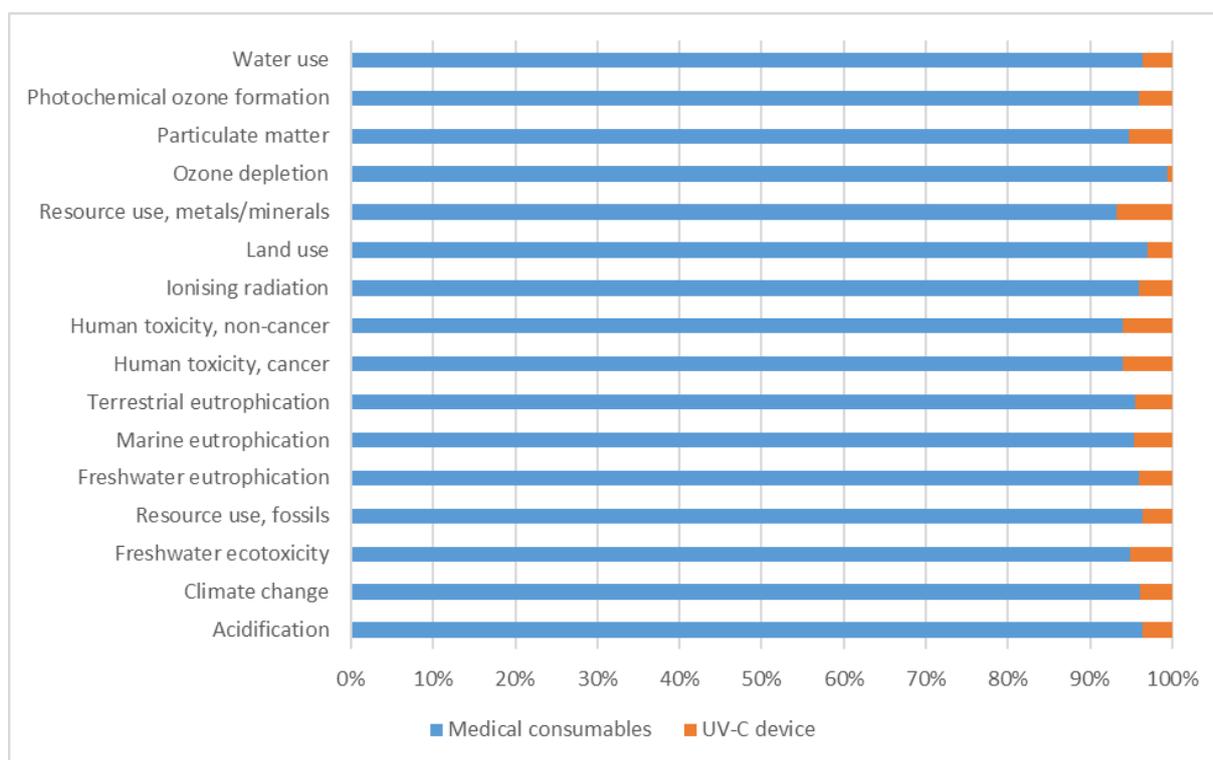
The disinfection alternative contains only half the quantity of medical consumables compared to the disposal alternative but is modelled with the same production and end-of-life processes. Additionally, the disinfection alternative includes the full life cycle of the UV-C device. As a result, the relative contributions of the UV-C device and medical consumables to the LCIA results of the disinfection alternative can be calculated as follows:

$$C_{UV-C} = R_{Disinfection} - R_{Disposal} / 2$$
$$C_{Medical\ consumable} = R_{Disposal} / 2$$

The contributions of the UV-C device and medical consumables to the LCIA results of the disinfection alternative are shown in *Figure 9.1*. The UV-C device has a contribution of 1–7% to the total impacts with the lowest contribution to ozone depletion and the highest contribution to resource use of metals and minerals. This shows that the majority of the impacts are coming from the life cycle of the medical consumables.

**Table 9.1:** LCIA results of the disposal and disinfection of bedside carts at the ICU of the LUMC in 2024. The results are calculated using the EF impact assessment method. The disinfection characterisation results are compared and the relative differences are shown. The impact categories are sorted based on relative differences.

| Impact category                               | Unit                             | Disposal | Disinfection |
|---|----------------------------------|----------|--------------|
| Ozone depletion                               | kg CFC-11-Eq                     | 2.41E-04 | -50%         |
| Land use                                      | dimensionless                    | 1.01E+04 | -48%         |
| Acidification                                 | mol H <sup>+</sup> -Eq           | 1.52E+01 | -48%         |
| Energy resources: non-renewable               | MJ, net calorific value          | 2.45E+04 | -48%         |
| Water use                                     | m <sup>3</sup> world Eq deprived | 6.04E+02 | -48%         |
| Climate change                                | kg CO <sub>2</sub> -Eq           | 1.84E+03 | -48%         |
| Photochemical oxidant formation: human health | kg NMVOC-Eq                      | 7.40E+00 | -48%         |
| Ionising radiation: human health              | kBq U235-Eq                      | 1.26E+02 | -48%         |
| Eutrophication: freshwater                    | kg P-Eq                          | 1.16E+00 | -48%         |
| Eutrophication: terrestrial                   | mol N-Eq                         | 2.16E+01 | -48%         |
| Eutrophication: marine                        | kg N-Eq                          | 1.99E+00 | -48%         |
| Ecotoxicity: freshwater                       | CTUe                             | 1.59E+04 | -47%         |
| Particulate matter formation                  | disease incidence                | 8.75E-05 | -47%         |
| Human toxicity: non-carcinogenic              | CTUh                             | 9.74E-05 | -47%         |
| Human toxicity: carcinogenic                  | CTUh                             | 1.28E-06 | -47%         |
| Material resources: metals/minerals           | kg Sb-Eq                         | 1.17E-01 | -46%         |



**Figure 9.1:** Contribution of medical consumables and the UV-C device to the LCIA results of the disinfection of a bedside cart inventory at the ICU of the LUMC in 2024. The EF impact family was used.

## 9.2. Sensitivity analyses

In total, three sensitivity analyses have been performed. For the first sensitivity analysis, the LCIA results have been calculated per medical consumable; blood gas syringe, CO<sub>2</sub> filter line, SpO<sub>2</sub> sensor, and vacutainer. For the second sensitivity analysis, the inventory levels of the bedside carts are reduced so that fewer medical consumables are present in the bedside carts before disposal or disinfection. For the third sensitivity analysis, a different impact assessment method, ReCiPe 2016 v1.03 midpoint (H), has been used.

### 9.2.1. Individual medical consumables

For this analysis, the environmental impacts of the disposal and disinfection of a single medical consumable were calculated and compared. The four medical consumables investigated were the blood gas syringe, CO<sub>2</sub> filter line, SpO<sub>2</sub> sensor, and vacutainer. It was assumed that one disinfection cycle was performed with the disinfection chamber of the UV-C device being filled with one type of medical consumable. For the blood gas syringe, CO<sub>2</sub> filter line, SpO<sub>2</sub> sensor, and vacutainer, a total of 7, 2, 2, and 4 items respectively can be simultaneously disinfected with one cycle (*Appendix III*). The unit processing tables can be found in *Appendix V*.

The LCIA results of the SpO<sub>2</sub> sensor show that disinfection has lower impacts across all impact categories, with reductions of 49–50% compared to disposal (*Table 9.2*). The reduction arises since the disposal alternative modelled two SpO<sub>2</sub> sensors while the disinfection alternative modelled only one. This suggests that the impacts are primarily driven by the life cycle of the SpO<sub>2</sub> sensor. The contribution analysis confirms that the SpO<sub>2</sub> sensor accounts for nearly the entire calculated difference in impacts (*Table 9.3*).

For the blood gas syringe, CO<sub>2</sub> filter line, and vacutainer, disinfection only shows a higher impact on metal and mineral use with increases of 120%, 49%, and 11% respectively (*Table 9.2*). The calculated impact for metal and mineral arises from the materials used to manufacture these medical consumables. The vacutainer contains steel for the needle which accounts for less than 1% of the total mass whereas the blood gas syringe and CO<sub>2</sub> filter line are solely made out of plastics. In contrast, the UV-C device does require metals and minerals to be manufactured. The disinfection alternative mainly showed higher impacts for metal and mineral use as a result of the rare metals (gold and tellurium) required for the electronic components of the UV-C device. This metal and mineral use impact was not observed for the SpO<sub>2</sub> sensor since it contained metals for the cable and LED. The disinfection alternative shows a reduction in impacts for all the other impact categories with the contributions of the blood gas syringe, CO<sub>2</sub> filter line, and vacutainer ranging between 60–96%, 59–98%, and 77–100% respectively.

**Table 9.2:** Relative LCIA results of the disposal and disinfection of different medical consumables. The results are calculated using the EF impact assessment method. The disinfection characterisation results are compared and the relative differences are shown. The results in bold indicate that the disinfection alternative has a higher impact than disposal.

| Impact category                               | Blood gas syringe | CO <sub>2</sub> filter line | SpO <sub>2</sub> sensor | Vacutainer |
|---|-------------------|-----------------------------|-------------------------|------------|
| Acidification                                 | -40%              | -38%                        | -50%                    | -45%       |
| Climate change                                | -46%              | -45%                        | -49%                    | -48%       |
| Ecotoxicity: freshwater                       | -40%              | -38%                        | -49%                    | -44%       |
| Energy resources: non-renewable               | -47%              | -45%                        | -49%                    | -48%       |
| Eutrophication: freshwater                    | -36%              | -29%                        | -50%                    | -43%       |
| Eutrophication: marine                        | -44%              | -42%                        | -49%                    | -46%       |
| Eutrophication: terrestrial                   | -43%              | -41%                        | -49%                    | -46%       |
| Human toxicity: carcinogenic                  | -32%              | -44%                        | -50%                    | -41%       |
| Human toxicity: non-carcinogenic              | -17%              | -16%                        | -50%                    | -35%       |
| Ionising radiation: human health              | -43%              | -39%                        | -50%                    | -47%       |
| Land use                                      | -48%              | -39%                        | -49%                    | -48%       |
| Material resources: metals/minerals           | <b>120%</b>       | <b>49%</b>                  | -49%                    | <b>11%</b> |
| Ozone depletion                               | -45%              | -49%                        | -49%                    | -50%       |
| Particulate matter formation                  | -42%              | -37%                        | -49%                    | -46%       |
| Photochemical oxidant formation: human health | -45%              | -43%                        | -49%                    | -47%       |
| Water use                                     | -45%              | -45%                        | -50%                    | -47%       |

**Table 9.3:** Contribution of individual medical consumables to the LCIA results of the disinfection of a single blood gas syringe, CO<sub>2</sub> filter line, SpO<sub>2</sub> sensor, or vacutainer. The contributions of the UV-C devices are not shown but are the remaining percentages required to reach 100%.

| Impact category                               | Blood gas syringe | CO <sub>2</sub> filter line | SpO <sub>2</sub> sensor | Vacutainer |
|---|-------------------|-----------------------------|-------------------------|------------|
| Acidification                                 | 84%               | 81%                         | 99%                     | 91%        |
| Climate change                                | 93%               | 91%                         | 99%                     | 96%        |
| Ecotoxicity: freshwater                       | 84%               | 80%                         | 99%                     | 89%        |
| Energy resources: non-renewable               | 94%               | 91%                         | 99%                     | 97%        |
| Eutrophication: freshwater                    | 78%               | 71%                         | 99%                     | 88%        |
| Eutrophication: marine                        | 89%               | 85%                         | 99%                     | 93%        |
| Eutrophication: terrestrial                   | 88%               | 85%                         | 99%                     | 93%        |
| Human toxicity: carcinogenic                  | 73%               | 90%                         | 99%                     | 85%        |
| Human toxicity: non-carcinogenic              | 60%               | 59%                         | 100%                    | 77%        |
| Ionising radiation: human health              | 88%               | 82%                         | 99%                     | 94%        |
| Land use                                      | 96%               | 82%                         | 99%                     | 97%        |
| Material resources: metals/minerals           | 23%               | 34%                         | 99%                     | 45%        |
| Ozone depletion                               | 91%               | 98%                         | 99%                     | 100%       |
| Particulate matter formation                  | 86%               | 79%                         | 99%                     | 93%        |
| Photochemical oxidant formation: human health | 92%               | 88%                         | 99%                     | 95%        |
| Water use                                     | 91%               | 91%                         | 99%                     | 94%        |

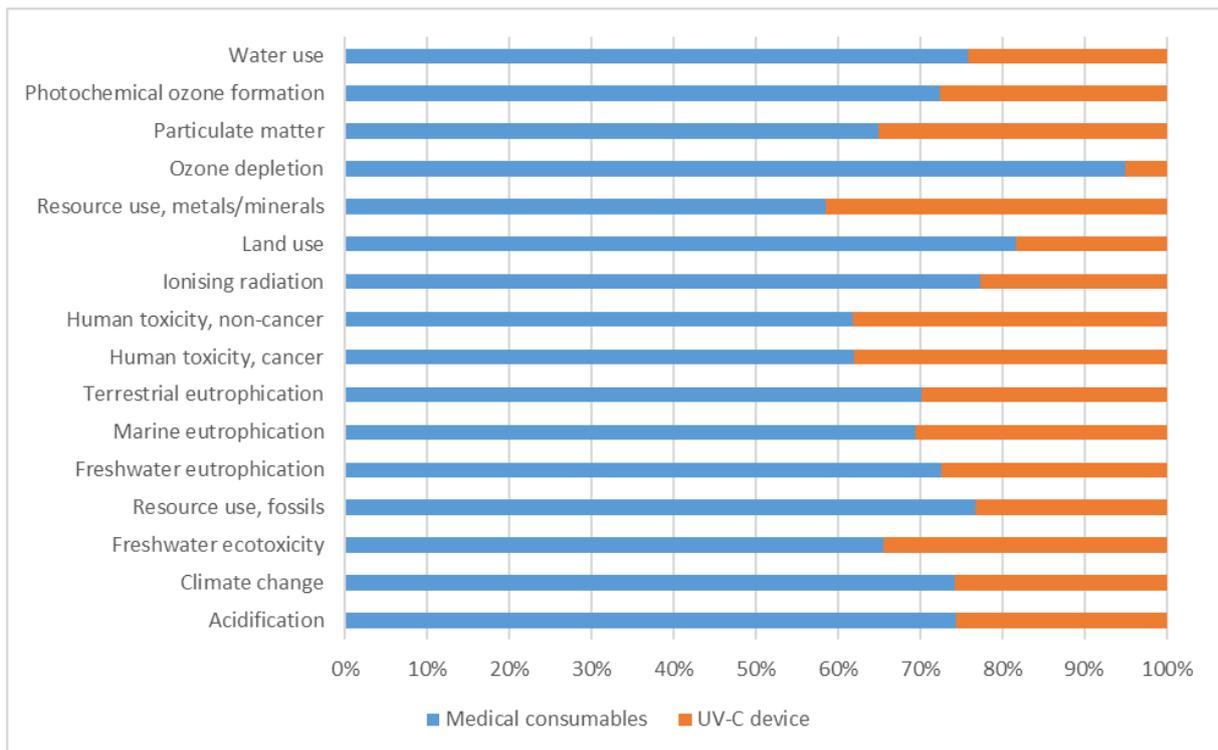
### 9.2.2. Inventory levels of bedside cart

It is highly unlikely that the contaminated bedside carts at the ICU of LUMC are completely filled, as healthcare professionals use medical consumables to provide care to patients in complete isolation. Therefore, an important variable to investigate for a sensitivity analysis is the inventory level of the contaminated bedside carts.

The LCIA results were calculated for bedside cart inventories of 50%, 30%, and 10% (*Appendix VII*). Even at a bedside cart inventory of just 10%, disinfection shows lower impacts across all impact categories with reductions of 14–47% compared to disposal (*Table 9.4*). The contribution of the UV-C device to the impacts of the disinfection alternative ranges between 5–45% (*Figure 9.2*). These results show that even if fewer medical consumables are contaminated, disinfection would still be more environmentally sustainable.

**Table 9.4:** LCIA results of the disposal and disinfection of bedside carts inventories of 10% at the ICU of the LUMC in 2024. The results are calculated using the EF impact assessment method. The disinfection characterisation results are compared and the relative differences are shown. The impact categories are sorted based on relative differences.

| Impact category                               | Unit                             | Disposal | Disinfection |
|---|----------------------------------|----------|--------------|
| Ozone depletion                               | kg CFC-11-Eq                     | 2.41E-05 | -47%         |
| Land use                                      | dimensionless                    | 1.01E+03 | -39%         |
| Ionising radiation: human health              | kBq U235-Eq                      | 1.26E+01 | -35%         |
| Energy resources: non-renewable               | MJ, net calorific value          | 2.45E+03 | -35%         |
| Water use                                     | m <sup>3</sup> world Eq deprived | 6.04E+01 | -34%         |
| Acidification                                 | mol H <sup>+</sup> -Eq           | 1.52E+00 | -33%         |
| Climate change                                | kg CO <sub>2</sub> -Eq           | 1.84E+02 | -33%         |
| Eutrophication: freshwater                    | kg P-Eq                          | 1.16E-01 | -31%         |
| Photochemical oxidant formation: human health | kg NMVOC-Eq                      | 7.40E-01 | -31%         |
| Eutrophication: terrestrial                   | mol N-Eq                         | 2.16E+00 | -29%         |
| Eutrophication: marine                        | kg N-Eq                          | 1.99E-01 | -28%         |
| Ecotoxicity: freshwater                       | CTUe                             | 1.59E+03 | -24%         |
| Particulate matter formation                  | disease incidence                | 8.75E-06 | -23%         |
| Human toxicity: carcinogenic                  | CTUh                             | 1.28E-07 | -19%         |
| Human toxicity: non-carcinogenic              | CTUh                             | 9.74E-06 | -19%         |
| Material resources: metals/minerals           | kg Sb-Eq                         | 1.17E-02 | -14%         |



**Figure 9.2:** Contribution of medical consumables and the UV-C device to the LCIA results of the disinfection of a bedside cart inventory of 10% at the ICU of the LUMC in 2024. The EF impact family was used.

### 9.2.3. ReCiPe impact assessment method

The last sensitivity analysis is based on the impact family used for the calculations of the characterisation results. For this analysis, the ReCiPe 2016 v1.03 midpoint (H) impact assessment method was selected (Huijbregts et al., 2017). ReCiPe 2016 has similar impact categories to EF but uses different characterisation models and factors.

The sensitivity analysis confirms that disinfecting medical consumables stored in ICU bedside carts results in lower environmental impacts than disposal across all impact categories (Table 9.5). These findings are in line with the previously calculated LCIA results for the bedside carts. Using the ReCiPe 2016 method, the disinfection alternative shows reductions in impacts between 48–49% while the EF method indicates reductions between 46–50%. This consistency across both impact assessment methods demonstrates that the findings are not a consequence of the chosen impact assessment method.

**Table 9.5:** LCIA results of the disposal and disinfection of bedside carts at the ICU of the LUMC in 2024. The results are calculated using the ReCiPe impact assessment method. The disinfection characterisation results are compared and the relative differences are shown. The impact categories are sorted based on relative differences.

| Impact category   | Unit                      | Disposal | Disinfection |
|---|---------------------------|----------|--------------|
| Ozone depletion   | kg CFC-11-Eq              | 1.04E-03 | -49%         |
| Land use  | m <sup>2</sup> *a crop-Eq | 7.16E+01 | -48%         |
| Human toxicity: non-carcinogenic                        | kg 1,4-DCB-Eq             | 1.04E+04 | -48%         |
| Material resources: metals/minerals                     | kg Cu-Eq                  | 7.62E+01 | -48%         |
| Acidification: terrestrial                              | kg SO <sub>2</sub> -Eq    | 1.06E+01 | -48%         |
| Energy resources: non-renewable, fossil                 | kg oil-Eq                 | 5.21E+02 | -48%         |
| Ecotoxicity: terrestrial                                | kg 1,4-DCB-Eq             | 1.74E+04 | -48%         |
| Water use   | m <sup>3</sup>            | 1.41E+01 | -48%         |
| Particulate matter formation                            | kg PM2.5-Eq               | 4.30E+00 | -48%         |
| Ecotoxicity: freshwater                                 | kg 1,4-DCB-Eq             | 6.27E+02 | -48%         |
| Climate change  | kg CO <sub>2</sub> -Eq    | 1.87E+03 | -48%         |
| Ecotoxicity: marine                                     | kg 1,4-DCB-Eq             | 7.91E+02 | -48%         |
| Eutrophication: freshwater                              | kg P-Eq                   | 1.16E+00 | -48%         |
| Ionising radiation                                      | kBq Co-60-Eq              | 1.09E+02 | -48%         |
| Photochemical oxidant formation: terrestrial ecosystems | kg NO <sub>x</sub> -Eq    | 5.12E+00 | -48%         |
| Photochemical oxidant formation: human health           | kg NO <sub>x</sub> -Eq    | 4.88E+00 | -48%         |

## 10. Discussion

The aim of this LCA study was to compare the potential environmental impacts of disposal and disinfection of medical consumables stored in the bedside carts of the ICU of the LUMC. The results of this study showed that UV-C disinfection has lower impacts for all impact categories compared to disposal.

For the UV-C device, data was provided by the manufacturer including the bill of materials and the locations of the different manufacturing sites. However, the energy consumption and capital goods required for the production as well as the packaging of the UV-C device were missing. Since the LCIA results of the disinfection of bedside carts were 46-50% smaller than disposal, it is expected that these cut-offs did not change the main outcomes.

Moreover, according to the manufacturer, customers may return the discarded UV-C devices at the end of their lifespan. Some components are commonly reused or recycled, such as the aluminium housing and glass plates. The direct reuse or recycling of the UV-C device at its end-of-life was not incorporated into the LCA study.

With the help of expert consultancy, the blood gas syringe, CO<sub>2</sub> filter line, SpO<sub>2</sub> sensor, and vacutainer were selected for the LCA study. The production processes were estimated based on the masses of the medical consumables and their different components. The manufacturers were not contacted. For some medical consumables, the main material (e.g. PVC or PE) was assumed for the entire medical consumable. Especially the SpO<sub>2</sub> sensor, which consisted of multiple components, required additional assumptions to define the inputs of the production processes. By contacting the manufacturers, the production processes could be more detailed.

These four medical consumables were used to create the proxy of the entire bedside cart. The proxy was created based on the quantities in which these four medical consumables were present in the bedside cart inventory. If more medical consumables were included, a more detailed proxy could have been made of the bedside cart. The sensitivity analysis showed that for all impact categories except metal/mineral use, UV-C disinfection of individual medical consumables had lower impacts compared to disposal. The three medical consumables that gave higher impacts for metal/mineral use for the disinfection alternative, contained no metal or less than 1% of their total mass. Besides the SpO<sub>2</sub> sensor, other medical consumables comprising the bedside cart inventory also contain metals but were not included. Therefore, it is expected that the main findings still hold if more medical consumables were included to create the bedside cart proxy.

Literature contains no LCA studies on UV-C disinfection of medical consumables. The results of this LCA study are one-of-a-kind and may confirm previous hypotheses regarding the impacts of disposal and disinfection as infection prevention methods.

The results of the LCA study may be used in broader efforts to create more sustainable policies for the Dutch healthcare sector and to reach the objectives set in the latest Green Deal for Sustainable Healthcare. As part of the Green Deal, an inventory analysis of all disposable medical consumables used in all university teaching hospitals was conducted (Noort et al., 2024). A shortlist of 22 medical consumables was compiled that offers the greatest potential for environmental benefits in the short term. Solutions include reducing the use of these single-use products or replacing them with reusable or more easily recyclable alternatives. Five medical consumables presented in this shortlist are stored in the bedside cart inventories including the two highest-ranked medical consumables; needleless syringes and SpO<sub>2</sub> sensors. UV-C disinfection would reduce the use of these medical consumables.

The efforts of this LCA study may also be useful to other ongoing research such as the ESCH-R project that aims to accelerate the adoption of circular interventions in Dutch hospitals. As part of this project, an evidence-based roadmap will be created for the successful implementation and upscaling of circular interventions in hospitals (Huijben et al., 2025). UVGI of medical consumables could be recommended as an intervention to hospitals to, ultimately, support the transformation of the healthcare value chain from linear to circular.

All in all, the conducted LCA study can be used to inform healthcare professionals that disposal of medical consumables as an infection prevention method has higher potential environmental impacts than UV-C disinfection. Manufacturers of UV-C devices may use these findings to promote their products as a more sustainable alternative. Manufacturers of medical consumables may use these findings to improve material sourcing and product design.

## 11. Conclusions

This study demonstrated that UV-C disinfection of unused medical consumables stored in bedside carts is a suitable and more environmentally sustainable alternative to disposal. It could be implemented at the ICU of the LUMC but also has the potential to be integrated into practices at ICU departments of other Dutch hospitals.

A bedside cart inventory contains medical consumables of which approximately 75% are considered manufacturer-proven or literature-supported suitable for UV-C disinfection. Additional studies should be conducted and more guidelines should be developed to create more clarity about UV-C compatibility of different materials. More research should be conducted to determine the effects of UV-C exposure on paper packaging and the (potential) degradation of medical consumables inside the packaging. The disinfection of a full bedside cart inventory including preparatory steps was estimated to be 65 minutes. The estimated time it takes to disinfect the materials does not substantially increase the workload of healthcare professionals. When ICU departments are considered similar or larger in size as described in this study, the avoided costs related to disposal would outweigh the costs related to disinfection.

The cradle-to-grave environmental impacts of disinfection of unused medical consumables are lower compared to disposal. No previous LCA studies on UVGI of medical consumables were identified. These findings align with national goals for a more circular healthcare sector and may support policy development under initiatives such as the Green Deal for Sustainable Healthcare. Adaptation of UVGI would reduce the material and CO<sub>2</sub> footprints of the healthcare sector.

## 12. Recommendations

Based on the findings of this thesis research, recommendations to the several stakeholders are defined and elaborated below.

### 12.1. LUMC

The LUMC is recommended to consider implementing UVGI in the ICU. The infection prevention team should assess the safety of UV-C disinfection of medical consumables. Medical consumables with plastic packaging are manufacturer-proven and confirmed to be suitable for UV-C exposure. Medical consumables with paper packaging are literature-supported and presumed to be suitable for UV-C exposure. Depending on the outcome of the decision of the infection prevention team, UVGI may or may not be implemented. If UVGI is deemed not ready to be implemented, additional research should be conducted to investigate the suitability of paper packaging. Additionally, the effects of UV-C exposure to the medical consumables inside the packaging should be determined. Besides, a risk analysis could be performed to investigate the risks and consequences associated with the incorrect use of the UV-C device.

If UVGI is deemed to be ready to be implemented, clear work protocols for care assistants should be formed. These protocols should be based on the user manual of the UV-C device and align with other hospital protocols. The user manual of the D25+ clearly states the workflow and correct use of the device. Educational sessions should be planned to teach the care assistants who will operate the UV-C device. They should be clearly instructed on how to place the medical consumables in the disinfection chamber of the UV-C device and how to maintain hand hygiene between disinfection cycles. To enable smooth use, it is advised to place the contaminated bedside cart, UV-C device, and clean bedside cart close to each other. Since the bedside carts are standardised, the compartments may be colour coded to quickly select which medical consumables are suitable for UV-C disinfection and which medical consumables must be disposed of.

If UV-C disinfection of all suitable medical consumables is too time-consuming, prioritising the disinfection of the most expensive consumables could offer a practical compromise between workload and reducing disposal costs. Additionally, the medical consumables in the bedside cart inventory that are unsuitable for UV-C disinfection may be replaced with suitable ones. UVGI may also be implemented in other departments of the LUMC. The use of UVGI may be further extended to disinfect reusable medical products or devices such as ultrasound probes or channel-less endoscopes. Depending on the sizes of these medical products or devices, UV-C devices with different dimensions are required.

## 12.2. Manufacturers

Manufacturers of UV-C devices are recommended to implement alarm systems that notify the operator if the device is used incorrectly. The UV-C devices usually notify the operator if insufficient UV-C radiation is generated by the device but not if the items inside the disinfection chamber are placed incorrectly. Manufacturers of UV-C devices address these issues in their user manuals but might consider design features such as sensors to prevent incorrect use.

Medical consumable, packaging, and UV-C device manufacturers should increase collaboration to ensure that medical consumables are manufacturer-proven suitable for UV-C disinfection. Such collaboration might be done in accordance with the European Union's SSbD framework. This framework highlights the need for transparent communication of material compatibility, robust safety standards, and the minimisation of environmental impact. By ensuring that medical consumables and packaging are manufacturer-proven suitable for UV-C disinfection, it becomes easier for hospitals to adopt UVGI.

## 12.3. Other hospitals

Other hospitals that are interested in the use of UV-C disinfection of contaminated and unused medical consumables should conduct an inventory analysis to determine the suitability of the medical consumables present at their facility. Unsuitable medical consumables may be switched with suitable alternatives. Additionally, they may conduct a workflow analysis, risk analysis, and cost-benefit analysis to assess the potential of UVGI. Taking into account patient isolation needs and financial factors, implementation of UV-C disinfection of medical consumables is considered most suitable for ICU departments comparable in size or larger than the LUMC (25 beds). For additional recommendations see section 12.1. *LUMC*.

## 13. References

- Amobonye, A. E., Bhagwat, P., Singh, S., & Pillai, S. (2023). Chapter 10—Biodegradability of Polyvinyl chloride. In A. Sarkar, B. Sharma, & S. Shekh (pp. 201–220). Elsevier.  
<https://doi.org/10.1016/B978-0-323-89858-4.00017-8>
- Apevienyeku, H. K., Ampofo, J., & Amankwaa Amoako, J. (2024). Recycling potential of medical plastic waste. *Discover Environment*, 2(1), 69. <https://doi.org/10.1007/s44274-024-00109-2>
- AZW. (2024). *De staat van de arbeidsmarkt zorg en welzijn 2024—Sectoranalyse*. AZWinfo.  
<https://www.azwinfo.nl/longread/de-staat-van-de-arbeidsmarkt-zorg-en-welzijn-2024-sectoranalyse/>
- Bergman, R. S. (2021). Germicidal UV Sources and Systems. *Photochemistry and Photobiology*, 97(3), 466–470. <https://doi.org/10.1111/php.13387>
- Boronat, C., Correcher, V., García-Guinea, J., & Bravo-Yagüe, J. C. (2024). Ultraviolet C radiation on polypropylene: A potential way to reduce plastic pollution. *Polymer Degradation and Stability*, 225, 110784. <https://doi.org/10.1016/j.polymdegradstab.2024.110784>
- Boyce, J. M., & Donskey, C. J. (2019). Understanding ultraviolet light surface decontamination in hospital rooms: A primer. *Infection Control & Hospital Epidemiology*, 40(9), 1030–1035. <https://doi.org/10.1017/ice.2019.161>
- Brady, R. R. W., Verran, J., Damani, N. N., & Gibb, A. P. (2009). Review of mobile communication devices as potential reservoirs of nosocomial pathogens. *Journal of Hospital Infection*, 71(4), 295–300. <https://doi.org/10.1016/j.jhin.2008.12.009>
- Brouwer, M., Picuno, C., Thoden van Velzen, E. U., Kuchta, K., De Meester, S., & Ragaert, K. (2019). The impact of collection portfolio expansion on key performance indicators of the Dutch recycling system for Post-Consumer Plastic Packaging Waste, a comparison

between 2014 and 2017. *Waste Management*, 100, 112–121.

<https://doi.org/10.1016/j.wasman.2019.09.012>

Caldeira, C., Farcal, R., Garmendia, A. I., Mancini, L., Tosches, D., Amelio, A., Rasmussen, K., Rauscher, H., Riego, S. J., & Sala, S. (2022). *Safe and sustainable by design chemicals and materials—Framework for the definition of criteria and evaluation procedure for chemicals and materials*. JRC Publications Repository. <https://doi.org/10.2760/487955>

Casini, B., Tuvo, B., Cristina, M. L., Spagnolo, A. M., Totaro, M., Baggiani, A., & Privitera, G. P. (2019). Evaluation of an Ultraviolet C (UVC) Light-Emitting Device for Disinfection of High Touch Surfaces in Hospital Critical Areas. *International Journal of Environmental Research and Public Health*, 16(19), Article 19. <https://doi.org/10.3390/ijerph16193572>

CBS. (2025, March 11). *Gemiddelde energietarieven voor consumenten*. Centraal Bureau voor de Statistiek. <https://www.cbs.nl/nl-nl/cijfers/detail/85592NED>

Chartier, Y. (2014). *Safe Management of Wastes from Health-care Activities*. World Health Organization. [https://apps.who.int/iris/bitstream/handle/10665/85349/9789241548564\\_eng.pdf](https://apps.who.int/iris/bitstream/handle/10665/85349/9789241548564_eng.pdf)

Cremers-Pijpers, S., van Rossum, C., Dautzenberg, M., Wertheim, H., Tostmann, A., & Hopman, J. (2021). Disinfecting handheld electronic devices with UV-C in a healthcare setting. *Infection Prevention in Practice*, 3(2), 100133. <https://doi.org/10.1016/j.infpip.2021.100133>

Cutler, T. D., & Zimmerman, J. J. (2011). Ultraviolet irradiation and the mechanisms underlying its inactivation of infectious agents. *Animal Health Research Reviews*, 12(1), 15–23. <https://doi.org/10.1017/S1466252311000016>

d'Aranda, E., Pons, S., Chelly, J., Atchade, E., Bonnet, L., Allary, C., Bonnet, L., Bruyere, M., d'Aranda, E., Deryckere, S., Gendre, A., Griton, M., Fournier, S., Hafiani, M., Lallemand, F., Martin, C., Pauchard, J.-C., Pons, S., Schoeffler, M., ... for the SFAR Research Network. (2025). Discarded intravenous medication in the ICU: The GAME-OVER multicenter

- prospective observational study. *Critical Care*, 29(1), 84. <https://doi.org/10.1186/s13054-025-05299-6>
- Demeersseman, N., Saegeman, V., Cossey, V., Devriese, H., & Schuermans, A. (2023). Shedding a light on ultraviolet-C technologies in the hospital environment. *Journal of Hospital Infection*, 132, 85–92. <https://doi.org/10.1016/j.jhin.2022.12.009>
- Duffy, J., Slutzman, J. E., Thiel, C. L., & Landes, M. (2023). Sustainable Purchasing Practices: A Comparison of Single-use and Reusable Pulse Oximeters in the Emergency Department. *Western Journal of Emergency Medicine*, 24(6), 1034–1042. <https://doi.org/10.5811/westjem.58258>
- Elstner, M., Contino, A., & Zaccaria, M. (2024). Recycle Glass: A contribution to the Circularity of Flat Glass. *Challenging Glass Conference Proceedings*, 9. <https://doi.org/10.47982/cgc.9.572>
- Eurofins. (2022). *Validation studies UV Smart D25*.
- European Environment Agency. (2023, June 8). *Early warning assessment related to the 2025 targets for municipal waste and packaging waste—The Netherlands*. <https://www.eea.europa.eu/publications/many-eu-member-states/netherlands>
- European Union. (2021). Commission Recommendation (EU) 2021/2279 of 15 December 2021 on the use of the Environmental Footprint methods to measure and communicate the life cycle environmental performance of products and organisations. In *OJ L* (Vol. 471). <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021H2279>
- European Union. (2022, September 6). *Emissions from heavy-duty vehicles (Euro VI): Certification rules*. EUR-Lex. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=legisum:mi0029>
- Fischer, I., Schmitt, W. F., Porth, H.-C., Allsopp, M. W., & Vianello, G. (2014). Poly(Vinyl Chloride). In *Ullmann's Encyclopedia of Industrial Chemistry* (pp. 1–30). John Wiley & Sons, Ltd. [https://doi.org/10.1002/14356007.a21\\_717.pub2](https://doi.org/10.1002/14356007.a21_717.pub2)

- Gahleitner, M., & Paulik, C. (2017). Chapter 11—Polypropylene and Other Polyolefins. In M. Gilbert (Ed.), *Brydson's Plastics Materials (Eighth Edition)* (pp. 279–309). Butterworth-Heinemann. <https://doi.org/10.1016/B978-0-323-35824-8.00011-6>
- Guinée, J. B., Gorrée, M., Heijungs, R., Huppes, G., Kleijn, R., Koning, A. de., Oers, L. van., Wegener Sleswijk, A., Suh, S., Udo de Haes, H. A., Bruijn, H. de., Duin, R. van., & Huijbregts, M. A. J. (Eds.). (2002). *Handbook on Life Cycle Assessment: Operational Guide to the ISO Standards* (Vol. 7). Springer Netherlands. <https://doi.org/10.1007/0-306-48055-7>
- Guinée, J. B., Heijungs, R., Huppes, G., Zamagni, A., Masoni, P., Buonamici, R., Ekvall, T., & Rydberg, T. (2011). Life Cycle Assessment: Past, Present, and Future. *Environmental Science & Technology*, 45(1), 90–96. <https://doi.org/10.1021/es101316v>
- Hamzavi, I. H., Lyons, A. B., Kohli, I., Narla, S., Parks-Miller, A., Gelfand, J. M., Lim, H. W., & Ozog, D. M. (2020). Ultraviolet germicidal irradiation: Possible method for respirator disinfection to facilitate reuse during the COVID-19 pandemic. *Journal of the American Academy of Dermatology*, 82(6), 1511–1512. <https://doi.org/10.1016/j.jaad.2020.03.085>
- Hosein, I., Madeloso, R., Nagaratnam, W., Villamaria, F., Stock, E., & Jinadatha, C. (2016). Evaluation of a pulsed xenon ultraviolet light device for isolation room disinfection in a United Kingdom hospital. *American Journal of Infection Control*, 44(9), e157–e161. <https://doi.org/10.1016/j.ajic.2016.01.044>
- Huffman, S., Webb, C., & Spina, S. P. (2020). Investigation into the cleaning methods of smartphones and wearables from infectious contamination in a patient care environment (I-SWIPE). *American Journal of Infection Control*, 48(5), 545–549. <https://doi.org/10.1016/j.ajic.2019.09.009>
- Huijben, J., van Raaij, E., Wagelmans, A., Piscicelli, L., Shen, W.-S., van Vliet, B., Gommers, D., Tibboel, D., Bakker, E., Dekkers, F., van Leeuwen, R., Diehl, J. C., & Hunfeld, N. (2025). Accelerating the transition from a linear to a circular healthcare sector: ESCH-R: study

- design and methodology. *Frontiers in Public Health*, 13.  
<https://doi.org/10.3389/fpubh.2025.1542187>
- Huijbregts, M. A. J., Steinmann, Z. J. N., Elshout, P. M. F., Stam, G., Verones, F., Vieira, M., Zijp, M., Hollander, A., & van Zelm, R. (2017). ReCiPe2016: A harmonised life cycle impact assessment method at midpoint and endpoint level. *The International Journal of Life Cycle Assessment*, 22(2), 138–147. <https://doi.org/10.1007/s11367-016-1246-y>
- ISO. (2006a). *Environmental management—Life cycle assessment—Principles and framework*. ISO14040. <https://www.iso.org/standard/37456.html>
- ISO. (2006b). *Environmental management—Life cycle assessment—Requirements and guidelines*. ISO14044. <https://www.iso.org/standard/38498.html>
- Jiménez-Reyes, M., Tenorio, D., García-Rosales, G., Jimenez-Becerril, J., & Luna-Castro, G. (2020). Effects of UV Radiation on Paper: A Chromatic Study. *Brazilian Journal of Analytical Chemistry*, 8. <https://doi.org/10.30744/brjac.2179-3425.AR-51-2020>
- Joseph, B., James, J., Kalarikkal, N., & Thomas, S. (2021). Recycling of medical plastics. *Advanced Industrial and Engineering Polymer Research*, 4(3), 199–208.  
<https://doi.org/10.1016/j.aiepr.2021.06.003>
- Khan, A., Rao, A., Reyes-Sacin, C., Hayakawa, K., Szpunar, S., Riederer, K., Kaye, K., Fishbain, J. T., & Levine, D. (2015). Use of portable electronic devices in a hospital setting and their potential for bacterial colonization. *American Journal of Infection Control*, 43(3), 286–288. <https://doi.org/10.1016/j.ajic.2014.11.013>
- Klasen, J., Rijcks, S., Gommers, D., Diehl, J. C., & Hunfeld, N. (2025). Circular material flow of medication in the intensive care unit. *Critical Care*, 29(1), 205.  
<https://doi.org/10.1186/s13054-025-05434-3>
- Kowalski, W. J., & Bahnfleth, W. P. (2000). UVGI Design basics for air and surface disinfection. *HPAC Heating, Piping, Air Conditioning*, 72(1), 10.

- Kumar, H., Kumagai, S., Saito, Y., & Yoshioka, T. (2024). Latest trends and challenges in PVC and copper recovery technologies for End-of-Life thin cables. *Waste Management*, 174, 400–410. <https://doi.org/10.1016/j.wasman.2023.12.012>
- Liang, S. Y., Theodoro, D. L., Schuur, J. D., & Marschall, J. (2014). Infection Prevention in the Emergency Department. *Annals of Emergency Medicine*, 64(3), 299–313. <https://doi.org/10.1016/j.annemergmed.2014.02.024>
- Lindsley, W. G., Martin Jr., S. B., Thewlis, R. E., Sarkisian, K., Nwoko, J. O., Mead, K. R., & Noti, J. D. (2015). Effects of Ultraviolet Germicidal Irradiation (UVGI) on N95 Respirator Filtration Performance and Structural Integrity. *Journal of Occupational and Environmental Hygiene*, 12(8), 509–517. <https://doi.org/10.1080/15459624.2015.1018518>
- Liscynesky, C., Hines, L. P., Smyer, J., Hanrahan, M., Orellana, R. C., & Mangino, J. E. (2017). The Effect of Ultraviolet Light on Clostridium difficile Spore Recovery Versus Bleach Alone. *Infection Control & Hospital Epidemiology*, 38(9), 1116–1117. <https://doi.org/10.1017/ice.2017.126>
- Lokate, M., & Brühwasser, C. (2019). *Report UVc Smart machine Efficacy testing* [Unpublished].
- LUMC. (2023). *Isolatie, Strikte isolatie (LUMC-protocol)*.
- MacNeill, A. J., Hopf, H., Khanuja, A., Alizamir, S., Bilec, M., Eckelman, M. J., Hernandez, L., McGain, F., Simonsen, K., Thiel, C., Young, S., Lagasse, R., & Sherman, J. D. (2020). Transforming The Medical Device Industry: Road Map To A Circular Economy. *Health Affairs*, 39(12), 2088–2097. <https://doi.org/10.1377/hlthaff.2020.01118>
- Magill, S. S., Edwards, J. R., Bamberg, W., Beldavs, Z. G., Dumyati, G., Kainer, M. A., Lynfield, R., Maloney, M., McAllister-Hollod, L., Nadle, J., Ray, S. M., Thompson, D. L., Wilson, L. E., & Fridkin, S. K. (2014). Multistate Point-Prevalence Survey of Health Care–Associated Infections. *New England Journal of Medicine*, 370(13), 1198–1208. <https://doi.org/10.1056/NEJMoa1306801>

Mahida, N., Vaughan, N., & Boswell, T. (2013). First UK evaluation of an automated ultraviolet-C room decontamination device (Tru-D™). *Journal of Hospital Infection*, 84(4), 332–335.

<https://doi.org/10.1016/j.jhin.2013.05.005>

Mathew, J. I., Cadnum, J. L., Sankar, T., Jencson, A. L., Kundrapu, S., & Donskey, C. J. (2016). Evaluation of an enclosed ultraviolet-C radiation device for decontamination of mobile handheld devices. *American Journal of Infection Control*, 44(6), 724–726.

<https://doi.org/10.1016/j.ajic.2015.12.043>

McKeen, L. (2012). 4—Styrenic Plastics. In L. McKeen (Ed.), *The Effect of Sterilization on Plastics and Elastomers (Third Edition)* (pp. 85–132). William Andrew Publishing.

<https://doi.org/10.1016/B978-1-4557-2598-4.00004-6>

Memarzadeh, F., Olmsted, R. N., & Bartley, J. M. (2010). Applications of ultraviolet germicidal irradiation disinfection in health care facilities: Effective adjunct, but not stand-alone technology. *American Journal of Infection Control*, 38(5, Supplement), S13–S24.

<https://doi.org/10.1016/j.ajic.2010.04.208>

Ministerie van Infrastructuur en Waterstaat. (2024a, January 1). *21 AVI-vliegas*

[Overzichtspagina]. LAP3. <https://lap3.nl/sectorplannen/sectorplannen/avi-vliegas/>

Ministerie van Infrastructuur en Waterstaat. (2024b, April 30). *Afvalverwerking in Nederland gegevens 2022* [Rapport]. Ministerie van Algemene Zaken.

<https://www.rijksoverheid.nl/documenten/rapporten/2024/04/30/afvalverwerking-in-nederland-gegevens-2022>

Ministerie van Infrastructuur en Waterstaat. (2025, January 31). *Samenstelling van het huishoudelijk restafval, sorteeranalyses 2023 en gemiddelde driejaarlijkse samenstelling 2022—Rapport—Rijksoverheid.nl* [Report]. Ministerie van Algemene Zaken.

<https://www.rijksoverheid.nl/documenten/rapporten/2025/01/31/samenstelling-van-het-huishoudelijk-restafval-sorteeranalyses-2023-en-gemiddelde-driejaarlijkse-samenstelling-2022>

- Mitxelena-Iribarren, O., Mondragon, B., Pérez-Lorenzo, E., Smerdou, C., Guillen-Grima, F., Sierra-Garcia, J. E., Rodriguez-Merino, F., & Arana, S. (2022). Evaluation of the degradation of materials by exposure to germicide UV-C light through colorimetry, tensile strength and surface microstructure analyses. *Materials Today Communications*, 31, 103690. <https://doi.org/10.1016/j.mtcomm.2022.103690>
- Mughal, F., Mallen, C. D., & McKee, M. (2021). The impact of COVID-19 on primary care in Europe. *The Lancet Regional Health – Europe*, 6. <https://doi.org/10.1016/j.lanepe.2021.100152>
- Nerandzic, M. M., Cadnum, J. L., Pultz, M. J., & Donskey, C. J. (2010). Evaluation of an automated ultraviolet radiation device for decontamination of *Clostridium difficile* and other healthcare-associated pathogens in hospital rooms. *BMC Infectious Diseases*, 10(1), 197. <https://doi.org/10.1186/1471-2334-10-197>
- NFU. (2024). *Caio universitair medische centra 2024-2025*. <https://www.nfu.nl/voor-umc-medewerkers/caio-universitair-medische-centra>
- Noort, B., Gorter, S., Vree, C. de., Smit, A., Vork, K., Visser, I., Cepalla, G., Nijeholt, J. à., Pijl, M. van der., & Breed, R. (2024, March). *Landelijke Inventarisatie Medische Disposables umc's*. <https://www.greendealduurzamezorg.nl/files/rapport-nfu-project-disposables-260624.pdf>
- NVIC. (2023, November). *IC-register*. <https://www.nvic.nl/ic-register/>
- O'Hearn, K., Gertsman, S., Sampson, M., Webster, R., Tsampalieros, A., Ng, R., Gibson, J., Lobos, A. T., Acharya, N., Agarwal, A., Boggs, S., Chamberlain, G., Staykov, E., Sikora, L., & McNally, J. D. (2020). Decontaminating N95 and SN95 masks with ultraviolet germicidal irradiation does not impair mask efficacy and safety. *Journal of Hospital Infection*, 106(1), 163–175. <https://doi.org/10.1016/j.jhin.2020.07.014>
- Ozkaynak, M., Unertl, K., Johnson, S., Brixey, J., & Haque, S. N. (2022). Clinical Workflow Analysis, Process Redesign, and Quality Improvement. In J. T. Finnell & B. E. Dixon (Eds.),

- Clinical Informatics Study Guide: Text and Review* (pp. 103–118). Springer International Publishing. [https://doi.org/10.1007/978-3-030-93765-2\\_8](https://doi.org/10.1007/978-3-030-93765-2_8)
- PBL. (2025, February 20). *Integrale Circulaire Economie Rapportage 2025 | Planbureau voor de Leefomgeving*. <https://www.pbl.nl/publicaties/integrale-circulaire-economie-rapportage-2025>
- Reed, N. G. (2010). The History of Ultraviolet Germicidal Irradiation for Air Disinfection. *Public Health Reports*, 125(1), 15–27. <https://doi.org/10.1177/003335491012500105>
- Reid, D., Ternes, K., Winowiecki, L., Yonke, C., Riege, B., Fregoli, F., Passey, D., Stibich, M., & Olmsted, R. N. (2020). Germicidal irradiation of portable medical equipment: Mitigating microbes and improving the margin of safety using a novel, point of care, germicidal disinfection pod. *American Journal of Infection Control*, 48(1), 103–105. <https://doi.org/10.1016/j.ajic.2019.07.021>
- Rijksoverheid. (2015). *C-190 Green Deal Nederland op weg naar duurzame zorg*. [https://www.greendeals.nl/sites/default/files/downloads/Intentieverklaring\\_C-190-Duurzame-zorg-v2.pdf](https://www.greendeals.nl/sites/default/files/downloads/Intentieverklaring_C-190-Duurzame-zorg-v2.pdf)
- Rijksoverheid. (2018). *C-226 Green Deal: Duurzame zorg voor een gezonde toekomst*. [https://www.greendeals.nl/sites/default/files/2019-05/Deal%20tekst%20GreenDeal%20226%20Duurzame%20zorg%20voor%20gezonde%20toekomst\\_0.pdf](https://www.greendeals.nl/sites/default/files/2019-05/Deal%20tekst%20GreenDeal%20226%20Duurzame%20zorg%20voor%20gezonde%20toekomst_0.pdf)
- Rijksoverheid. (2022). *C-238 Green Deal Working together towards sustainable healthcare*. <https://www.greendeals.nl/sites/default/files/2023-01/C-238%20Green%20Deal%20Working%20together%20towards%20sustainable%20healthcare.pdf>
- Rijksoverheid. (2024). *Meer duurzaamheid in de zorg* [Onderwerp]. Ministerie van Algemene Zaken. <https://www.rijksoverheid.nl/onderwerpen/duurzame-zorg/meer-duurzaamheid-in-de-zorg>

- Rizan, C., Mortimer, F., Stancliffe, R., & Bhutta, M. F. (2020). Plastics in healthcare: Time for a re-evaluation. *Journal of the Royal Society of Medicine*, 113(2), 49–53.  
<https://doi.org/10.1177/0141076819890554>
- Romanello, M., Napoli, C. di, Green, C., Kennard, H., Lampard, P., Scamman, D., Walawender, M., Ali, Z., Ameli, N., Ayeb-Karlsson, S., Beggs, P. J., Belesova, K., Ford, L. B., Bowen, K., Cai, W., Callaghan, M., Campbell-Lendrum, D., Chambers, J., Cross, T. J., ... Costello, A. (2023). The 2023 report of the Lancet Countdown on health and climate change: The imperative for a health-centred response in a world facing irreversible harms. *The Lancet*, 402(10419), 2346–2394. [https://doi.org/10.1016/S0140-6736\(23\)01859-7](https://doi.org/10.1016/S0140-6736(23)01859-7)
- Ronca, S. (2017). Chapter 10—Polyethylene. In M. Gilbert (Ed.), *Brydson's Plastics Materials (Eighth Edition)* (pp. 247–278). Butterworth-Heinemann. <https://doi.org/10.1016/B978-0-323-35824-8.00010-4>
- Rutala, W. A., Boyce, J. M., & Weber, D. J. (2023). Disinfection, sterilization and antisepsis: An overview. *American Journal of Infection Control*, 51(11), A3–A12.  
<https://doi.org/10.1016/j.ajic.2023.01.001>
- Rutala, W. A., Gergen, M. F., & Weber, D. J. (2010). Room decontamination with UV radiation. *Infection Control and Hospital Epidemiology*, 31(10), 1025–1029.  
<https://doi.org/10.1086/656244>
- Scott, R., Joshi, L. T., & McGinn, C. (2022). Hospital surface disinfection using ultraviolet germicidal irradiation technology: A review. *Healthcare Technology Letters*, 9(3), 25–33.  
<https://doi.org/10.1049/htl2.12032>
- Steenmeijer, M., Pieters, L., Warmenhoven, N., Huiberts, E., & Stoelinga, M. (2022). *Het effect van de Nederlandse zorg op het milieu. Methode voor milieuoetafdruk en voorbeelden voor een goede zorgomgeving*. Rijksinstituut voor Volksgezondheid en Milieu RIVM.  
<https://doi.org/10.21945/RIVM-2022-0127>

- Stichting Verpact. (2024, July 18). *Toelichting op het verslagleggingsformulier—Resultaten verpakkingen 2023*. <https://www.verpact.nl/sites/default/files/2024-08/Toelichting%20op%20het%20verslagleggingsformulier%202023.pdf>
- Streeklaboratorium voor de Volksgezondheid Kennemerland. (2019). *Validation study: Microbiological efficacy of UVC-disinfection with UV Smart D25*.
- UV Smart. (2020). *D25 radiation information*.
- UV Smart. (2021, January 6). *Whitepaper UV-C disinfection | Safety, efficiency and practical application*. [https://cdn.prod.website-files.com/6751adf98efab483e51c2ef5/6751adf98efab483e51c30f7\\_DOC-997%20rev1%20-%20UVSmart\\_Whitepaper\\_EN.pdf](https://cdn.prod.website-files.com/6751adf98efab483e51c2ef5/6751adf98efab483e51c30f7_DOC-997%20rev1%20-%20UVSmart_Whitepaper_EN.pdf)
- UV Smart. (2023). *D25 V2—Clinical Evaluation Report*.
- UV Smart. (2024). *UV Smart D25 Gebruiksaanwijzing*.
- UV Smart. (2025). *UV Smart D25 Material Compatibility Index*.
- Verhaar, E., van de Pol, M., Verhoeven, R., & van Rooijen, M. (2023). *Materiaalcompatibiliteit van medische verpakkingen met UV-C straling* [Bachelor thesis].
- Visser-Hoekstra, D. D. (2021). *Desinfectie van disposable verpakkingen door middel van UV-C* [Unpublished].
- Wong, T., Woznow, T., Petrie, M., Murzello, E., Muniak, A., Kadora, A., & Bryce, E. (2016). Postdischarge decontamination of MRSA, VRE, and *Clostridium difficile* isolation rooms using 2 commercially available automated ultraviolet-C-emitting devices. *American Journal of Infection Control*, 44(4), 416–420. <https://doi.org/10.1016/j.ajic.2015.10.016>
- Yang, H., Hu, J., Li, P., & Zhang, C. (2020). Ultraviolet germicidal irradiation for filtering facepiece respirators disinfection to facilitate reuse during COVID-19 pandemic: A review. *Photodiagnosis and Photodynamic Therapy*, 31, 101943. <https://doi.org/10.1016/j.pdpdt.2020.101943>
- Yang, J.-H., Wu, U.-I., Tai, H.-M., & Sheng, W.-H. (2019). Effectiveness of an ultraviolet-C disinfection system for reduction of healthcare-associated pathogens. *Journal of*

*Microbiology, Immunology and Infection*, 52(3), 487–493.

<https://doi.org/10.1016/j.jmii.2017.08.017>

Yin, R., Dai, T., Avci, P., Jorge, A. E. S., de Melo, W. C., Vecchio, D., Huang, Y.-Y., Gupta, A., & Hamblin, M. R. (2013). Light based anti-infectives: Ultraviolet C irradiation, photodynamic therapy, blue light, and beyond. *Current Opinion in Pharmacology*, 13(5), 731–762. <https://doi.org/10.1016/j.coph.2013.08.009>

Zijp, M., Velders, G., & Waaijers, S. (2020, November 18). *Duurzame zorg komt dubbel tot zijn recht*. <https://www.medischcontact.nl/actueel/laatste-nieuws/artikel/duurzame-zorg-komt-dubbel-tot-zijn-recht>

## 14. Appendices

### 14.1. Appendix I: Inventory analysis

**Table 14.1:** List of medical consumables stored in a bedside cart alongside their quantity and purchase price.

| Name   | Price (€) | Quantity | Total price (€) |
|--|-----------|----------|-----------------|
| 3-way stopcock   | 0.59      | 6        | 3.54            |
| 3-way stopcock with extension line 14 cm               | 1.3       | 4        | 5.2             |
| Adult nasal cannula with curved prongs and tube        | 0.59      | 1        | 0.59            |
| Adult SpO <sub>2</sub> sensor                          | 14.68     | 2        | 27.36           |
| Adult-paediatric intubated CO <sub>2</sub> filter line | 20.88     | 2        | 41.76           |
| Anaerobic culture vial blue                            | 4.79      | 2        | 9.58            |
| Anaerobic culture vial orange                          | 4.79      | 2        | 9.58            |
| Arterial cannula                                       | 3.91      | 3        | 11.73           |
| Artery clamp   | 3.28      | 3        | 9.84            |
| Bionector  | 1.44      | 5        | 7.2             |
| Blood collection adapter                               | 0.14      | 8        | 1.12            |
| Blood collection pod                                   | 0.04      | 2        | 0.08            |
| Blood collection tube CAT 10 ml                        | 0.13      | 1        | 0.13            |
| Blood collection tube CAT 14 ml                        | 0.13      | 2        | 0.26            |
| Blood collection tube citrate 2.7 ml                   | 0.14      | 8        | 1.12            |
| Blood collection tube citrate 3.5 ml                   | 0.14      | 2        | 0.28            |
| Blood collection tube EDTA 10 ml                       | 0.14      | 1        | 0.14            |
| Blood collection tube EDTA 2 ml                        | 0.13      | 5        | 0.65            |
| Blood collection tube EDTA 4 ml                        | 0.13      | 1        | 0.13            |
| Blood collection tube EST 3 ml                         | 0.18      | 2        | 0.36            |
| Blood collection tube SST 3.5 ml                       | 0.18      | 5        | 0.9             |
| Blood collection tube SST 8.5 ml                       | 0.22      | 1        | 0.22            |
| Blood culture syringe                                  | 0.2       | 2        | 0.4             |
| Blood gas syringe                                      | 1.28      | 15       | 19.2            |
| Cannula with air filter                                | 0.86      | 3        | 2.58            |
| Catheter spigot  | 0.18      | 2        | 0.36            |
| Catheter tip syringe                                   | 0.5       | 3        | 1.5             |
| Cavilon spray  | 14.14     | 1        | 14.14           |
| Cavilon stick  | 1.64      | 2        | 3.28            |
| Climatrach HME filter                                  | 1.8       | 2        | 3.6             |
| Cohesive fixation bandage 4 x 4 cm                     | 0.74      | 1        | 0.74            |
| Cohesive fixation bandage 4 x 6 cm                     | 0.88      | 1        | 0.88            |
| Combi-lock   | 0.09      | 10       | 0.9             |
| Compress 10 x 10 cm pack                               | 1.15      | 1        | 1.15            |
| Compress 5 x 5 cm pack                                 | 0.4       | 1        | 0.4             |
| Connector feeding tube                                 | 0.34      | 5        | 1.7             |
| Container with red lid                                 | 0.32      | 4        | 1.28            |
| Cotton tip   | 0.02      | 5        | 0.1             |
| Disinfecting cap for needleless connectors             | 0.41      | 20       | 8.2             |

|   |      |    |       |
|---|------|----|-------|
| Disposable tourniquet                       | 5.13 | 2  | 10.26 |
| ECG sticker                                 | 1.66 | 20 | 33.2  |
| Elastic bandage 6 cm                        | 0.16 | 1  | 0.16  |
| Elastic bandage 8 cm                        | 0.16 | 1  | 0.16  |
| Endotracheal tube holder                    | 8.46 | 2  | 16.92 |
| Enfit 3-way stopcock                        | 3.59 | 2  | 7.18  |
| Enfit female                                | 2.75 | 2  | 5.5   |
| Enfit male                                  | 0.81 | 2  | 1.62  |
| Enteral syringe                             | 0.58 | 2  | 1.16  |
| Enteral syringe cap                         | 0.34 | 5  | 1.7   |
| Extension line 30 cm                        | 1.33 | 2  | 2.66  |
| Eye ointment                                | 1.35 | 1  | 1.35  |
| Filta-guard bacterial filter                | 1.67 | 1  | 1.67  |
| Flask of distilled water NaCl 0.9% 10 ml    | ?    | 4  | ?     |
| Green Venflon needle protected IV cannula   | 2.52 | 2  | 5.04  |
| Hypodermic needle                           | 0.16 | 5  | 0.8   |
| Infusion set                                | 4.37 | 2  | 8.74  |
| Klinion absorbent wound dressing 10 x 20 cm | 0.47 | 2  | 0.94  |
| Klinion absorbent wound dressing 20 x 20 cm | 0.76 | 2  | 1.52  |
| Klinion absorbent wound dressing 9 x 12 cm  | 0.58 | 2  | 1.16  |
| Klinion compress 10 x 10 cm 2 pcs           | 0.09 | 4  | 0.36  |
| Klinion compress 10 x 10 cm 5 pcs           | 0.36 | 10 | 3.6   |
| Klinion compress 5 x 5 cm                   | 0.05 | 5  | 0.25  |
| Klinion drain compress 10 x 10 cm           | 0.09 | 5  | 0.45  |
| Leukomed wound dressing 10 x 25 cm          | 0.47 | 2  | 0.94  |
| Leukomed wound dressing 10 x 30 cm          | 0.58 | 2  | 1.16  |
| Leukomed wound dressing 5 x 7.2 cm          | 0.09 | 5  | 0.45  |
| Leukomed wound dressing 8 x 10 cm           | 0.18 | 5  | 0.9   |
| Leukomed wound dressing 8 x 15 cm           | 0.27 | 5  | 1.35  |
| Leukoplast adhesive plaster 1.25 cm x 5 m   | 0.57 | 1  | 0.57  |
| Leukoplast roll plaster 2.5 cm x 5 m        | ?    | 1  | ?     |
| Leukoplast wound closure strip              | 1.01 | 5  | 5.05  |
| Leukosilk adhesive plaster 1.25 cm x 5 m    | 0.57 | 1  | 0.57  |
| Leukosilk adhesive plaster 2.5 cm x 5 m     | 0.86 | 1  | 0.86  |
| Mepilex border flex lite                    | 2.07 | 5  | 10.35 |
| Mepitel one                                 | 0.74 | 5  | 3.7   |
| Microbiological swab                        | 0.47 | 5  | 2.35  |
| Monitoring line                             | 0.99 | 3  | 2.97  |
| Mucus specimen trap set                     | 3.4  | 2  | 6.8   |
| Nasal fix plaster                           | 0.4  | 3  | 1.2   |
| Needleless shielded cannula                 | 0.49 | 15 | 7.35  |
| Non-woven retention tape 5 x 10 cm          | 0.29 | 1  | 0.29  |
| Oral care swab                              | 0.16 | 10 | 1.6   |
| Oxygen catheter                             | 0.5  | 2  | 1     |
| Oxygen tube                                 | 0.85 | 1  | 0.85  |
| Permanent marker                            | 0.18 | 1  | 0.18  |

|   |       |   |       |
|---|-------|---|-------|
| pH-indicator strips                             | 22.45 | 1 | 22.45 |
| Pink Venflon needle protected IV cannula        | 2.52  | 2 | 5.04  |
| Purol lipstick                                  | 2.32  | 1 | 2.32  |
| Rectal temperature probe                        | 3.06  | 2 | 6.12  |
| Scissor   | 2.56  | 3 | 7.68  |
| Secondary line for infusion therapy             | 1.24  | 3 | 3.72  |
| Stitch cutter                                   | 0.16  | 3 | 0.48  |
| Stomahesive                                     | 2.68  | 2 | 5.36  |
| Syringe 10 ml                                   | 0.14  | 5 | 0.7   |
| Syringe 20 ml                                   | 0.02  | 5 | 0.1   |
| Syringe 5 ml                                    | 0.13  | 5 | 0.65  |
| Syringe 50 ml                                   | 0.5   | 2 | 1     |
| Syringe NaCl 0.9% 10 ml                         | ?     | 8 | ?     |
| Tegaderm CHG I.V. securement dressing           | 10.17 | 2 | 20.34 |
| Tegaderm I.V. securement dressing 1681          | 0.43  | 5 | 2.15  |
| Tegaderm transparant film dressing 1624W        | 0.47  | 5 | 2.35  |
| Tegaderm transparant film dressing 1626W        | 1.08  | 5 | 5.4   |
| Tensoplas elastic adhesive plaster 2.5 x 4.5 cm | 2.9   | 1 | 2.9   |
| Tipstop compression dressing                    | 0.86  | 2 | 1.72  |
| Transafix fixation strip                        | 2.23  | 5 | 11.15 |
| Urine bag                                       | 0.65  | 2 | 1.3   |
| Venipuncture blood collection set               | 1.4   | 2 | 2.8   |
| Wooden tongue depressor                         | 0.02  | 5 | 0.1   |
| Yellow utility clip                             | 8.1   | 5 | 40.5  |

**Table 14.2:** Results of the inventory analysis of the medical consumables stored in a bedside cart.

| Name   | Manufacturer      | Reference number | Packaging front | Packaging back |
|--|-------------------|------------------|-----------------|----------------|
| 3-way stopcock   | Codan             | 44.5852          | Plastic         | Paper          |
| 3-way stopcock with extension line 14 cm               | Codan             | 71.4550          | Plastic         | Paper          |
| Adult nasal cannula with curved prongs and tube        | Intersurgical     | 1165000          | Plastic         | Plastic        |
| Adult SpO <sub>2</sub> sensor                          | Covidien          | MAXAI            | Plastic         | Plastic        |
| Adult-paediatric intubated CO <sub>2</sub> filter line | Medtronic         | MVAIH            | Plastic         | Plastic        |
| Anaerobic culture vial blue                            | BD                | 442023           | Plastic         | Plastic        |
| Anaerobic culture vial orange                          | BD                | 442022           | Plastic         | Plastic        |
| Arterial cannula                                       | BD                | 682245           | Plastic         | Paper          |
| Artery clamp   | -                 | -                | -               | -              |
| Bionector  | Vygon             | 896.03           | Plastic         | Paper          |
| Blood collection adapter                               | BD                | 143168           | Plastic         | Plastic        |
| Blood collection pod                                   | ?                 | ?                | Plastic         | Plastic        |
| Blood collection tube CAT 10 ml                        | BD                | 367896           | Plastic         | Plastic        |
| Blood collection tube CAT 14 ml                        | BD                | 369032           | Plastic         | Plastic        |
| Blood collection tube citrate 2.7 ml                   | BD                | 364305           | Plastic         | Plastic        |
| Blood collection tube citrate 3.5 ml                   | Greiner Bio-One   | 454332           | Plastic         | Plastic        |
| Blood collection tube EDTA 10 ml                       | BD                | 367525           | Plastic         | Plastic        |
| Blood collection tube EDTA 2 ml                        | BD                | 368841           | Plastic         | Plastic        |
| Blood collection tube EDTA 4 ml                        | BD                | 368861           | Plastic         | Plastic        |
| Blood collection tube EST 3 ml                         | BD                | 362725           | Plastic         | Plastic        |
| Blood collection tube SST 3.5 ml                       | BD                | 367957           | Plastic         | Plastic        |
| Blood collection tube SST 8.5 ml                       | BD                | 367953           | Plastic         | Plastic        |
| Blood culture syringe                                  | BD                | 307737           | Plastic         | Paper          |
| Blood gas syringe                                      | Westmed           | 11561344         | Plastic         | Paper          |
| Cannula with air filter                                | Codan             | 64.6008          | Plastic         | Paper          |
| Catheter spigot  | Medicoplast       | 901000           | Plastic         | Paper          |
| Catheter tip syringe                                   | BD                | 300867           | Plastic         | Paper          |
| Cavilon spray  | Essity            | 72653-00         | Paper           | Paper          |
| Cavilon stick  | Essity            | 72654-01         | Paper           | Paper          |
| Climatrach HME filter                                  | Flexicare Medical | 300-730-000      | Plastic         | Paper          |
| Cohesive fixation bandage 4 x 4 cm                     | Medeco            | 132378           | Paper           | Paper          |
| Cohesive fixation bandage 4 x 6 cm                     | Medeco            | 132379           | Paper           | Paper          |
| Combi-lock   | Codan             | 16.5285          | Plastic         | Paper          |
| Compress 10 x 10 cm pack                               | ?                 | ?                | None            | None           |
| Compress 5 x 5 cm pack                                 | ?                 | ?                | None            | None           |
| Connector feeding tube                                 | Vygon             | 801.00D          | Plastic         | Paper          |
| Container with red lid                                 | ?                 | ?                | Plastic         | Plastic        |
| Cotton tip   | Servoprax         | G80215           | Plastic         | Plastic        |
| Disinfecting cap for needleless connectors             | 3M                | CFF10-250R       | Plastic         | Plastic        |
| Disposable tourniquet                                  | Vygon             | -                | Plastic         | Plastic        |

|   |                          |                        |         |         |
|---|--------------------------|------------------------|---------|---------|
| ECG sticker                                 | 3M                       | 7100212973             | None    | Paper   |
| Elastic bandage 6 cm                        | Medeco                   | 40132228               | Plastic | Plastic |
| Elastic bandage 8 cm                        | Medeco                   | 40132229               | Plastic | Plastic |
| Endotracheal tube holder                    | Insight Medical Products | TFP/200 Adult Standard | Plastic | Plastic |
| Enfit 3-way stopcock                        | Danumed                  | DA10517022             | Plastic | Paper   |
| Enfit female                                | Cair                     | NCE101A                | Plastic | Paper   |
| Enfit male                                  | Cair                     | NCE104A                | Plastic | Paper   |
| Enteral syringe                             | Danumed                  | DA10216001             | Plastic | Paper   |
| Enteral syringe cap                         | ?                        | ?                      | Plastic | Paper   |
| Extension line 30 cm                        | Codan                    | 71.4586                | Plastic | Paper   |
| Eye ointment                                | Added Pharma             | 8717729310878          | Plastic | Paper   |
| Filta-guard bacterial filter                | Intersurgical            | 1944000                | Plastic | Plastic |
| Flask of distilled water NaCl 0.9% 10 ml    | Fresenius kabi           | ?                      | Plastic | Plastic |
| Green Venflon needle protected IV cannula   | BD                       | 393227                 | Plastic | Paper   |
| Hypodermic needle                           | BD                       | 303262                 | Plastic | Paper   |
| Infusion set                                | Arcomed                  | 1033050591             | Plastic | Paper   |
| Klinion absorbent wound dressing 10 x 20 cm | Medeco                   | 170002                 | Plastic | Paper   |
| Klinion absorbent wound dressing 20 x 20 cm | Medeco                   | 170003                 | Plastic | Paper   |
| Klinion absorbent wound dressing 9 x 12 cm  | Medeco                   | 170000                 | Plastic | Paper   |
| Klinion compress 10 x 10 cm 2 pcs           | Medeco                   | 175031                 | Paper   | Paper   |
| Klinion compress 10 x 10 cm 5 pcs           | Medeco                   | 175033                 | Plastic | Paper   |
| Klinion compress 5 x 5 cm                   | Medeco                   | 175002                 | Paper   | Paper   |
| Klinion drain compress 10 x 10 cm           | Medeco                   | 175051                 | Paper   | Paper   |
| Leukomed wound dressing 10 x 25 cm          | Essity                   | 72380-04               | Plastic | Paper   |
| Leukomed wound dressing 10 x 30 cm          | Essity                   | 72380-05               | Plastic | Paper   |
| Leukomed wound dressing 5 x 7,2 cm          | Essity                   | 72380-00               | Plastic | Paper   |
| Leukomed wound dressing 8 x 10 cm           | Essity                   | 72380-01               | Plastic | Paper   |
| Leukomed wound dressing 8 x 15 cm           | Essity                   | 72380-02               | Plastic | Paper   |
| Leukoplast adhesive plaster 1.25 cm x 5 m   | Essity                   | ?                      | None    | None    |
| Leukoplast roll plaster 2.5 cm x 5 m        | Essity                   | ?                      | None    | None    |
| Leukoplast wound closure strip              | Essity                   | 72740-04               | Plastic | Paper   |
| Leukosilk adhesive plaster 1.25 cm x 5 m    | Essity                   | 0102100                | None    | None    |
| Leukosilk adhesive plaster 2.5 cm x 5 m     | Essity                   | 0102200                | None    | None    |
| Mepilex border flex lite                    | Mölnlycke                | 581277                 | Plastic | Paper   |
| Mepitel one                                 | Mölnlycke                | 289000                 | Plastic | Paper   |
| Microbiological swab                        | Copan Italia             | ?                      | Plastic | Plastic |
| Monitoring line                             | Vygon                    | 70222.301              | Plastic | Paper   |
| Mucus specimen trap set                     | Pennine                  | MST-3000               | Plastic | Paper   |
| Nasal fix plaster                           | Hony Medical             | Fix-N-1                | Plastic | Paper   |
| Needleless shielded cannula                 | Edwards Lifesciences     | VMP400                 | Plastic | Paper   |

|  |                           |                   |                  |                  |
|--|---------------------------|-------------------|------------------|------------------|
| Non-woven retention tape 5 x 10 cm               | Hartmann                  | 900602            | Paper            | Paper            |
| Oral care swab                                   | Medeco                    | 3059279           | Plastic          | Plastic          |
| Oxygen catheter                                  | Medicoplast International | 302               | Plastic          | Paper            |
| Oxygen tube                                      | Intersurgical             | 1174000           | Plastic          | Plastic          |
| Permanent marker                                 | Royal Talens              | -                 | Plastic          | Plastic          |
| pH-indicator strips                              | Merck                     | -                 | Plastic          | Plastic          |
| Pink Venflon needle protected IV cannula         | BD                        | 393224            | Plastic          | Paper            |
| Purol lipstick                                   | Labori                    | 87175240724<br>45 | Paper            | Paper            |
| Rectal temperature probe                         | Smiths Medical ASD        | ER400-9           | Plastic          | Paper            |
| Scissor  | -                         | -                 | -                | -                |
| Secondary line for infusion therapy              | Codan                     | 76.4432           | Plastic          | Paper            |
| Stitch cutter                                    | Swann-Morton              | 0420              | Plastic          | Plastic          |
| Stomahesive                                      | ConvaTec                  | 21713             | Plastic          | Paper            |
| Syringe 10 ml                                    | BD                        | 305959            | Plastic          | Paper            |
| Syringe 20 ml                                    | BD                        | 300629            | Plastic          | Paper            |
| Syringe 5 ml                                     | BD                        | 309649            | Plastic          | Paper            |
| Syringe 50 ml                                    | BD                        | 300865            | Plastic          | Paper            |
| Syringe NaCl 0.9% 10 ml                          | BD                        | 306575            | Plastic          | Plastic          |
| Tegaderm CHG I.V. securement dressing            | 3M                        | 1657R             | Plastic          | Paper            |
| Tegaderm I.V. securement dressing 1681           | 3M                        | 1681              | Plastic          | Paper            |
| Tegaderm transparant film dressing 1624W         | 3M                        | 1624W             | Plastic          | Paper            |
| Tegaderm transparant film dressing 1626W         | 3M                        | 1626W             | Plastic          | Paper            |
| Tensoplast elastic adhesive plaster 2.5 x 4.5 cm | Essity                    | 72067-00          | Paper            | Paper            |
| Tipstop compression dressing                     | Baxter Healthcare         | 114555            | Plastic          | Plastic          |
| Transafix fixation strip                         | BD                        | 3034283           | Plastic / velcro | Paper            |
| Urine bag  | ZARYS                     | WMD2000-90        | Plastic          | Plastic          |
| Venipuncture blood collection set                | BD                        | 368657            | Plastic          | Paper            |
| Wooden tongue depressor                          | CMT                       | 229510            | Plastic          | Plastic          |
| Yellow utility clip                              | ?                         | ?                 | Textile / velcro | Textile / velcro |

**Table 14.3:** Medical consumables stored in a bedside cart tested along the three defined criteria for suitable disinfection with the D25<sup>+</sup>. As for the material compatibility, 'Likely' indicates that the compatibility of the packaging material is not claimed by the manufacturer of the D25<sup>+</sup> but was determined by previous studies.

| Name   | Size compatible | Sterile stored | Material compatible | Maximum number disinfected per cycle | Comments  |
|--|-----------------|----------------|---------------------|--------------------------------------|---|
| 3-way stopcock   | Yes             | Yes            | Likely              | 14                                   |   |
| 3-way stopcock with extension line 14 cm               | Yes             | Yes            | Likely              | 8                                    |   |
| Adult nasal cannula with curved prongs and tube        | Yes             | Yes            | Yes                 | 2                                    |   |
| Adult SpO <sub>2</sub> sensor                          | Yes             | Yes            | Yes                 | 4                                    |   |
| Adult-paediatric intubated CO <sub>2</sub> filter line | Yes             | Yes            | Yes                 | 2                                    |   |
| Anaerobic culture vial blue                            | Yes             | No             | Yes                 | 45                                   | Plastic flask without additional packaging.   |
| Anaerobic culture vial orange                          | Yes             | No             | Yes                 | 45                                   | Plastic flask without additional packaging.   |
| Arterial cannula                                       | Yes             | Yes            | Likely              | 11                                   |   |
| Artery clamp   | -               | -              | -                   | -                                    | Disinfected in-house.   |
| Bionector  | Yes             | Yes            | Likely              | 22                                   |   |
| Blood collection adapter                               | Yes             | No             | No                  | 56                                   |   |
| Blood collection pod                                   | Yes             | No             | Yes                 | ?                                    | Plastic pod without additional packaging.   |
| Blood collection tube CAT 10 ml                        | Yes             | No             | Yes                 | 162                                  | Plastic tubes without additional packaging. Tubes placed upside down (balancing on the lid). Not ideal because the tubes can fall over. If placed horizontally, 30 tubes fit but they tend to roll. |
| Blood collection tube CAT 14 ml                        | Yes             | No             | Yes                 | 162                                  | Plastic tubes without additional packaging. Tubes placed upside down (balancing on the lid). Not ideal because the tubes can fall over. If placed horizontally, 40 tubes fit but they tend to roll. |
| Blood collection tube citrate 2.7 ml                   | Yes             | No             | Yes                 | 162                                  | Plastic tubes without additional packaging. Tubes placed upside down (balancing on the lid). Not ideal because the tubes can fall over. If placed horizontally, 40 tubes fit but they tend to roll. |
| Blood collection tube citrate 3.5 ml                   | Yes             | No             | Yes                 | 162                                  | Plastic tubes without additional packaging. Tubes placed upside down (balancing on the lid). Not ideal because the tubes can fall over. If placed horizontally, 40 tubes fit but they tend to roll. |

|                                    |     |     |        |     |   |
|------------------------------------|-----|-----|--------|-----|---|
| Blood collection tube EDTA 10 ml   | Yes | No  | Yes    | 162 | Plastic tubes without additional packaging. Tubes placed upside down (balancing on the lid). Not ideal because the tubes can fall over. If placed horizontally, 30 tubes fit but they tend to roll. |
| Blood collection tube EDTA 2 ml    | Yes | No  | Yes    | 162 | Plastic tubes without additional packaging. Tubes placed upside down (balancing on the lid). Not ideal because the tubes can fall over. If placed horizontally, 40 tubes fit but they tend to roll. |
| Blood collection tube EDTA 4 ml    | Yes | No  | Yes    | 162 | Plastic tubes without additional packaging. Tubes placed upside down (balancing on the lid). Not ideal because the tubes can fall over. If placed horizontally, 40 tubes fit but they tend to roll. |
| Blood collection tube EST 3 ml     | Yes | No  | Yes    | 162 | Plastic tubes without additional packaging. Tubes placed upside down (balancing on the lid). Not ideal because the tubes can fall over. If placed horizontally, 40 tubes fit but they tend to roll. |
| Blood collection tube SST 3.5 ml   | Yes | No  | Yes    | 162 | Plastic tubes without additional packaging. Tubes placed upside down (balancing on the lid). Not ideal because the tubes can fall over. If placed horizontally, 40 tubes fit but they tend to roll. |
| Blood collection tube SST 8.5 ml   | Yes | No  | Yes    | 162 | Plastic tubes without additional packaging. Tubes placed upside down (balancing on the lid). Not ideal because the tubes can fall over. If placed horizontally, 30 tubes fit but they tend to roll. |
| Blood culture syringe              | Yes | Yes | Likely | 10  |   |
| Blood gas syringe                  | Yes | Yes | Likely | 7   | Watch out, the paper-glue-plastic interface has the tendency to curl up. Maybe also the case for other similar packaging materials.   |
| Cannula with air filter            | Yes | Yes | Likely | 9   |   |
| Catheter spigot                    | Yes | Yes | Likely | 21  |   |
| Catheter tip syringe               | Yes | Yes | Likely | 6   |   |
| Cavilon spray                      | Yes | No  | Likely | 12  | Packaging varies; paper box or no packaging. The spray is fully made out of plastic including plastic cap.  |
| Cavilon stick                      | Yes | Yes | Likely | 12  | Packaging is white like paper but feels a bit plastic.  |
| Climatrach HME filter              | Yes | Yes | Likely | 6   |   |
| Cohesive fixation bandage 4 x 4 cm | Yes | No  | Likely | 30  | Inside a paper/cartridge box, box not opened. New brand; klinifix instead of elastomul.   |

|   |     |     |        |     |   |
|---|-----|-----|--------|-----|---|
| Cohesive fixation bandage 4 x 6 cm          | Yes | No  | Likely | 24  | Inside a paper/cartridge box, box not opened. New brand; klinifix instead of elastomul.   |
| Combi-lock                                  | Yes | Yes | Likely | 81  |   |
| Compress 10 x 10 cm pack                    | Yes | No  | No     | -   | Nonwoven textile compress with no additional packaging.   |
| Compress 5 x 5 cm pack                      | Yes | No  | No     | -   | Nonwoven textile compress with no additional packaging.   |
| Connector feeding tube                      | Yes | Yes | Likely | 32  |   |
| Container with red lid                      | Yes | No  | Yes    | 40  | Plastic container without additional packaging.   |
| Cotton tip                                  | Yes | No  | Yes    | ?   | Inside a paper/cartridge box but stored in the bedside cart in a plastic zip-lock bag alongside the wooden tongue depressors.   |
| Disinfecting cap for needleless connectors  | Yes | Yes | Yes    | 190 | Not handy, the strip curls up. Inside the bedside cart, it is stored individually (no strip). However, easy to disinfect a lot at the same time since they are attached to a strip. |
| Disposable tourniquet                       | Yes | No  | Yes    | 7   |   |
| ECG sticker                                 | Yes | No  | No     | -   | Not sterile packed. Front had no packaging. Do not recommend  |
| Elastic bandage 6 cm                        | Yes | Yes | Yes    | 24  |   |
| Elastic bandage 8 cm                        | Yes | Yes | Yes    | 20  |   |
| Endotracheal tube holder                    | Yes | Yes | Yes    | 6   | Has a zip-lock at the top of the packaging.   |
| Enfit 3-way stopcock                        | Yes | Yes | Likely | 10  |   |
| Enfit female                                | Yes | Yes | Likely | 8   |   |
| Enfit male                                  | Yes | Yes | Likely | 10  |   |
| Enteral syringe                             | Yes | Yes | Likely | 6   |   |
| Enteral syringe cap                         | Yes | Yes | Likely | ?   | Not found in the bedside cart.  |
| Extension line 30 cm                        | Yes | Yes | Likely | 4   |   |
| Eye ointment                                | Yes | Yes | Likely | 4   |   |
| Filta-guard bacterial filter                | Yes | Yes | Yes    | 5   |   |
| Flask of distilled water NaCl 0.9% 10 ml    | Yes | Yes | Likely | 60  | Flasks are stored in sets of 5. No additional packaging.  |
| Green Venflon needle protected IV cannula   | Yes | Yes | Likely | 15  |   |
| Hypodermic needle                           | Yes | Yes | Likely | 48  |   |
| Infusion set                                | Yes | Yes | Likely | 3   |   |
| Klinion absorbent wound dressing 10 x 20 cm | Yes | Yes | Likely | 1   |   |

|   |     |     |        |    |   |
|---|-----|-----|--------|----|---|
| Klinion absorbent wound dressing 20 x 20 cm | Yes | Yes | Likely | 1  |   |
| Klinion absorbent wound dressing 9 x 12 cm  | Yes | Yes | Likely | 3  |   |
| Klinion compress 10 x 10 cm 2 pcs           | Yes | Yes | Likely | 3  | New brand; Klinion instead of Cutisoft. Packed per 50 x 2 Pcs.                                |
| Klinion compress 10 x 10 cm 5 pcs           | Yes | Yes | Likely | 3  | New brand; Klinion instead of Cutisoft. Packed per 20 x 5 Pcs.                                |
| Klinion compress 5 x 5 cm                   | Yes | Yes | Likely | 8  | New brand; Klinion instead of Cutisoft. Packed per 50 x 2 Pcs.                                |
| Klinion drain compress 10 x 10 cm           | Yes | Yes | Likely | 2  | New brand; Klinion instead of Cutisoft.   |
| Leukomed wound dressing 10 x 25 cm          | Yes | Yes | Likely | 2  |   |
| Leukomed wound dressing 10 x 30 cm          | Yes | Yes | Likely | 1  |   |
| Leukomed wound dressing 5 x 7,2 cm          | Yes | Yes | Likely | 9  |   |
| Leukomed wound dressing 8 x 10 cm           | Yes | Yes | Likely | 4  |   |
| Leukomed wound dressing 8 x 15 cm           | Yes | Yes | Likely | 4  |   |
| Leukoplast adhesive plaster 1.25 cm x 5 m   | Yes | No  | No     | 18 | Textile roller bandage without additional packaging. Do not recommend.                        |
| Leukoplast roll plaster 2.5 cm x 5 m        | Yes | No  | No     | 18 | Textile roller bandage without additional packaging. Do not recommend.                        |
| Leukoplast wound closure strip              | Yes | Yes | Likely | 6  | New name: Leukoplast instead of Leukosan.   |
| Leukosilk adhesive plaster 1.25 cm x 5 m    | Yes | No  | No     | 30 | Textile roller bandage without additional packaging. Do not recommend.                        |
| Leukosilk adhesive plaster 2.5 cm x 5 m     | Yes | No  | No     | 30 | Textile roller bandage without additional packaging. Do not recommend.                        |
| Mepitex border flex lite                    | Yes | Yes | Likely | 6  |   |
| Mepitel one                                 | Yes | Yes | Likely | 6  |   |
| Microbiological swab                        | Yes | Yes | Yes    | 11 | Different brand; E-swab is currently used.  |
| Monitoring line                             | Yes | Yes | Likely | 2  |   |
| Mucus specimen trap set                     | Yes | Yes | Likely | 5  |   |
| Nasal fix plaster                           | Yes | Yes | Likely | 5  |   |
| Needleless shielded cannula                 | Yes | Yes | Likely | 39 |   |
| Non-woven retention tape 5 x 10 cm          | Yes | No  | Likely | 8  | Inside a paper/cartridge box, box not opened. New brand; omnifix elastic instead of fixomull. |
| Oral care swab                              | Yes | Yes | Yes    | 11 |   |
| Oxygen catheter                             | Yes | Yes | Likely | 1  | Only fits diagonally.   |

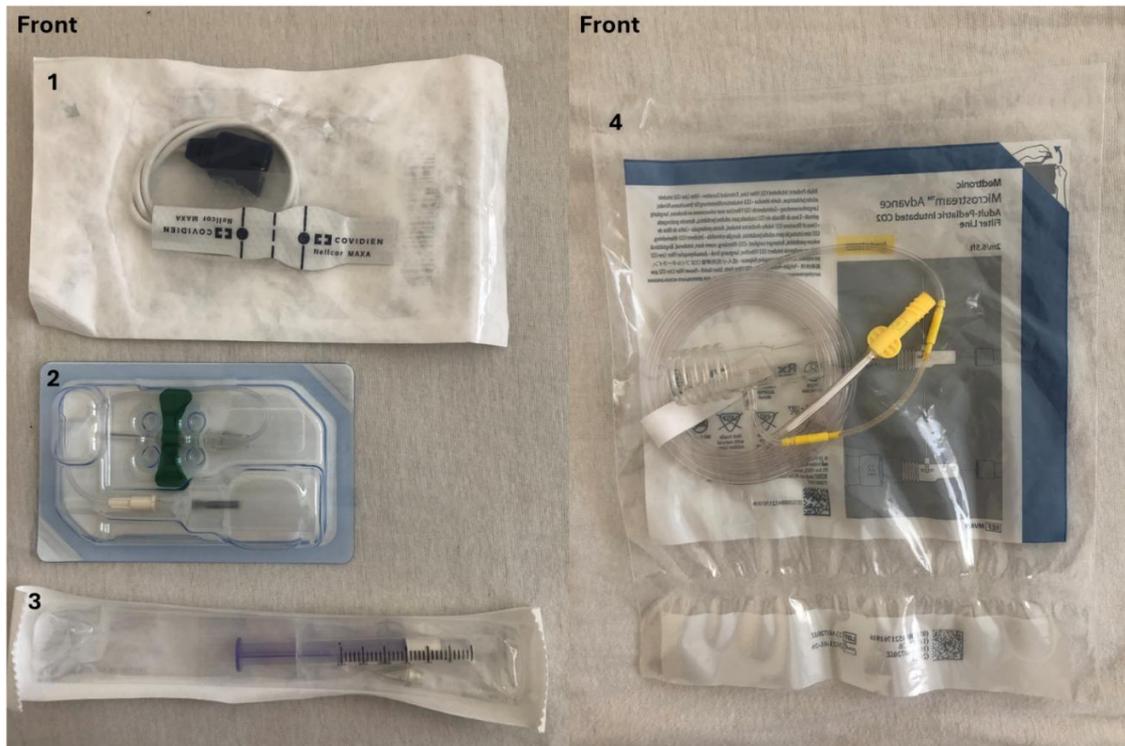
|  |     |     |        |    |  |
|--|-----|-----|--------|----|--|
| Oxygen tube                                      | Yes | Yes | Yes    | 2  |  |
| Permanent marker                                 | Yes | No  | Likely | ?  | Plastic marker without additional packaging.   |
| pH-indicator strips                              | Yes | No  | Yes    | ?  | Inside a plastic box. Not sterile stored.  |
| Pink Venflon needle protected IV cannula         | Yes | Yes | Likely | 15 |  |
| Purol lipstick                                   | Yes | Yes | Likely | 9  |  |
| Rectal temperature probe                         | Yes | Yes | Likely | 1  | Only fits sideways and slightly curled.  |
| Scissor  | -   | -   | -      | -  | Disinfected in-house.  |
| Secondary line for infusion therapy              | Yes | Yes | Likely | 4  |  |
| Stitch cutter                                    | Yes | Yes | Yes    | 28 | The backside looks a bit metallic  |
| Stomahesive                                      | Yes | Yes | Likely | 6  |  |
| Syringe 10 ml                                    | Yes | Yes | Likely | 12 |  |
| Syringe 20 ml                                    | Yes | Yes | Likely | 10 |  |
| Syringe 5 ml                                     | Yes | Yes | Likely | 15 |  |
| Syringe 50 ml                                    | Yes | Yes | Likely | 8  |  |
| Syringe NaCl 0.9% 10 ml                          | Yes | Yes | Yes    | 10 |  |
| Tegaderm CHG I.V. securement dressing            | Yes | Yes | Likely | 2  |  |
| Tegaderm I.V. securement dressing 1681           | Yes | Yes | Likely | 4  |  |
| Tegaderm transparant film dressing 1624W         | Yes | Yes | Likely | 6  |  |
| Tegaderm transparant film dressing 1626W         | Yes | Yes | Likely | 3  |  |
| Tensoplast elastic adhesive plaster 2.5 x 4.5 cm | Yes | No  | Likely | 24 | Inside a paper/cartridge box, box not opened.  |
| Tipstop compression dressing                     | Yes | Yes | Yes    | 13 |  |
| Transafix fixation strip                         | Yes | Yes | Yes    | 24 |  |
| Urine bag  | Yes | Yes | Yes    | 3  |  |
| Venipuncture blood collection set                | Yes | Yes | Likely | 6  |  |
| Wooden tongue depressor                          | Yes | No  | Yes    | ?  | Inside a paper/cartridge box but stored in the bedside cart in a plastic zip-lock bag alongside the cotton tips. |
| Yellow utility clip                              | Yes | No  | No     | 26 | Not suited because textile + has also metal clip part  |

## 14.2. Appendix II: Intensive care beds in Dutch hospitals

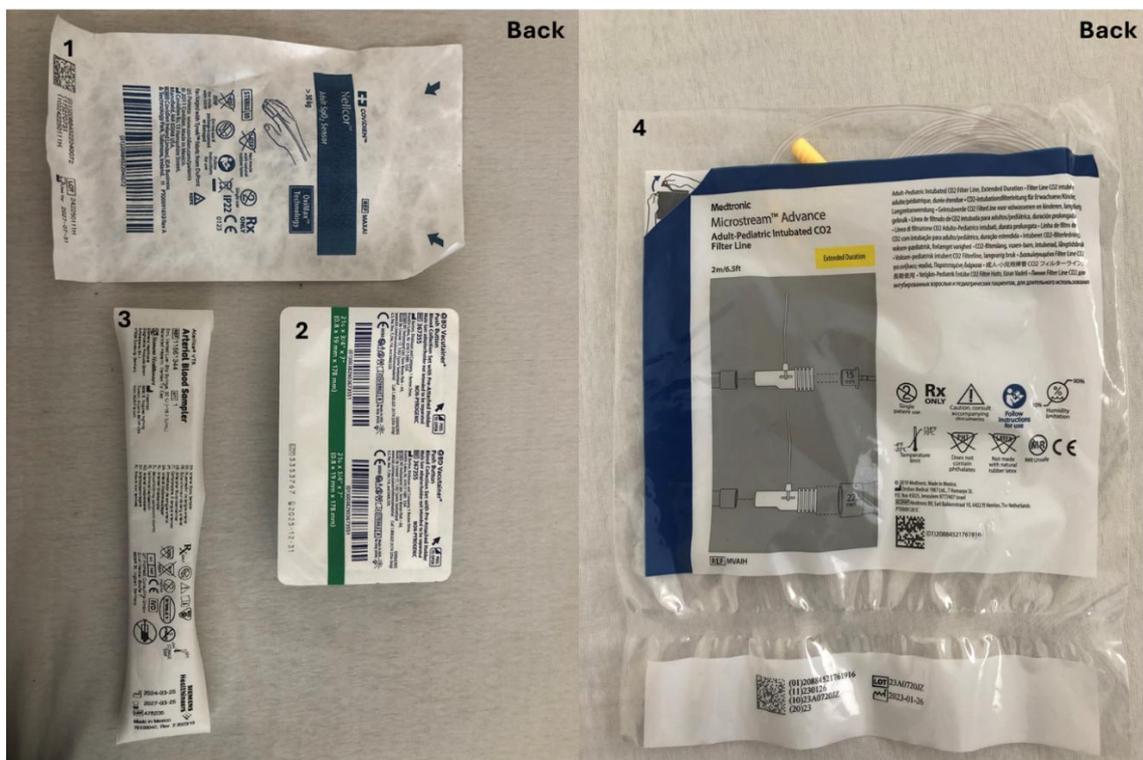
**Table 14.4:** Overview of Dutch hospitals with ICU departments. Only hospitals with at least 15 ICU beds in are displayed. Numbers are a snapshot of November 2023. Table adapted from NVIC (2023.)

| Hospital   | ICU beds |
|--|----------|
| Erasmus MC   | 50       |
| Isala Klinieken  | 36       |
| Universitair Medisch Centrum Groningen                   | 33       |
| Amsterdam UMC - locatie AMC                              | 32       |
| Maastricht UMC+  | 31       |
| Medisch Spectrum Twente                                  | 28       |
| LUMC   | 26       |
| Universitair Medisch Centrum Utrecht                     | 25       |
| Amphia Ziekenhuis  | 24       |
| ETZ - locatie Elisabeth                                  | 24       |
| Radboudumc   | 24       |
| Zuyderland   | 24       |
| Amsterdam UMC - locatie VUmc                             | 22       |
| OLVG - locatie Oost en West                              | 20       |
| St. Antonius Ziekenhuis                                  | 20       |
| Rijnstate Ziekenhuis                                     | 18       |
| Franciscus Gasthuis en Vlietland                         | 17       |
| Albert Schweitzer Ziekenhuis                             | 16       |
| Catharina Ziekenhuis                                     | 16       |
| HagaZiekenhuis   | 16       |
| Maasstad ziekenhuis                                      | 16       |
| Medisch Centrum Leeuwarden                               | 16       |
| Spaarne Gasthuis   | 16       |
| Bravis ziekenhuis - locatie Bergen op Zoom en Roosendaal | 15       |

### 14.3. Appendix III: Medical consumables for LCA



**Figure 14.1:** Front view of the four medical consumables selected for the LCA study. 1) SpO<sub>2</sub> sensor, 2) Vacutainer, 3) Blood gas syringe, 4) CO<sub>2</sub> filter line.



**Figure 14.2:** Back view of the four medical consumables selected for the LCA study. 1) SpO<sub>2</sub> sensor, 2) Vacutainer, 3) Blood gas syringe, 4) CO<sub>2</sub> filter line.



**Figure 14.3:** The four medical consumables selected for the LCA study placed inside the disinfection chamber of the D25<sup>+</sup>. 1) SpO<sub>2</sub> sensor, 2) Vacutainer, 3) Blood gas syringe, 4) CO<sub>2</sub> filter line.

# 14.4. Appendix IV: Flowcharts

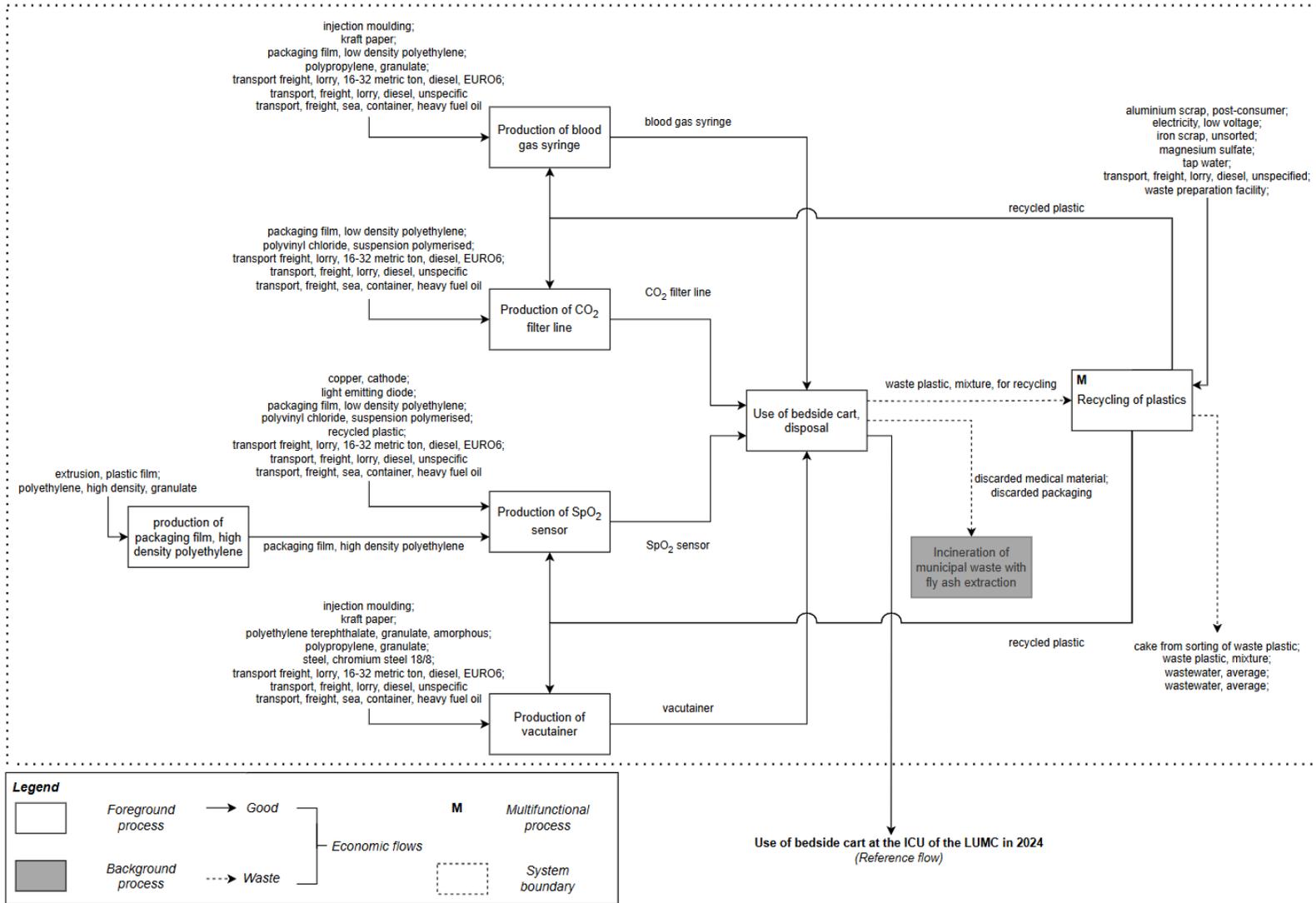
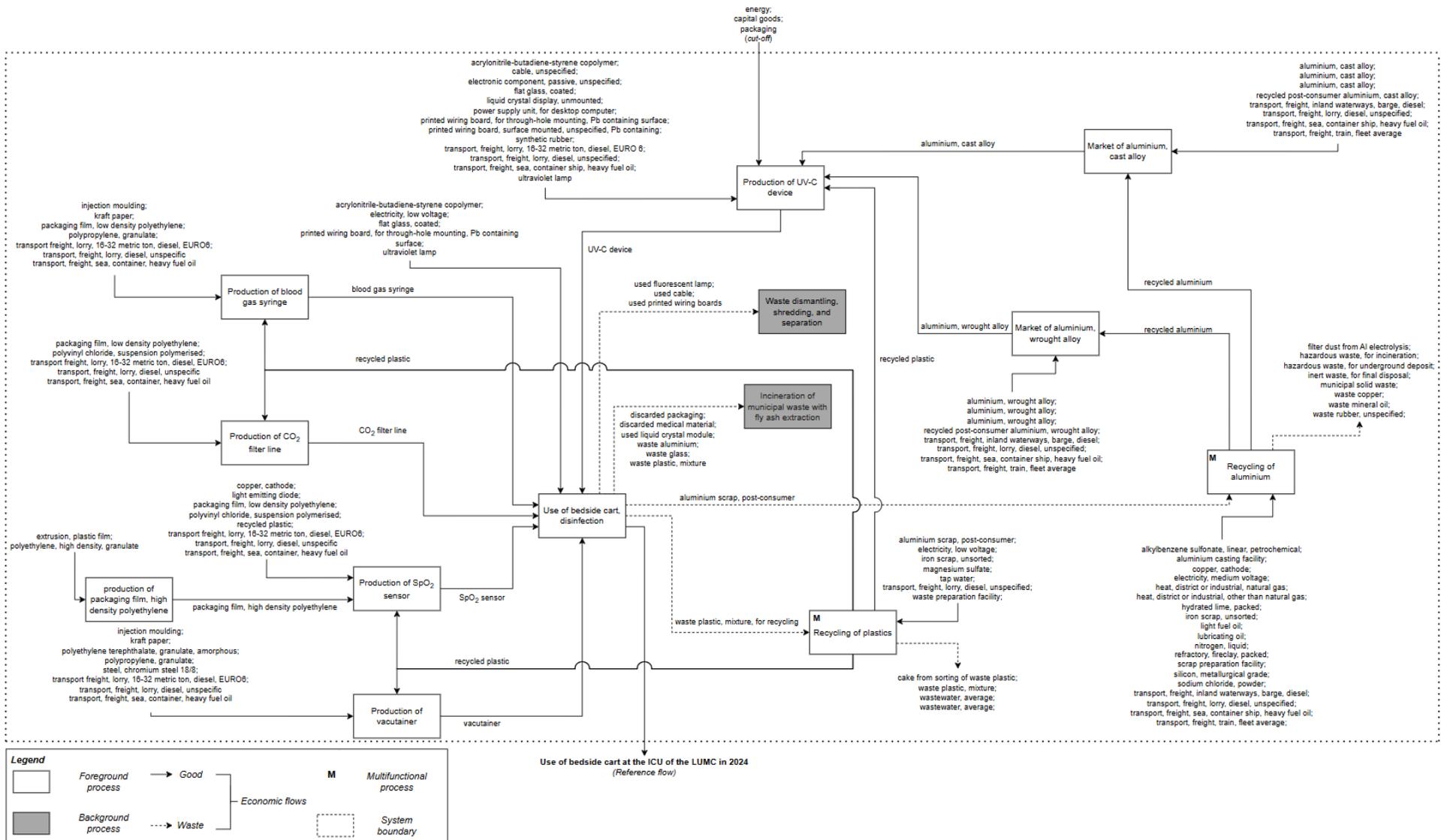


Figure 14.4: Detailed flowchart of the disposal of bedside cart inventories product system.



**Figure 14.5:** Detailed flow chart of the disinfection of bedside cart inventories product system.

## 14.5. Appendix V: Unit processing tables

The tables below show the different unit processes used for the LCA model. The flows in bold are the functional flows of their respective unit processes.

Tables 14.5-14.12 show the production unit processes.

Table 14.13 shows the disposal use unit processes of the main results.

Table 14.14 shows the disinfection use unit processes of the main results.

Tables 14.15-14.20 show the end-of-life unit processes.

Tables 14.21-14.24 show the disposal use phases of the individual medical consumables.

Tables 14.25-14.28 show the disinfection use phases of the individual medical consumables.

Tables 14.29-14.31 show the disposal use phases at different bedside cart inventory levels.

Tables 14.32-14.34 show the disinfection use phases at different bedside cart inventory levels.

**Table 14.5:** Production of blood gas syringe.

| <b>Unit process: production of blood gas syringe</b> |         |   |  |          |                      |   |  |
|--|---------|---|--|----------|----------------------|---|--|
| <b>Economic flows, in:</b>                           |         |   |  |          |                      |   |  |
| Amount   | Unit    | Flow Name   | Provider   | Location | Data source          | Additional documentation  |  |
| 4.00E-03   | kg      | injection moulding  | market for injection moulding   injection moulding   Cutoff, U - GLO   | GLO      |                      | Collected by weighing. Required for the production of the plastic blood gas syringe.  |  |
| 1.00E-03   | kg      | kraft paper   | market for kraft paper   kraft paper   Cutoff, U - RoW   | RoW      |                      | Paper packaging. Collected by weighing.   |  |
| 1.86E-03   | kg      | packaging film, low density polyethylene                    | market for packaging film, low density polyethylene   packaging film, low density polyethylene   Cutoff, U - GLO                                       | GLO      |                      | Plastic packaging. Collected by weighing. Recycled plastic partly substitutes for virgin plastic.                                   |  |
| 3.72E-03   | kg      | polypropylene, granulate                                    | market for polypropylene, granulate   polypropylene, granulate   Cutoff, U - GLO   | GLO      |                      | Plastic for the blood gas syringe. Collected by weighing. Recycled plastic partly substitutes for virgin plastic.                   |  |
| 4.20E-04   | kg      | recycled plastic, mixture                                   | recycling of waste plastic   | NL       | Brouwer et al., 2019 | In the Netherlands, 7% of plastic found in residual waste is recycled. Both recycled plastic from medical consumable and packaging. |  |
| 3.91E-04   | t*km    | transport, freight, lorry, 16-32 metric ton, diesel, EURO 6 | market for transport, freight, lorry, 16-32 metric ton, diesel, EURO 6   transport, freight, lorry, 16-32 metric ton, diesel, EURO 6   Cutoff, U - RER | RER      |                      | Transport port of Rotterdam to LUMC.  |  |
| 2.15E-02   | t*km    | transport, freight, lorry, diesel, unspecified              | market for transport, freight, lorry, unspecified   transport, freight, lorry, diesel, unspecified   Cutoff, U - RoW                                   | RoW      |                      | Transport plant Mexico to port of Veracruz.   |  |
| 7.00E-02   | t*km    | transport, freight, sea, container ship, heavy fuel oil     | market for transport, freight, sea, container ship, heavy fuel oil   transport, freight, sea, container ship, heavy fuel oil   Cutoff, U - GLO         | GLO      |                      | Transport port of Veracruz to port of Rotterdam.  |  |
| <b>Economic flows, out:</b>                          |         |   |  |          |                      |   |  |
| Amount   | Unit    | Flow Name   | Provider   | Location | Data source          | Additional documentation  |  |
| 1  | Item(s) | <b>blood gas syringe</b>                                    | production of blood gas syringe  | NL       |                      | 1 blood gas syringe = 0.007 kg.   |  |

**Table 14.6:** Production of CO<sub>2</sub> filter line.

**Unit process: production of CO<sub>2</sub> filter line**

| Economic flows, in:  |         |   |  |          |                      |   |
|----------------------|---------|---|--|----------|----------------------|---|
| Amount               | Unit    | Flow Name   | Provider   | Location | Data source          | Additional documentation  |
| 3.72E-03             | kg      | packaging film, low density polyethylene                    | market for packaging film, low density polyethylene   packaging film, low density polyethylene   Cutoff, U - GLO                                       | GLO      |                      | Plastic packaging. Collected by weighing. Recycled plastic partly substitutes for virgin plastic.                                   |
| 1.86E-02             | kg      | polyvinyl chloride, suspension polymerised                  | market for polyvinyl chloride, suspension polymerised   polyvinyl chloride, suspension polymerised   Cutoff, U - RoW                                   | GLO      |                      | Collected by weighing. Recycled plastic partly substitutes for virgin plastic.  |
| 1.68E-03             | kg      | recycled plastic, mixture                                   | recycling of waste plastic   | NL       | Brouwer et al., 2019 | In the Netherlands, 7% of plastic found in residual waste is recycled. Both recycled plastic from medical consumable and packaging. |
| 1.34E-03             | t*km    | transport, freight, lorry, 16-32 metric ton, diesel, EURO 6 | market for transport, freight, lorry, 16-32 metric ton, diesel, EURO 6   transport, freight, lorry, 16-32 metric ton, diesel, EURO 6   Cutoff, U - RER | RER      |                      | Transport port of Rotterdam to LUMC   |
| 5.35E-03             | t*km    | transport, freight, lorry, diesel, unspecified              | market for transport, freight, lorry, unspecified   transport, freight, lorry, diesel, unspecified   Cutoff, U - RoW                                   | RoW      |                      | Transport plant Mexico to port of Los Angeles/Long Beach  |
| 3.45E-01             | t*km    | transport, freight, sea, container ship, heavy fuel oil     | market for transport, freight, sea, container ship, heavy fuel oil   transport, freight, sea, container ship, heavy fuel oil   Cutoff, U - GLO         | GLO      |                      | Transport port of Los Angeles/Long Beach to port of Rotterdam   |
| Economic flows, out: |         |   |  |          |                      |   |
| Amount               | Unit    | Flow Name   | Provider   | Location | Data source          | Additional documentation  |
| 1                    | Item(s) | <b>CO2 filter line</b>                                      | production of CO2 filter line  | NL       |                      | 1 CO2 filter line = 0.024 kg  |

**Table 14.7:** Production of high density polyethylene packaging film. This unit process produces the high density polyethylene packaging of the SpO<sub>2</sub> sensor and is based on the followingecoinvent process: packaging film production, low density polyethylene | packaging film, low density polyethylene | Cutoff, U – RoW.

**Unit process: production of packaging film, high density polyethylene**

| Economic flows, in:  |      |  |  |          |             |  |
|----------------------|------|--|--|----------|-------------|--|
| Amount               | Unit | Flow Name  | Provider   | Location | Data source | Additional documentation                                       |
| 1.02                 | kg   | extrusion, plastic film                          | market for extrusion, plastic film   extrusion, plastic film   Cutoff, U - GLO                             | GLO      | Ecoinvent   | 1 kg of this process equals 0.976 kg of extruded plastic film. |
| 1.02                 | kg   | polyethylene, high density, granulate            | market for polyethylene, high density, granulate   polyethylene, high density, granulate   Cutoff, U - GLO | GLO      | Ecoinvent   |  |
| Economic flows, out: |      |  |  |          |             |  |
| Amount               | Unit | Flow Name  | Provider   | Location | Data source | Additional documentation                                       |
| 1.00                 | kg   | <b>packaging film, high density polyethylene</b> | production of packaging film, high density polyethylene  | GLO      | Ecoinvent   |  |

**Table 14.8:** Production of SpO<sub>2</sub> sensor.

**Unit process: production of SpO<sub>2</sub> sensor**

| Economic flows, in:  |         |   |  |          |  |  |
|----------------------|---------|---|--|----------|--|--|
| Amount               | Unit    | Flow Name   | Provider   | Location | Data source                            | Additional documentation   |
| 7.50E-03             | kg      | copper, cathode   | market for copper, cathode   copper, cathode   Cutoff, U - GLO   | GLO      | Duffy et al., 2023; Kumar et al., 2024 | Copper part of cable of the SpO <sub>2</sub> sensor. Mass collected by weighting and ratio between cable and LED sensor estimated. Plastic to metal ratio of cable assumed to be 45:55.  |
| 1.33E-03             | kg      | light emitting diode  | market for light emitting diode   light emitting diode   Cutoff, U - GLO   | GLO      | Duffy et al., 2023                     | LED sensor of the SpO <sub>2</sub> sensor. Mass collected by weighting and ratio between cable and LED sensor estimated.   |
| 1.86E-03             | kg      | packaging film, high density polyethylene                   | production of packaging film, high density polyethylene  | GLO      |  | High density plastic packaging. Collected by weighing. Recycled plastic partly substitutes for virgin plastic.   |
| 1.86E-03             | kg      | packaging film, low density polyethylene                    | market for packaging film, low density polyethylene   packaging film, low density polyethylene   Cutoff, U - GLO                                       | GLO      |  | Low density plastic packaging. Collected by weighing. Recycled plastic partly substitutes for virgin plastic.  |
| 8.52E-03             | kg      | polyvinyl chloride, suspension polymerised                  | market for polyvinyl chloride, suspension polymerised   polyvinyl chloride, suspension polymerised   Cutoff, U - GLO                                   | GLO      | Duffy et al., 2023; Kumar et al., 2024 | PVC part of cable of the SpO <sub>2</sub> sensor. Mass collected by weighting and ratio between cable and LED sensor estimated. Recycled plastic partly substitutes for virgin plastic. Plastic to metal ratio of cable assumed to be 45:55. |
| 9.22E-04             | kg      | recycled plastic, mixture                                   | recycling of waste plastic   | NL       | Brouwer et al., 2019                   | In the Netherlands, 7% of plastic found in residual waste is recycled. Both recycled plastic from medical consumable and packaging.  |
| 1.12E-03             | t*km    | transport, freight, lorry, 16-32 metric ton, diesel, EURO 6 | market for transport, freight, lorry, 16-32 metric ton, diesel, EURO 6   transport, freight, lorry, 16-32 metric ton, diesel, EURO 6   Cutoff, U - RER | RER      |  | Transport port of Rotterdam to LUMC  |
| 4.46E-03             | t*km    | transport, freight, lorry, diesel, unspecified              | market for transport, freight, lorry, unspecified   transport, freight, lorry, diesel, unspecified   Cutoff, U - RoW                                   | RoW      |  | Transport plant Mexico to port of Los Angeles/Long Beach   |
| 2.87E-01             | t*km    | transport, freight, sea, container ship, heavy fuel oil     | market for transport, freight, sea, container ship, heavy fuel oil   transport, freight, sea, container ship, heavy fuel oil   Cutoff, U - GLO         | GLO      |  | Transport port of Los Angeles/Long Beach to port of Rotterdam  |
| 7.50E-03             | kg      | wire drawing, copper  | market for wire drawing, copper   wire drawing, copper   Cutoff, U - GLO   | GLO      |  | Used for the production of cables.   |
| Economic flows, out: |         |   |  |          |  |  |
| Amount               | Unit    | Flow Name   | Provider   | Location | Data source                            | Additional documentation   |
| 1                    | Item(s) | <b>SpO<sub>2</sub> sensor</b>                               | production of SpO <sub>2</sub> sensor  | NL       |  | 1 SpO <sub>2</sub> sensor = 0.020 kg   |

**Table 14.9: Production of vacutainer.**

**Unit process: production of vacutainer**

| <b>Economic flows, in:</b>  |             |   |  |                 |                      |   |
|-----------------------------|-------------|---|--|-----------------|----------------------|---|
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>  | <i>Provider</i>  | <i>Location</i> | <i>Data source</i>   | <i>Additional documentation</i>   |
| 1.30E-02                    | kg          | injection moulding  | market for injection moulding   injection moulding   Cutoff, U - GLO   | GLO             |                      | Required for the production of the plastic vacutainer.  |
| 1.00E-03                    | kg          | kraft paper   | market for kraft paper   kraft paper   Cutoff, U - RoW   | RoW             |                      | Paper packaging. Collected by weighing  |
| 6.51E-03                    | kg          | polyethylene terephthalate, granulate, amorphous            | market for polyethylene terephthalate, granulate, amorphous   polyethylene terephthalate, granulate, amorphous   Cutoff, U - GLO                       | GLO             |                      | Plastic packaging. Collected by weighing. Recycled plastic partly substitutes for virgin plastic.                                   |
| 5.51E-03                    | kg          | polypropylene, granulate                                    | market for polypropylene, granulate   polypropylene, granulate   Cutoff, U - GLO   | GLO             |                      | Plastic for the vacutainer. Collected by weighing. Recycled plastic partly substitutes for virgin plastic.                          |
| 9.05E-04                    | kg          | recycled plastic, mixture                                   | recycling of waste plastic   | NL              | Brouwer et al., 2019 | In the Netherlands, 7% of plastic found in residual waste is recycled. Both recycled plastic from medical consumable and packaging. |
| 7.42E-05                    | kg          | steel, chromium steel 18/8                                  | market for steel, chromium steel 18/8   steel, chromium steel 18/8   Cutoff, U - GLO   | GLO             |                      | Stainless steel 21g needle for vacutainer.  |
| 7.83E-04                    | t*km        | transport, freight, lorry, 16-32 metric ton, diesel, EURO 6 | market for transport, freight, lorry, 16-32 metric ton, diesel, EURO 6   transport, freight, lorry, 16-32 metric ton, diesel, EURO 6   Cutoff, U - RER | RER             |                      | Transport port of Rotterdam to LUMC.  |
| 3.05E-02                    | t*km        | transport, freight, lorry, diesel, unspecified              | market for transport, freight, lorry, unspecified   transport, freight, lorry, diesel, unspecified   Cutoff, U - RoW                                   | RoW             |                      | Transport plant Nebraska, USA to port of New York & New Jersey.   |
| 8.77E-02                    | t*km        | transport, freight, sea, container ship, heavy fuel oil     | market for transport, freight, sea, container ship, heavy fuel oil   transport, freight, sea, container ship, heavy fuel oil   Cutoff, U - GLO         | GLO             |                      | Transport port of New York & New Jersey to port of Rotterdam.   |
| <b>Economic flows, out:</b> |             |   |  |                 |                      |   |
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>  | <i>Provider</i>  | <i>Location</i> | <i>Data source</i>   | <i>Additional documentation</i>   |
| 1                           | Item(s)     | <b>vacutainer</b>   | production of vacutainer   | NL              |                      | 1 vacutainer = 0.014 kg.  |

**Table 14.10:** Market for cast alloy aluminium including recycling. This unit process produces the cast alloy aluminium of the UV-C device and is based on the following ecoinvent process: market for aluminium, cast alloy | aluminium, cast alloy | Cutoff, U – GLO.

**Unit process: market for aluminium, cast alloy, including recycling**

| <b>Economic flows, in:</b>  |             |   |  |                 |                    |  |
|-----------------------------|-------------|---|--|-----------------|--------------------|--|
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>  | <i>Provider</i>  | <i>Location</i> | <i>Data source</i> | <i>Additional documentation</i>  |
| 5.10E-01                    | kg          | aluminium, cast alloy                                   | treatment of aluminium scrap, new, at refiner   aluminium, cast alloy   Cutoff, U - RoW  | RoW             | Ecoinvent          |  |
| 3.12E-01                    | kg          | aluminium, cast alloy                                   | aluminium ingot, primary, to aluminium, cast alloy market   aluminium, cast alloy   Cutoff, U - GLO  | GLO             | Ecoinvent          |  |
| 7.76E-02                    | kg          | aluminium, cast alloy                                   | treatment of aluminium scrap, new, at refiner   aluminium, cast alloy   Cutoff, U - RER  | RER             | Ecoinvent          |  |
| 1.01E-01                    | kg          | recycled post-consumer aluminium, cast alloy            | recycling of post-consumer aluminium scrap, cast alloy   | NL              | Ecoinvent          | Post-consumer aluminium scrap from the UV-C EOL is modeled as closed loop recycling. |
| 3.63E-02                    | t*km        | transport, freight, inland waterways, barge, diesel     | market group for transport, freight, inland waterways, barge, diesel   transport, freight, inland waterways, barge, diesel   Cutoff, U - GLO   | GLO             | Ecoinvent          |  |
| 3.61E-01                    | t*km        | transport, freight, lorry, diesel, unspecified          | market for transport, freight, lorry, unspecified   transport, freight, lorry, diesel, unspecified   Cutoff, U - RoW                           | GLO             | Ecoinvent          |  |
| 3.63E-01                    | t*km        | transport, freight, sea, container ship, heavy fuel oil | market for transport, freight, sea, container ship, heavy fuel oil   transport, freight, sea, container ship, heavy fuel oil   Cutoff, U - GLO | GLO             | Ecoinvent          |  |
| 3.45E-01                    | t*km        | transport, freight, train, fleet average                | market group for transport, freight, train, fleet average   transport, freight, train, fleet average   Cutoff, U - GLO                         | GLO             | Ecoinvent          |  |
| <b>Economic flows, out:</b> |             |   |  |                 |                    |  |
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>  | <i>Provider</i>  | <i>Location</i> | <i>Data source</i> | <i>Additional documentation</i>  |
| 1.00                        | kg          | <b>aluminium, cast alloy</b>                            | market for aluminium, cast alloy, including recycling  | GLO             | Ecoinvent          |  |

**Table 14.11:** Market for wrought alloy aluminium including recycling. This unit process produces the wrought alloy aluminium of the UV-C device and is based on the following ecoinvent process: market for aluminium, wrought alloy | aluminium, wrought alloy | Cutoff, U – GLO.

**Unit process: market for aluminium, wrought alloy, including recycling**

| <b>Economic flows, in:</b>  |             |   |  |                 |                    |  |
|-----------------------------|-------------|---|--|-----------------|--------------------|--|
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>  | <i>Provider</i>  | <i>Location</i> | <i>Data source</i> | <i>Additional documentation</i>  |
| 2.53E-02                    | kg          | aluminium, wrought alloy                                | treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, U - RER  | RER             | Ecoinvent          |  |
| 6.96E-01                    | kg          | aluminium, wrought alloy                                | aluminium ingot, primary, to aluminium, wrought alloy market   aluminium, wrought alloy   Cutoff, U - GLO                                      | GLO             | Ecoinvent          |  |
| 2.22E-01                    | kg          | aluminium, wrought alloy                                | treatment of aluminium scrap, new, at remelter   aluminium, wrought alloy   Cutoff, U - RoW  | RoW             | Ecoinvent          |  |
| 5.70E-02                    | kg          | recycled post-consumer aluminium, wrought alloy         | recycling of post-consumer aluminium scrap, wrought alloy  | NL              | Ecoinvent          | Post-consumer aluminium scrap from the UV-C EOL is modeled as closed loop recycling. |
| 3.63E-02                    | t*km        | transport, freight, inland waterways, barge, diesel     | market group for transport, freight, inland waterways, barge, diesel   transport, freight, inland waterways, barge, diesel   Cutoff, U - GLO   | GLO             | Ecoinvent          |  |
| 3.61E-01                    | t*km        | transport, freight, lorry, diesel, unspecified          | market group for transport, freight, lorry, diesel, unspecified   transport, freight, lorry, diesel, unspecified   Cutoff, U - GLO             | GLO             | Ecoinvent          |  |
| 3.63E-01                    | t*km        | transport, freight, sea, container ship, heavy fuel oil | market for transport, freight, sea, container ship, heavy fuel oil   transport, freight, sea, container ship, heavy fuel oil   Cutoff, U - GLO | GLO             | Ecoinvent          |  |
| 3.45E-01                    | t*km        | transport, freight, train, fleet average                | market group for transport, freight, train, fleet average   transport, freight, train, fleet average   Cutoff, U - GLO                         | GLO             | Ecoinvent          |  |
| <b>Economic flows, out:</b> |             |   |  |                 |                    |  |
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>  | <i>Provider</i>  | <i>Location</i> | <i>Data source</i> | <i>Additional documentation</i>  |
| 1.00                        | kg          | <b>aluminium, cast alloy</b>                            | market for aluminium, wrought alloy, including recycling   | GLO             | Ecoinvent          |  |

**Table 14.12: Production of UV-C device.**

**Unit process: production of UV-C device**

| Economic flows, in:  |         |  |  |          |             |   |
|----------------------|---------|--|--|----------|-------------|---|
| Amount               | Unit    | Flow Name  | Provider   | Location | Data source | Additional documentation  |
| 1.56                 | kg      | acrylonitrile-butadiene-styrene copolymer                              | market for acrylonitrile-butadiene-styrene copolymer   acrylonitrile-butadiene-styrene copolymer   Cutoff, U - GLO   | GLO      | UV Smart    | Virgin acrylonitrile-butadiene-styrene copolymer. Input of acrylonitrile-butadiene-styrene copolymer consists of 49% recycled material and 51% virgin material.   |
| 1.25E+01             | kg      | aluminium, cast alloy  | market for aluminium, cast alloy, including recycling  | GLO      | UV Smart    |   |
| 2.13                 | kg      | aluminium, wrought alloy   | market for aluminium, wrought alloy, including recycling   | GLO      | UV Smart    |   |
| 3.00E-01             | kg      | cable, unspecified   | market for cable, unspecified   cable, unspecified   Cutoff, U - GLO   | GLO      | UV Smart    |   |
| 1.00E-01             | kg      | electronic component, passive, unspecified                             | market for electronic component, passive, unspecified   electronic component, passive, unspecified   Cutoff, U - GLO   | GLO      | UV Smart    | Proxy for the EMI filter.   |
| 5.00E-01             | kg      | flat glass, coated   | market for flat glass, coated   flat glass, coated   Cutoff, U - RoW   | RoW      | UV Smart    |   |
| 1.50E-01             | kg      | liquid crystal display, unmounted                                      | market for liquid crystal display, unmounted   liquid crystal display, unmounted   Cutoff, U - GLO   | GLO      | UV Smart    |   |
| 2.04E-01             | Item(s) | power supply unit, for desktop computer                                | market for power supply unit, for desktop computer   power supply unit, for desktop computer   Cutoff, U - GLO   | GLO      | UV Smart    | The power supply and power entry module have a total mass of 0.30 kg. The power supply unit defined in the Ecoinvent database has a mass of 1.47 kg.              |
| 4.22E-02             | m2      | printed wiring board, for through-hole mounting, Pb containing surface | market for printed wiring board, for through-hole mounting, Pb containing surface   printed wiring board, for through-hole mounting, Pb containing surface   Cutoff, U - GLO | GLO      | UV Smart    | The PCBAs has a mass of 0.13 kg. The Ecoinvent database defined 1 m2 of printed wiring board as 3.08 kg.  |
| 1.50E-01             | kg      | printed wiring board, surface mounted, unspecified, Pb containing      | market for printed wiring board, surface mounted, unspecified, Pb containing   printed wiring board, surface mounted, unspecified, Pb containing   Cutoff, U - GLO           | GLO      | UV Smart    | Proxy for ballast.  |
| 1.49                 | kg      | recycled plastic, mixture  | recycling of waste plastic   | NL       | Ecoinvent   | Recycled acrylonitrile-butadiene-styrene copolymer. Input of acrylonitrile-butadiene-styrene copolymer consists of 49% recycled material and 51% virgin material. |
| 2.00E-02             | kg      | synthetic rubber   | market for synthetic rubber   synthetic rubber   Cutoff, U - GLO   | GLO      | UV Smart    |   |
| 8.36                 | t*km    | transport, freight, lorry, 16-32 metric ton, diesel, EURO 6            | market for transport, freight, lorry, 16-32 metric ton, diesel, EURO 6   transport, freight, lorry, 16-32 metric ton, diesel, EURO 6   Cutoff, U - RER                       | RER      | UV Smart    | Transport port of Rotterdam to AIM & Transport AIM to LUMC  |
| 9.57                 | t*km    | transport, freight, lorry, diesel, unspecified                         | market for transport, freight, lorry, diesel, unspecified   transport, freight, lorry, diesel, unspecified   Cutoff, U - RoW   | RoW      | UV Smart    | Transport plant China to port of Shanghai   |
| 3.74E+02             | t*km    | transport, freight, sea, container ship, heavy fuel oil                | market for transport, freight, sea, container ship, heavy fuel oil   transport, freight, sea, container ship, heavy fuel oil   Cutoff, U - GLO                               | GLO      | UV Smart    | Transport port of Shanghai to port of Rotterdam   |
| 2.62E-01             | Item(s) | ultraviolet lamp   | market for ultraviolet lamp   ultraviolet lamp   Cutoff, U - GLO   | GLO      | UV Smart    | The UV-C device has 8 UV lamps with a total mass of 0.100 kg. The UV lamp defined in the Ecoinvent database has a mass of 0.382 kg.                               |
| Economic flows, out: |         |  |  |          |             |   |
| Amount               | Unit    | Flow Name  | Provider   | Location | Data source | Additional documentation  |
| 1                    | Item(s) | <b>UV-C device</b>   | production of UV-C device  | NL       |             | The UV-C device has a mass of 19.13 kg. Including the cables, the total mass is 19.43 kg.   |

**Table 14.13:** Use of a bedside cart with a 100% inventory, disposal.

**Unit process: use of bedside cart, 100% inventory, disposal**

| <b>Economic flows, in:</b>  |         |  |   |          |             |   |
|-----------------------------|---------|--|---|----------|-------------|---|
| Amount                      | Unit    | Flow Name  | Provider  | Location | Data source | Additional documentation  |
| 1.38E+04                    | Item(s) | blood gas syringe                                    | production of blood gas syringe   | NL       |             | A full bedside cart inventory contains 15 blood gas syringe, 2 CO2 filter lines, 2 SpO2 sensors, and 2 vacutainer. Assume the full bedside cart as blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer in a 15:2:2:2 ratio, respectively. A bedside cart has 292 suitable medical consumables for disinfection. A 100% bedside cart inventory is assumed. For disposal, an output of one used medical consumable requires the input of two medical consumables. |
| 1.84E+03                    | Item(s) | CO2 filter line                                      | production of CO2 filter line   | NL       |             |   |
| 1.84E+03                    | Item(s) | SpO2 sensor  | production of SpO2 sensor   | NL       |             |   |
| 1.84E+03                    | Item(s) | vacutainer   | production of vacutainer  | NL       |             |   |
| <b>Economic flows, out:</b> |         |  |   |          |             |   |
| Amount                      | Unit    | Flow Name  | Provider  | Location | Data source | Additional documentation  |
| 1                           | Item(s) | <b>use of bedside cart inventory, 100% inventory</b> | use of bedside cart inventory, 100%, disposal   | NL       |             |   |
| 1.33E+02                    | kg      | discarded plastic medical consumable                 | end-of-life plastic medical consumable  | NL       |             | Waste of blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer.   |
| 5.14E+01                    | kg      | discarded plastic packaging                          | end-of-life plastic packaging   | NL       |             | Plastic packaging waste of blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer.   |
| 1.56E+01                    | kg      | waste graphical paper                                | treatment of waste graphical paper, municipal incineration FAE   waste graphical paper   Cutoff, U - CH   | NL       |             | Paper packaging waste of blood gas syringe and vacutainer. Provider data is from Switzerland but assumed for the Netherlands.   |
| 2.45                        | kg      | waste plastic, mixture                               | treatment of waste plastic, mixture, municipal incineration FAE   waste plastic, mixture   Cutoff, U - CH | NL       |             | Waste of the LED sensor of the SpO2 sensor. Provider data is from Switzerland but assumed for the Netherlands.  |
| 1.36E-01                    | kg      | waste steel  | treatment of waste steel, municipal incineration FAE   waste steel   Cutoff, U - CH                       | NL       |             | Waste of the needle of the vacutainer. Provider data is from Switzerland but assumed for the Netherlands.   |

**Table 14.14:** Use of a bedside cart with a 100% inventory, disinfection.

**Unit process: use of bedside cart, 100% inventory, disinfection**

| Economic flows, in:  |         |  |  |          |             |   |
|----------------------|---------|--|--|----------|-------------|---|
| Amount               | Unit    | Flow Name  | Provider   | Location | Data source | Additional documentation  |
| 6.88E+03             | Item(s) | blood gas syringe  | production of blood gas syringe  | NL       |             | A full bedside cart inventory contains 15 blood gas syringe, 2 CO2 filter lines, 2 SpO2 sensors, and 2 vacutainer. Assume the full bedside cart as blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer in a 15:2:2:2 ratio, respectively. A bedside cart has 292 suitable medical consumables for disinfection. A 100% bedside cart inventory is assumed. |
| 9.18E+02             | Item(s) | CO2 filter line  | production of CO2 filter line  | NL       |             |   |
| 9.18E+02             | Item(s) | SpO2 sensor  | production of SpO2 sensor  | NL       |             |   |
| 9.18E+02             | Item(s) | vacutainer   | production of vacutainer   | NL       |             |   |
| 7.14E-04             | kg      | acrylonitrile-butadiene-styrene copolymer                              | market for acrylonitrile-butadiene-styrene copolymer   acrylonitrile-butadiene-styrene copolymer   Cutoff, U - GLO   | GLO      |             | Maintenance of lid clip hook. Assumed to be replaced once every seven years.  |
| 1.71E+01             | kWh     | electricity, low voltage   | market for electricity, low voltage   electricity, low voltage   Cutoff, U - NL  | NL       | UV Smart    | One disinfection cycle consumes 0.011 kWh. For 100% inventory, 1551 cycles are required per year.   |
| 7.14E-02             | kg      | flat glass, coated   | market for flat glass, coated   flat glass, coated   Cutoff, U - RoW   | RoW      |             | Maintenance of transmissive glass plate. Assumed to be replaced once every seven years.   |
| 1.41E-02             | m2      | printed wiring board, for through-hole mounting, Pb containing surface | market for printed wiring board, for through-hole mounting, Pb containing surface   printed wiring board, for through-hole mounting, Pb containing surface   Cutoff, U - GLO | GLO      |             | Maintenance of PCBA. Replaced once every three years.   |
| 2.62E-01             | Item(s) | ultraviolet lamp   | market for ultraviolet lamp   ultraviolet lamp   Cutoff, U - GLO   | GLO      |             | Maintenance of UV-C lamps. Assumed to be replaced annually.   |
| 1.43E-01             | Item(s) | UV-C device  | production of UV-C device  | NL       | UV Smart    | The UV-C device has a lifespan of 7 years. The functional unit covers one year of use.  |
| Economic flows, out: |         |  |  |          |             |   |
| Amount               | Unit    | Flow Name  | Provider   | Location | Data source | Additional documentation  |
| 1                    | Item(s) | <b>use of bedside cart inventory, 100% inventory</b>                   | use of bedside cart inventory, 100%, disinfection  | NL       |             |   |
| 6.66E+01             | kg      | discarded plastic medical consumable                                   | end-of-life plastic medical consumable   | NL       |             | Waste of blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer.   |
| 2.57E+01             | kg      | discarded plastic packaging  | end-of-life plastic packaging  | NL       |             | Plastic packaging waste of blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer.   |
| 1.43E-01             | Item(s) | discarded UV-C device  | end-of-life UV-C device  | NL       |             |   |
| 1.00E-01             | kg      | used fluorescent lamp  | treatment of used fluorescent lamp   used fluorescent lamp   Cutoff, U - GLO   | GLO      |             | Proxy for waste ultraviolet lamp.   |
| 4.33E-02             | kg      | used printed wiring boards   | treatment of scrap printed wiring boards, shredding and separation   used printed wiring boards   Cutoff, U - RoW  | RoW      |             | PCBA waste.   |
| 7.14E-04             | kg      | waste acrylonitrile-butadiene-styrene copolymer                        | end-of-life acrylonitrile-butadiene-styrene copolymer  | NL       |             | Waste of the lid clip hook.   |
| 7.14E-02             | kg      | waste glass  | treatment of waste glass, municipal incineration FAE   waste glass   Cutoff, U - CH  | NL       |             | Provider data from Switzerland but assumed for the Netherlands.   |
| 7.80                 | kg      | waste graphical paper  | treatment of waste graphical paper, municipal incineration FAE   waste graphical paper   Cutoff, U - CH  | NL       |             | Paper packaging waste of blood gas syringe and vacutainer. Provider data is from Switzerland but assumed for the Netherlands.   |

|          |    |                        |   |    |  |  |
|----------|----|------------------------|---|----|--|--|
| 1.22     | kg | waste plastic, mixture | treatment of waste plastic, mixture, municipal incineration FAE   waste plastic, mixture   Cutoff, U - CH | NL |  | Waste of the LED sensor of the SpO2 sensor. Provider data is from Switzerland but assumed for the Netherlands. |
| 6.81E-02 | kg | waste steel            | treatment of waste steel, municipal incineration FAE   waste steel   Cutoff, U - CH                       | NL |  | Waste of the needle of the vacutainer. Provider data is from Switzerland but assumed for the Netherlands.      |

**Table 14.15:** End-of-life plastic medical consumables. The discarded medical consumables are sent to recycling or incineration plants.

**Unit process: end-of-life plastic medical consumable**

| <b>Economic flows, in:</b>  |      |   |  |          |                      |   |
|-----------------------------|------|---|--|----------|----------------------|---|
| Amount                      | Unit | Flow Name                                   | Provider   | Location | Data source          | Additional documentation  |
| 1                           | kg   | <b>discarded plastic medical consumable</b> | use of blood gas syringe, disposal ;<br>use of blood gas syringe, disinfection;<br>use of CO2 filter line, disposal;<br>use of CO2 filter line, disinfection;<br>use of SpO2 sensor, disposal;<br>use of SpO2 sensor, disinfection;<br>use of vacutainer, disposal;<br>use of vacutainer, disinfection | NL       |                      |   |
| <b>Economic flows, out:</b> |      |   |  |          |                      |   |
| Amount                      | Unit | Flow Name                                   | Provider   | Location | Data source          | Additional documentation  |
| 9.20E-01                    | kg   | waste plastic, mixture                      | treatment of waste plastic, mixture, municipal incineration FAE   waste plastic, mixture   Cutoff, U - CH  | NL       | Brouwer et al., 2019 | In the Netherlands, 93% of plastic found in residual waste is sent to incineration. Provider data is from Switzerland but assumed for the Netherlands.  |
| 7.99E-02                    | kg   | waste plastic, mixture, for recycling       | end-of-life plastic medical consumable   | NL       | Brouwer et al., 2019 | In the Netherlands, 7% of plastic found in residual waste is recycled. Due to losses during the recycling process (according to Ecoinvent), to model closed loop recycling, a recycling rate of 7.99% is required |

**Table 14.16:** End-of-life plastic packaging. The discarded plastic packaging is sent to recycling or incineration plants.

**Unit process: end-of-life plastic packaging**

| Economic flows, in:  |      |                                       |  |          |                      |   |
|----------------------|------|---------------------------------------|--|----------|----------------------|---|
| Amount               | Unit | Flow Name                             | Provider   | Location | Data source          | Additional documentation  |
| 1                    | kg   | <b>discarded plastic packaging</b>    | use of blood gas syringe, disposal ;<br>use of blood gas syringe, disinfection;<br>use of CO2 filter line, disposal;<br>use of CO2 filter line, disinfection;<br>use of SpO2 sensor, disposal;<br>use of SpO2 sensor, disinfection;<br>use of vacutainer, disposal;<br>use of vacutainer, disinfection | NL       |                      |   |
| Economic flows, out: |      |                                       |  |          |                      |   |
| Amount               | Unit | Flow Name                             | Provider   | Location | Data source          | Additional documentation  |
| 9.20E-01             | kg   | waste plastic, mixture                | treatment of waste plastic, mixture, municipal incineration FAE   waste plastic, mixture   Cutoff, U - CH  | NL       | Brouwer et al., 2019 | In the Netherlands, 93% of plastic found in residual waste is sent to incineration. Provider data is from Switzerland but assumed for the Netherlands.  |
| 7.99E-02             | kg   | waste plastic, mixture, for recycling | end-of-life blood plastic packaging  | NL       | Brouwer et al., 2019 | In the Netherlands, 7% of plastic found in residual waste is recycled. Due to losses during the recycling process (according to Ecoinvent), to model closed loop recycling, a recycling rate of 7.99% is required |

**Table 14.17:** End-of-life waste acrylonitrile-butadiene-styrene copolymer. The waste acrylonitrile-butadiene-styrene copolymer is sent to recycling or incineration plants.

**Unit process: end-of-life waste acrylonitrile-butadiene-styrene copolymer**

| Economic flows, in:  |      |  |   |          |                         |   |
|----------------------|------|--|---|----------|-------------------------|---|
| Amount               | Unit | Flow Name  | Provider  | Location | Data source             | Additional documentation  |
| 1                    | kg   | <b>waste acrylonitrile-butadiene-styrene copolymer</b> | end-of-life UV-C device   | NL       |                         |   |
| Economic flows, out: |      |  |   |          |                         |   |
| Amount               | Unit | Flow Name  | Provider  | Location | Data source             | Additional documentation  |
| 4.41E-01             | kg   | waste plastic, mixture                                 | treatment of waste plastic, mixture, municipal incineration FAE   waste plastic, mixture   Cutoff, U - CH | NL       | Stichting Verpact, 2024 | In the Netherlands, 51% of plastic packaging waste is recycled. Provider data is from Switzerland but assumed for the Netherlands.  |
| 5.59E-01             | kg   | waste plastic, mixture, for recycling                  | end-of-life waste acrylonitrile-butadiene-styrene copolymer   | NL       | Stichting Verpact, 2024 | In the Netherlands, 49% of plastic packaging waste is recycled. This percentage is used as a proxy for waste acrylonitrile-butadiene-styrene copolymer. Due to losses during the recycling process (according to Ecoinvent), to model closed loop recycling, a recycling rate of 55.90% is required |

**Table 14.18:** Recycling of post-consumer cast alloy aluminium scrap. This unit process is based on the following ecoinvent processes: market for aluminium scrap, post-consumer | aluminium scrap, post-consumer | Cutoff, U – GLO & treatment of aluminium scrap, post-consumer, by collecting, sorting, cleaning, pressing | aluminium scrap, post-consumer, prepared for melting | Cutoff, U – RER & treatment of aluminium scrap, post-consumer, prepared for recycling, at refiner | aluminium, cast alloy | Cutoff, U – RER.

**Unit process: recycling of post-consumer aluminium scrap, cast alloy**

| Economic flows, in: |         |   |  |           |             |                                       |
|---------------------|---------|---|--|-----------|-------------|---------------------------------------|
| Amount              | Unit    | Flow Name   | Provider   | Location  | Data source | Additional documentation              |
| 1.29                | kg      | aluminium scrap, post-consumer                          | end-of-life UV-C device  | NL        | Ecoinvent   | Aluminium scrap from the UV-C device. |
| 1.24E-04            | kg      | alkylbenzene sulfonate, linear, petrochemical           | market for alkylbenzene sulfonate, linear, petrochemical   alkylbenzene sulfonate, linear, petrochemical   Cutoff, U - GLO                                 | GLO       | Ecoinvent   |                                       |
| 1.50E-10            | Item(s) | aluminium casting facility                              | aluminium casting facility construction   aluminium casting facility   Cutoff, U - RER   | RER       | Ecoinvent   |                                       |
| 1.95E-09            | Item(s) | aluminium melting furnace                               | aluminium melting furnace production   aluminium melting furnace   Cutoff, U - RER   | RER       | Ecoinvent   |                                       |
| 9.48E-04            | kg      | argon, liquid   | market for argon, liquid   argon, liquid   Cutoff, U - RER   | RER       | Ecoinvent   |                                       |
| 2.44E-04            | kg      | chlorine, liquid  | market for chlorine, liquid   chlorine, liquid   Cutoff, U - RER   | RER       | Ecoinvent   |                                       |
| 1.07E-03            | kg      | copper, cathode   | market for copper, cathode   copper, cathode   Cutoff, U - GLO   | GLO       | Ecoinvent   |                                       |
| 7.04E-04            | kg      | cryolite  | market for cryolite   cryolite   Cutoff, U - GLO   | GLO       | Ecoinvent   |                                       |
| 1.24E-01            | kWh     | electricity, medium voltage                             | market group for electricity, medium voltage   electricity, medium voltage   Cutoff, U - RER   | RER       | Ecoinvent   |                                       |
| 4.18                | MJ      | heat, district or industrial, natural gas               | market group for heat, district or industrial, natural gas   heat, district or industrial, natural gas   Cutoff, U - RER                                   | RER       | Ecoinvent   |                                       |
| 2.31E-01            | MJ      | heat, district or industrial, other than natural gas    | heat production, heavy fuel oil, at industrial furnace 1MW   heat, district or industrial, other than natural gas   Cutoff, U - Europe without Switzerland | EU w/o CH | Ecoinvent   |                                       |
| 4.00E-03            | kg      | hydrated lime, packed                                   | market for hydrated lime, packed   hydrated lime, packed   Cutoff, U - RER   | RER       | Ecoinvent   |                                       |
| 2.05E-04            | kg      | hydrochloric acid, without water, in 30% solution state | market for hydrochloric acid, without water, in 30% solution state   hydrochloric acid, without water, in 30% solution state   Cutoff, U - RER             | RER       | Ecoinvent   |                                       |
| -3.67E-02           | kg      | iron scrap, unsorted                                    | iron scrap, unsorted, Recycled Content cut-off   iron scrap, unsorted   Cutoff, U - GLO  | GLO       | Ecoinvent   |                                       |
| 1.77E-04            | kg      | light fuel oil  | market group for light fuel oil   light fuel oil   Cutoff, U - RER   | RER       | Ecoinvent   |                                       |
| 1.18E-04            | kg      | lubricating oil   | market for lubricating oil   lubricating oil   Cutoff, U - RER   | RER       | Ecoinvent   |                                       |
| 3.13E-03            | kg      | nitrogen, liquid  | market for nitrogen, liquid   nitrogen, liquid   Cutoff, U - RER   | RER       | Ecoinvent   |                                       |
| 2.35E-03            | kg      | refractory, basic, packed                               | market for refractory, basic, packed   refractory, basic, packed   Cutoff, U - GLO   | GLO       | Ecoinvent   |                                       |
| 2.06E-09            | Item(s) | scrap preparation facility                              | scrap preparation facility construction   scrap preparation facility   Cutoff, U - RER   | RER       | Ecoinvent   |                                       |
| 1.11E-02            | kg      | silicon, metallurgical grade                            | market for silicon, metallurgical grade   silicon, metallurgical grade   Cutoff, U - GLO   | GLO       | Ecoinvent   |                                       |
| 1.10E-02            | kg      | sodium chloride, powder                                 | market for sodium chloride, powder   sodium chloride, powder   Cutoff, U - GLO   | GLO       | Ecoinvent   |                                       |
| 1.55E-03            | kg      | sodium hydroxide, without water, in 50% solution state  | market for sodium hydroxide, without water, in 50% solution state   sodium hydroxide, without water, in 50% solution state   Cutoff, U - RER               | RER       | Ecoinvent   |                                       |
| 7.78E-03            | kg      | sulfuric acid   | market for sulfuric acid   sulfuric acid   Cutoff, U - RER   | RER       | Ecoinvent   |                                       |

|                                 |             |   |  |                 |                    |                                 |
|---------------------------------|-------------|---|--|-----------------|--------------------|---------------------------------|
| 2.56E-02                        | t*km        | transport, freight, inland waterways, barge, diesel     | market group for transport, freight, inland waterways, barge, diesel   transport, freight, inland waterways, barge, diesel   Cutoff, U - GLO   | GLO             | Ecoinvent          |                                 |
| 2.49E-01                        | t*km        | transport, freight, lorry, diesel, unspecified          | market group for transport, freight, lorry, diesel, unspecified   transport, freight, lorry, diesel, unspecified   Cutoff, U - GLO             | GLO             | Ecoinvent          |                                 |
| 2.72E-01                        | t*km        | transport, freight, sea, container ship, heavy fuel oil | market for transport, freight, sea, container ship, heavy fuel oil   transport, freight, sea, container ship, heavy fuel oil   Cutoff, U - GLO | GLO             | Ecoinvent          |                                 |
| 1.44E-01                        | t*km        | transport, freight, train, fleet average                | market group for transport, freight, train, fleet average   transport, freight, train, fleet average   Cutoff, U - GLO                         | GLO             | Ecoinvent          |                                 |
| 5.21E-02                        | kg          | zinc  | market for zinc   zinc   Cutoff, U - GLO   | GLO             | Ecoinvent          |                                 |
| <b>Economic flows, out:</b>     |             |   |  |                 |                    |                                 |
| <i>Amount</i>                   | <i>Unit</i> | <i>Flow Name</i>  | <i>Provider</i>  | <i>Location</i> | <i>Data source</i> | <i>Additional documentation</i> |
| 1                               | kg          | <b>recycled post-consumer aluminium, cast alloy</b>     | recycling of post-consumer aluminium scrap, cast alloy   | NL              | Ecoinvent          |                                 |
| 1.65E-02                        | kg          | inert waste, for final disposal                         | market for inert waste, for final disposal   inert waste, for final disposal   Cutoff, U - CH  | CH              | Ecoinvent          |                                 |
| 1.66E-03                        | kg          | municipal solid waste                                   | market group for municipal solid waste   municipal solid waste   Cutoff, U - RER   | RER             | Ecoinvent          |                                 |
| 5.31E-03                        | kg          | waste copper  | market for waste copper   waste copper   Cutoff, U - CH  | CH              | Ecoinvent          |                                 |
| 1.13E-01                        | kg          | waste copper  | market for waste copper   waste copper   Cutoff, U - Europe without Switzerland  | EU w/o CH       | Ecoinvent          |                                 |
| 2.44E-02                        | kg          | waste polyethylene                                      | treatment of waste polyethylene, municipal incineration   waste polyethylene   Cutoff, U - GLO   | GLO             | Ecoinvent          |                                 |
| 1.95E-03                        | kg          | waste rubber, unspecified                               | market for waste rubber, unspecified   waste rubber, unspecified   Cutoff, U - CH  | CH              | Ecoinvent          |                                 |
| 4.65E-02                        | kg          | waste rubber, unspecified                               | market for waste rubber, unspecified   waste rubber, unspecified   Cutoff, U - Europe without Switzerland                                      | EU w/o CH       | Ecoinvent          |                                 |
| 2.06E-02                        | kg          | filter dust from Al electrolysis                        | market for filter dust from Al electrolysis   filter dust from Al electrolysis   Cutoff, U - CH  | CH              | Ecoinvent          |                                 |
| 7.63E-03                        | kg          | hazardous waste, for underground deposit                | market for hazardous waste, for underground deposit   hazardous waste, for underground deposit   Cutoff, U - RER                               | RER             | Ecoinvent          |                                 |
| 1.25E-03                        | kg          | waste mineral oil                                       | market for waste mineral oil   waste mineral oil   Cutoff, U - Europe without Switzerland  | EU w/o CH       | Ecoinvent          |                                 |
| 3.41E-05                        | kg          | waste mineral oil                                       | market for waste mineral oil   waste mineral oil   Cutoff, U - CH  | CH              | Ecoinvent          |                                 |
| <b>Environmental flows, in</b>  |             |   |  |                 |                    |                                 |
| <i>Amount</i>                   | <i>Unit</i> | <i>Flow Name</i>  | <i>Compartment</i>   |                 | <i>Data source</i> | <i>Additional documentation</i> |
| 1.74E-02                        | m3          | Water, unspecified natural origin                       | Resource/in water  |                 | Ecoinvent          |                                 |
| <b>Environmental flows, out</b> |             |   |  |                 |                    |                                 |
| <i>Amount</i>                   | <i>Unit</i> | <i>Flow Name</i>  | <i>Compartment</i>   |                 | <i>Data source</i> | <i>Additional documentation</i> |
| 1.96E-05                        | kg          | Ammonia   | Emission to air/unspecified  |                 | Ecoinvent          |                                 |
| 1.96E-06                        | kg          | Chlorine  | Emission to air/unspecified  |                 | Ecoinvent          |                                 |
| 4.89E-05                        | kg          | Hydrocarbons, chlorinated                               | Emission to air/unspecified  |                 | Ecoinvent          |                                 |
| 1.03E-05                        | kg          | Hydrochloric acid                                       | Emission to air/unspecified  |                 | Ecoinvent          |                                 |

**Table 14.19:** Recycling of post-consumer wrought alloy aluminium scrap. This unit process is based on the following ecoinvent processes: market for aluminium scrap, post-consumer | aluminium scrap, post-consumer | Cutoff, U – GLO & treatment of aluminium scrap, post-consumer, by collecting, sorting, cleaning, pressing | aluminium scrap, post-consumer, prepared for melting | Cutoff, U – RER & treatment of aluminium scrap, post-consumer, prepared for recycling, at remelter | aluminium, wrought alloy | Cutoff, U – RER.

**Unit process: recycling of post-consumer aluminium scrap, wrought alloy**

| Economic flows, in:  |         |   |  |           |             |                                       |
|----------------------|---------|---|--|-----------|-------------|---------------------------------------|
| Amount               | Unit    | Flow Name   | Provider   | Location  | Data source | Additional documentation              |
| 1.26                 | kg      | aluminium scrap, post-consumer                          | end-of-life UV-C device  | NL        | Ecoinvent   | Aluminium scrap from the UV-C device. |
| 1.21E-04             | kg      | alkylbenzene sulfonate, linear, petrochemical           | market for alkylbenzene sulfonate, linear, petrochemical   alkylbenzene sulfonate, linear, petrochemical   Cutoff, U - GLO                                 | GLO       | Ecoinvent   |                                       |
| 1.54E-10             | Item(s) | aluminium casting facility                              | aluminium casting facility construction   aluminium casting facility   Cutoff, U - RER   | RER       | Ecoinvent   |                                       |
| 1.43E-02             | kg      | copper, cathode   | market for copper, cathode   copper, cathode   Cutoff, U - GLO   | GLO       | Ecoinvent   |                                       |
| 1.97E-01             | kWh     | electricity, medium voltage                             | market group for electricity, medium voltage   electricity, medium voltage   Cutoff, U - RER   | RER       | Ecoinvent   |                                       |
| 3.69                 | MJ      | heat, district or industrial, natural gas               | market group for heat, district or industrial, natural gas   heat, district or industrial, natural gas   Cutoff, U - RER                                   | RER       | Ecoinvent   |                                       |
| 1.99E-01             | MJ      | heat, district or industrial, other than natural gas    | heat production, heavy fuel oil, at industrial furnace 1MW   heat, district or industrial, other than natural gas   Cutoff, U - Europe without Switzerland | EU w/o CH | Ecoinvent   |                                       |
| 1.41E-04             | kg      | hydrated lime, packed                                   | market for hydrated lime, packed   hydrated lime, packed   Cutoff, U - RER   | RER       | Ecoinvent   |                                       |
| -3.43E-02            | kg      | iron scrap, unsorted                                    | iron scrap, unsorted, Recycled Content cut-off   iron scrap, unsorted   Cutoff, U - GLO  | GLO       | Ecoinvent   |                                       |
| 1.72E-04             | kg      | light fuel oil  | market group for light fuel oil   light fuel oil   Cutoff, U - RER   | RER       | Ecoinvent   |                                       |
| 1.01E-05             | kg      | lubricating oil   | market for lubricating oil   lubricating oil   Cutoff, U - RER   | RER       | Ecoinvent   |                                       |
| 1.25E-03             | kg      | nitrogen, liquid  | market for nitrogen, liquid   nitrogen, liquid   Cutoff, U - RER   | RER       | Ecoinvent   |                                       |
| 1.40E-03             | kg      | refractory, fireclay, packed                            | market for refractory, fireclay, packed   refractory, fireclay, packed   Cutoff, U - GLO   | GLO       | Ecoinvent   |                                       |
| 2.02E-09             | Item(s) | scrap preparation facility                              | scrap preparation facility construction   scrap preparation facility   Cutoff, U - RER   | RER       | Ecoinvent   |                                       |
| 1.64E-02             | kg      | silicon, metallurgical grade                            | market for silicon, metallurgical grade   silicon, metallurgical grade   Cutoff, U - GLO   | GLO       | Ecoinvent   |                                       |
| 5.00E-04             | kg      | sodium chloride, powder                                 | market for sodium chloride, powder   sodium chloride, powder   Cutoff, U - GLO   | GLO       | Ecoinvent   |                                       |
| 2.51E-02             | t*km    | transport, freight, inland waterways, barge, diesel     | market group for transport, freight, inland waterways, barge, diesel   transport, freight, inland waterways, barge, diesel   Cutoff, U - GLO               | GLO       | Ecoinvent   |                                       |
| 2.44E-01             | t*km    | transport, freight, lorry, diesel, unspecified          | market group for transport, freight, lorry, diesel, unspecified   transport, freight, lorry, diesel, unspecified   Cutoff, U - GLO                         | GLO       | Ecoinvent   |                                       |
| 2.67E-01             | t*km    | transport, freight, sea, container ship, heavy fuel oil | market for transport, freight, sea, container ship, heavy fuel oil   transport, freight, sea, container ship, heavy fuel oil   Cutoff, U - GLO             | GLO       | Ecoinvent   |                                       |
| 1.41E-01             | t*km    | transport, freight, train, fleet average                | market group for transport, freight, train, fleet average   transport, freight, train, fleet average   Cutoff, U - GLO                                     | GLO       | Ecoinvent   |                                       |
| Economic flows, out: |         |   |  |           |             |                                       |
| Amount               | Unit    | Flow Name   | Provider   | Location  | Data source | Additional documentation              |
| 1                    | kg      | recycled post-consumer aluminium, wrought alloy         | recycling of post-consumer aluminium scrap, wrought alloy  | NL        | Ecoinvent   |                                       |
| 3.55E-03             | kg      | filter dust from Al electrolysis                        | market for filter dust from Al electrolysis   filter dust from Al electrolysis   Cutoff, U - CH  | CH        | Ecoinvent   |                                       |
| 1.53E-06             | kg      | hazardous waste, for incineration                       | market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, U - CH  | CH        | Ecoinvent   |                                       |
| 5.85E-05             | kg      | hazardous waste, for incineration                       | market for hazardous waste, for incineration   hazardous waste, for incineration   Cutoff, U - Europe without Switzerland                                  | EU w/o CH | Ecoinvent   |                                       |

|                                 |             |  |  |           |                    |                                 |
|---------------------------------|-------------|--|--|-----------|--------------------|---------------------------------|
| 9.35E-03                        | kg          | hazardous waste, for underground deposit | market for hazardous waste, for underground deposit   hazardous waste, for underground deposit   Cutoff, U - RER | RER       | Ecoinvent          |                                 |
| 1.78E-02                        | kg          | inert waste, for final disposal          | market for inert waste, for final disposal   inert waste, for final disposal   Cutoff, U - CH                    | CH        | Ecoinvent          |                                 |
| 1.62E-03                        | kg          | municipal solid waste                    | market group for municipal solid waste   municipal solid waste   Cutoff, U - RER                                 | RER       | Ecoinvent          |                                 |
| 5.20E-03                        | kg          | waste copper                             | market for waste copper   waste copper   Cutoff, U - CH  | CH        | Ecoinvent          |                                 |
| 1.11E-01                        | kg          | waste copper                             | market for waste copper   waste copper   Cutoff, U - Europe without Switzerland                                  | EU w/o CH | Ecoinvent          |                                 |
| 1.23E-03                        | kg          | waste mineral oil                        | market for waste mineral oil   waste mineral oil   Cutoff, U - Europe without Switzerland                        | EU w/o CH | Ecoinvent          |                                 |
| 3.34E-05                        | kg          | waste mineral oil                        | market for waste mineral oil   waste mineral oil   Cutoff, U - CH  | CH        | Ecoinvent          |                                 |
| 1.91E-03                        | kg          | waste rubber, unspecified                | market for waste rubber, unspecified   waste rubber, unspecified   Cutoff, U - CH                                | CH        | Ecoinvent          |                                 |
| 4.55E-02                        | kg          | waste rubber, unspecified                | market for waste rubber, unspecified   waste rubber, unspecified   Cutoff, U - Europe without Switzerland        | EU w/o CH | Ecoinvent          |                                 |
| <b>Environmental flows, in</b>  |             |  |  |           |                    |                                 |
| <i>Amount</i>                   | <i>Unit</i> | <i>Flow Name</i>                         | <i>Compartment</i>   |           | <i>Data source</i> | <i>Additional documentation</i> |
| 9.71E-03                        | m3          | Water, unspecified natural origin        | Resource/in water  |           | Ecoinvent          |                                 |
| <b>Environmental flows, out</b> |             |  |  |           |                    |                                 |
| <i>Amount</i>                   | <i>Unit</i> | <i>Flow Name</i>                         | <i>Compartment</i>   |           | <i>Data source</i> | <i>Additional documentation</i> |
| 6.00E-06                        | kg          | Chlorine                                 | Emission to air/unspecified  |           | Ecoinvent          |                                 |
| 3.90E-06                        | kg          | Hydrocarbons, chlorinated                | Emission to air/unspecified  |           | Ecoinvent          |                                 |
| 1.01E-05                        | kg          | Hydrochloric acid                        | Emission to air/unspecified  |           | Ecoinvent          |                                 |
| 3.30E-05                        | kg          | Hydrochloric acid                        | Emission to air/unspecified  |           | Ecoinvent          |                                 |
| 3.23E-05                        | kg          | Particulate Matter, < 2.5 um             | Emission to air/unspecified  |           | Ecoinvent          |                                 |
| 1.31E-05                        | kg          | Particulate Matter, < 2.5 um             | Emission to air/unspecified  |           | Ecoinvent          |                                 |
| 2.02E-05                        | kg          | Particulate Matter, > 10 um              | Emission to air/unspecified  |           | Ecoinvent          |                                 |
| 8.20E-06                        | kg          | Particulate Matter, > 10 um              | Emission to air/unspecified  |           | Ecoinvent          |                                 |
| 4.84E-05                        | kg          | Particulate Matter, > 2.5 um and < 10um  | Emission to air/unspecified  |           | Ecoinvent          |                                 |
| 1.97E-05                        | kg          | Particulate Matter, > 2.5 um and < 10um  | Emission to air/unspecified  |           | Ecoinvent          |                                 |
| 9.17E-06                        | m3          | Water                                    | Emission to water/unspecified  |           | Ecoinvent          |                                 |

**Table 14.20:** Recycling of waste plastic. This unit process is based on the following ecoinvent processes: market for waste plastic, mixed, for recycling, unsorted | waste plastic, mixed, for recycling, unsorted | Cutoff, U – RER & treatment of waste plastic, mixed, recycling | plastic, mixed, recycled | Cutoff, U – RER.

**Unit process: recycling of waste plastic**

| <b>Economic flows, in:</b>      |         |  |  |           |             |                          |
|---------------------------------|---------|--|--|-----------|-------------|--------------------------|
| Amount                          | Unit    | Flow Name                                      | Provider   | Location  | Data source | Additional documentation |
| 1.14                            | kg      | <b>waste plastic, mixture, for recycling</b>   | end-of-life plastic medical consumable; end-of-life plastic packaging; end-of-life acrylonitrile-butadiene-styrene copolymer | NL        | Ecoinvent   |                          |
| -2.76E-04                       | kg      | aluminium scrap, post-consumer                 | aluminium scrap, post-consumer, Recycled Content cut-off   aluminium scrap, post-consumer   Cutoff, U - GLO                  | GLO       | Ecoinvent   |                          |
| 8.25E-01                        | kWh     | electricity, low voltage                       | market group for electricity, low voltage   electricity, low voltage   Cutoff, U - RER                                       | RER       | Ecoinvent   |                          |
| -2.41E-02                       | kg      | iron scrap, unsorted                           | iron scrap, unsorted, Recycled Content cut-off   iron scrap, unsorted   Cutoff, U - GLO                                      | CH        | Ecoinvent   |                          |
| 1.49E-03                        | kg      | magnesium sulfate                              | market for magnesium sulfate   magnesium sulfate   Cutoff, U - GLO   | EU w/o CH | Ecoinvent   |                          |
| 9.29E-03                        | kg      | tap water                                      | market group for tap water   tap water   Cutoff, U - RER   | GLO       | Ecoinvent   |                          |
| 8.78E-02                        | t*km    | transport, freight, lorry, diesel, unspecified | market for transport, freight, lorry, unspecified   transport, freight, lorry, diesel, unspecified   Cutoff, U - RER         | CH        | Ecoinvent   |                          |
| 3.58E-10                        | Item(s) | waste preparation facility                     | market for waste preparation facility   waste preparation facility   Cutoff, U - GLO   | EU w/o CH | Ecoinvent   |                          |
| <b>Economic flows, out:</b>     |         |  |  |           |             |                          |
| Amount                          | Unit    | Flow Name                                      | Provider   | Location  | Data source | Additional documentation |
| 1                               | kg      | <b>recycled plastic, mixture</b>               | recycling of waste plastic   | NL        | Ecoinvent   |                          |
| 8.35E-02                        | kg      | cake from sorting of waste plastic             | market for cake from sorting of waste plastic   cake from sorting of waste plastic   Cutoff, U - RER                         | RER       | Ecoinvent   |                          |
| 2.56E-01                        | kg      | waste plastic, mixture                         | market group for waste plastic, mixture   waste plastic, mixture   Cutoff, U - RER   | RER       | Ecoinvent   |                          |
| 2.28E-07                        | m3      | wastewater, average                            | market for wastewater, average   wastewater, average   Cutoff, U - CH  | CH        | Ecoinvent   |                          |
| 9.06E-06                        | m3      | wastewater, average                            | market for wastewater, average   wastewater, average   Cutoff, U - Europe without Switzerland                                | EU w/o CH | Ecoinvent   |                          |
| <b>Environmental flows, out</b> |         |  |  |           |             |                          |
| Amount                          | Unit    | Flow Name                                      | Compartment  |           | Data source | Additional documentation |
| 5.96E-06                        | kg      | Particulate Matter, > 10 um                    | Emission to air/unspecified  |           | Ecoinvent   |                          |

**Table 14.21:** Use of blood gas syringe, disposal.

**Unit process: use of blood gas syringe, disposal**

| <b>Economic flows, in:</b>  |         |                                      |   |          |             |   |
|-----------------------------|---------|--------------------------------------|---|----------|-------------|---|
| Amount                      | Unit    | Flow Name                            | Provider  | Location | Data source | Additional documentation  |
| 2                           | Item(s) | blood gas syringe                    | production of blood gas syringe   | NL       |             | Of these two blood gas syringes, one is unused and disposed of while the other is used to provide care to a patient.        |
| <b>Economic flows, out:</b> |         |                                      |   |          |             |   |
| Amount                      | Unit    | Flow Name                            | Provider  | Location | Data source | Additional documentation  |
| 1                           | Item(s) | <b>use of blood gas syringe</b>      | use blood gas syringe, disposal   | NL       |             |   |
| 8.00E-03                    | kg      | discarded plastic medical consumable | end-of-life plastic medical consumable  | NL       |             |   |
| 4.00E-03                    | kg      | discarded plastic packaging          | end-of-life plastic packaging   | NL       |             |   |
| 2.00E-03                    | kg      | waste graphical paper                | treatment of waste graphical paper, municipal incineration FAE   waste graphical paper   Cutoff, U - CH | NL       |             | Waste graphical paper assumed for waste paper packaging. Provider data is from Switzerland but assumed for the Netherlands. |

**Table 14.22: Use of CO<sub>2</sub> filter line, disposal.**

**Unit process: use of CO<sub>2</sub> filter line, disposal**

| Economic flows, in:  |         |  |  |          |             |  |
|----------------------|---------|--|--|----------|-------------|--|
| Amount               | Unit    | Flow Name                                | Provider                                     | Location | Data source | Additional documentation   |
| 2                    | Item(s) | CO <sub>2</sub> filter line              | production of CO <sub>2</sub> filter line    | NL       |             | Of these two CO <sub>2</sub> filter lines, one is unused and disposed of while the other is used to provide care to a patient. |
| Economic flows, out: |         |  |  |          |             |  |
| Amount               | Unit    | Flow Name                                | Provider                                     | Location | Data source | Additional documentation   |
| 1                    | Item(s) | <b>use of CO<sub>2</sub> filter line</b> | use of CO <sub>2</sub> filter line, disposal | NL       |             |  |
| 4.00E-02             | kg      | discarded plastic medical consumable     | end-of-life plastic medical consumable       | NL       |             |  |
| 8.00E-03             | kg      | discarded plastic packaging              | end-of-life plastic packaging                | NL       |             |  |

**Table 14.23: Use of SpO<sub>2</sub> sensor, disposal.**

**Unit process: use of SpO<sub>2</sub> sensor, disposal**

| Economic flows, in:  |         |                                      |   |          |             |  |
|----------------------|---------|--------------------------------------|---|----------|-------------|--|
| Amount               | Unit    | Flow Name                            | Provider  | Location | Data source | Additional documentation   |
| 2                    | Item(s) | SpO <sub>2</sub> sensor              | production of SpO <sub>2</sub> sensor   | NL       |             | Of these two SpO <sub>2</sub> sensors, one is unused and disposed of while the other is used to provide care to a patient. |
| Economic flows, out: |         |                                      |   |          |             |  |
| Amount               | Unit    | Flow Name                            | Provider  | Location | Data source | Additional documentation   |
| 1                    | Item(s) | <b>use of SpO<sub>2</sub> sensor</b> | use of SpO <sub>2</sub> sensor, disposal  | NL       |             |  |
| 3.33E-02             | kg      | discarded plastic medical consumable | end-of-life plastic medical consumable  | NL       |             |  |
| 4.00E-03             | kg      | discarded plastic packaging          | end-of-life plastic packaging   | NL       |             |  |
| 2.67E-03             | kg      | waste plastic, mixture               | treatment of waste plastic, mixture, municipal incineration FAE   waste plastic, mixture   Cutoff, U - CH | NL       |             | Waste of the LED sensor. Provider data is from Switzerland but assumed for the Netherlands.                                |

**Table 14.24: Use of vacutainer, disposal.**

**Unit process: use of vacutainer, disposal**

| Economic flows, in:  |         |                                      |   |          |             |   |
|----------------------|---------|--------------------------------------|---|----------|-------------|---|
| Amount               | Unit    | Flow Name                            | Provider  | Location | Data source | Additional documentation  |
| 2                    | Item(s) | vacutainer                           | production of vacutainer  | NL       |             | Of these two vacutainers, one is unused and disposed of while the other is used to provide care to a patient.               |
| Economic flows, out: |         |                                      |   |          |             |   |
| Amount               | Unit    | Flow Name                            | Provider  | Location | Data source | Additional documentation  |
| 1                    | Item(s) | <b>use of vacutainer</b>             | use of vacutainer, disposal   | NL       |             |   |
| 1.19E-02             | kg      | discarded plastic medical consumable | end-of-life plastic medical consumable  | NL       |             |   |
| 1.40E-02             | kg      | discarded plastic packaging          | end-of-life plastic packaging   | NL       |             |   |
| 2.00E-03             | kg      | waste graphical paper                | treatment of waste graphical paper, municipal incineration FAE   waste graphical paper   Cutoff, U - CH | NL       |             | Waste graphical paper assumed for waste paper packaging. Provider data is from Switzerland but assumed for the Netherlands. |
| 1.48E-04             | kg      | waste steel                          | treatment of waste steel, municipal incineration FAE   waste steel   Cutoff, U - CH                     | NL       |             | Provider data is from Switzerland but assumed for the Netherlands.  |

**Table 14.25: Use of blood gas syringe, disinfection.**

**Unit process: use of blood gas syringe, disinfection**

| <b>Economic flows, in:</b>  |             |  |  |                 |                    |   |
|-----------------------------|-------------|--|--|-----------------|--------------------|---|
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>   | <i>Provider</i>  | <i>Location</i> | <i>Data source</i> | <i>Additional documentation</i>   |
| 9.40E-09                    | kg          | acrylonitrile-butadiene-styrene copolymer                              | market for acrylonitrile-butadiene-styrene copolymer   acrylonitrile-butadiene-styrene copolymer   Cutoff, U - GLO   | GLO             |                    | Maintenance of lid clip hook. Assumed to be replaced once every seven years.  |
| 1                           | Item(s)     | blood gas syringe  | production of blood gas syringe  | NL              |                    | Seven blood gas syringes can be disinfected simultaneously.   |
| 1.57E-03                    | kWh         | electricity, low voltage   | market for electricity, low voltage   electricity, low voltage   Cutoff, U - NL  | NL              | UV Smart           | One disinfection cycle consumes 0.011 kWh.  |
| 9.40E-07                    | kg          | flat glass, coated   | market for flat glass, coated   flat glass, coated   Cutoff, U - RoW   | RoW             |                    | Maintenance of transmissive glass plate. Assumed to be replaced once every seven years.                                     |
| 1.85E-07                    | m2          | printed wiring board, for through-hole mounting, Pb containing surface | market for printed wiring board, for through-hole mounting, Pb containing surface   printed wiring board, for through-hole mounting, Pb containing surface   Cutoff, U - GLO | GLO             |                    | Maintenance of PCBA. Replaced once every three years.   |
| 3.44E-06                    | Item(s)     | ultraviolet lamp   | market for ultraviolet lamp   ultraviolet lamp   Cutoff, U - GLO   | GLO             |                    | Maintenance of UV-C lamps. Assumed to be replaced annually.   |
| 1.32E-05                    | Item(s)     | UV-C device  | production of UV-C device  | NL              | UV Smart           | In 2024, 33 bedside carts were disposed of with a full bedside cart requiring 47 disinfection cycles.                       |
| <b>Economic flows, out:</b> |             |  |  |                 |                    |   |
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>   | <i>Provider</i>  | <i>Location</i> | <i>Data source</i> | <i>Additional documentation</i>   |
| 1                           | Item(s)     | <b>use of blood gas syringe</b>  | blood gas syringe use, disinfection  | NL              |                    |   |
| 4.00E-03                    | kg          | discarded plastic medical consumable                                   | end-of-life plastic medical consumable   | NL              |                    |   |
| 2.00E-03                    | kg          | discarded plastic packaging  | end-of-life plastic packaging  | NL              |                    |   |
| 1.32E-05                    | Item(s)     | discarded UV-C device  | end-of-life UV-C device  | NL              |                    |   |
| 1.32E-06                    | kg          | used fluorescent lamp  | treatment of used fluorescent lamp   used fluorescent lamp   Cutoff, U - GLO   | GLO             |                    | Proxy for waste ultraviolet lamp.   |
| 5.70E-07                    | kg          | used printed wiring boards   | treatment of scrap printed wiring boards, shredding and separation   used printed wiring boards   Cutoff, U - RoW  | RoW             |                    | PCBA waste.   |
| 9.40E-09                    | kg          | waste acrylonitrile-butadiene-styrene copolymer                        | end-of-life acrylonitrile-butadiene-styrene copolymer  | NL              |                    | Waste of the lid clip hook.   |
| 9.40E-07                    | kg          | waste glass  | treatment of waste glass, municipal incineration FAE   waste glass   Cutoff, U - CH  | NL              |                    | Provider data from Switzerland but assumed for the Netherlands.   |
| 1.00E-03                    | kg          | waste graphical paper  | treatment of waste graphical paper, municipal incineration FAE   waste graphical paper   Cutoff, U - CH  | NL              |                    | Waste graphical paper assumed for waste paper packaging. Provider data is from Switzerland but assumed for the Netherlands. |

**Table 14.26:** Use of CO<sub>2</sub> filter line, disinfection.

**Unit process: use of CO<sub>2</sub> filter line, disinfection**

| <b>Economic flows, in:</b>  |             |  |  |                 |                    |   |
|-----------------------------|-------------|--|--|-----------------|--------------------|---|
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>   | <i>Provider</i>  | <i>Location</i> | <i>Data source</i> | <i>Additional documentation</i>   |
| 3.29E-08                    | kg          | acrylonitrile-butadiene-styrene copolymer                              | market for acrylonitrile-butadiene-styrene copolymer   acrylonitrile-butadiene-styrene copolymer   Cutoff, U - GLO   | GLO             |                    | Maintenance of lid clip hook. Assumed to be replaced once every seven years.            |
| 1                           | Item(s)     | CO2 filter line  | production of CO2 filter line  | NL              |                    | Two CO2 filter lines can be disinfected simultaneously.                                 |
| 5.50E-03                    | kWh         | electricity, low voltage   | market for electricity, low voltage   electricity, low voltage   Cutoff, U - NL  | NL              | UV Smart           | One disinfection cycle consumes 0.011 kWh.  |
| 3.29E-06                    | kg          | flat glass, coated   | market for flat glass, coated   flat glass, coated   Cutoff, U - RoW   | RoW             |                    | Maintenance of transmissive glass plate. Assumed to be replaced once every seven years. |
| 6.48E-07                    | m2          | printed wiring board, for through-hole mounting, Pb containing surface | market for printed wiring board, for through-hole mounting, Pb containing surface   printed wiring board, for through-hole mounting, Pb containing surface   Cutoff, U - GLO | GLO             |                    | Maintenance of PCBA. Replaced once every three years.                                   |
| 1.21E-05                    | Item(s)     | ultraviolet lamp   | market for ultraviolet lamp   ultraviolet lamp   Cutoff, U - GLO   | GLO             |                    | Maintenance of UV-C lamps. Assumed to be replaced annually.                             |
| 4.61E-05                    | Item(s)     | UV-C device  | production of UV-C device  | NL              | UV Smart           |   |
| <b>Economic flows, out:</b> |             |  |  |                 |                    |   |
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>   | <i>Provider</i>  | <i>Location</i> | <i>Data source</i> | <i>Additional documentation</i>   |
| 1                           | Item(s)     | <b>use of CO2 filter line</b>  | CO2 filter line use, disinfection  | NL              |                    |   |
| 2.00E-02                    | kg          | discarded plastic medical consumable                                   | end-of-life plastic medical consumable   | NL              |                    |   |
| 4.00E-03                    | kg          | discarded plastic packaging  | end-of-life plastic packaging  | NL              |                    |   |
| 4.61E-05                    | Item(s)     | discarded UV-C device  | end-of-life UV-C device  | NL              |                    |   |
| 4.61E-06                    | kg          | used fluorescent lamp  | treatment of used fluorescent lamp   used fluorescent lamp   Cutoff, U - GLO   | GLO             |                    | Proxy for waste ultraviolet lamp.   |
| 2.00E-06                    | kg          | used printed wiring boards   | treatment of scrap printed wiring boards, shredding and separation   used printed wiring boards   Cutoff, U - RoW  | RoW             |                    | PCBA waste.   |
| 3.29E-08                    | kg          | waste acrylonitrile-butadiene-styrene copolymer                        | end-of-life acrylonitrile-butadiene-styrene copolymer  | NL              |                    | Waste of the lid clip hook.   |
| 3.29E-06                    | kg          | waste glass  | treatment of waste glass, municipal incineration FAE   waste glass   Cutoff, U - CH  | NL              |                    | Provider data from Switzerland but assumed for the Netherlands.                         |

**Table 14.27:** Use of SpO<sub>2</sub> sensor, disinfection.

**Unit process: use of SpO<sub>2</sub> sensor, disinfection**

| <b>Economic flows, in:</b>  |             |  |  |                 |                    |   |
|-----------------------------|-------------|--|--|-----------------|--------------------|---|
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>   | <i>Provider</i>  | <i>Location</i> | <i>Data source</i> | <i>Additional documentation</i>   |
| 1.64E-08                    | kg          | acrylonitrile-butadiene-styrene copolymer                              | market for acrylonitrile-butadiene-styrene copolymer   acrylonitrile-butadiene-styrene copolymer   Cutoff, U - GLO   | GLO             |                    | Maintenance of lid clip hook. Assumed to be replaced once every seven years.                |
| 2.75E-03                    | kWh         | electricity, low voltage   | market for electricity, low voltage   electricity, low voltage   Cutoff, U - NL  | NL              | UV Smart           | One disinfection cycle consumes 0.011 kWh.  |
| 1.64E-06                    | kg          | flat glass, coated   | market for flat glass, coated   flat glass, coated   Cutoff, U - RoW   | RoW             |                    | Maintenance of transmissive glass plate. Assumed to be replaced once every seven years.     |
| 3.24E-07                    | m2          | printed wiring board, for through-hole mounting, Pb containing surface | market for printed wiring board, for through-hole mounting, Pb containing surface   printed wiring board, for through-hole mounting, Pb containing surface   Cutoff, U - GLO | GLO             |                    | Maintenance of PCBA. Replaced once every three years.                                       |
| 1                           | Item(s)     | SpO <sub>2</sub> sensor  | production of SpO <sub>2</sub> sensor  | NL              |                    | Four SpO <sub>2</sub> sensor can be disinfected simultaneously.                             |
| 6.03E-06                    | Item(s)     | ultraviolet lamp   | market for ultraviolet lamp   ultraviolet lamp   Cutoff, U - GLO   | GLO             |                    | Maintenance of UV-C lamps. Assumed to be replaced annually.                                 |
| 2.30E-05                    | Item(s)     | UV-C device  | production of UV-C device  | NL              | UV Smart           |   |
| <b>Economic flows, out:</b> |             |  |  |                 |                    |   |
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>   | <i>Provider</i>  | <i>Location</i> | <i>Data source</i> | <i>Additional documentation</i>   |
| 1                           | Item(s)     | <b>use of SpO<sub>2</sub> sensor</b>                                   | SpO <sub>2</sub> sensor use, disinfection  | NL              |                    |   |
| 1.67E-02                    | kg          | discarded plastic medical consumable                                   | end-of-life plastic medical consumable   | NL              |                    |   |
| 2.00E-03                    | kg          | discarded plastic packaging  | end-of-life plastic packaging  | NL              |                    |   |
| 2.30E-05                    | Item(s)     | discarded UV-C device  | end-of-life UV-C device  | NL              |                    |   |
| 2.30E-06                    | kg          | used fluorescent lamp  | treatment of used fluorescent lamp   used fluorescent lamp   Cutoff, U - GLO   | GLO             |                    | Proxy for waste ultraviolet lamp.   |
| 9.98E-07                    | kg          | used printed wiring boards   | treatment of scrap printed wiring boards, shredding and separation   used printed wiring boards   Cutoff, U - RoW  | RoW             |                    | PCBA waste.   |
| 1.64E-08                    | kg          | waste acrylonitrile-butadiene-styrene copolymer                        | end-of-life acrylonitrile-butadiene-styrene copolymer  | NL              |                    | Waste of the lid clip hook.   |
| 1.64E-06                    | kg          | waste glass  | treatment of waste glass, municipal incineration FAE   waste glass   Cutoff, U - CH  | NL              |                    | Provider data from Switzerland but assumed for the Netherlands.                             |
| 1.33E-03                    | kg          | waste plastic, mixture   | treatment of waste plastic, mixture, municipal incineration FAE   waste plastic, mixture   Cutoff, U - CH  | NL              |                    | Waste of the LED sensor. Provider data is from Switzerland but assumed for the Netherlands. |

**Table 14.28: Use of vacutainer, disinfection.**

**Unit process: Use of vacutainer, disinfection**

| <b>Economic flows, in:</b>  |             |  |  |                 |                    |   |
|-----------------------------|-------------|--|--|-----------------|--------------------|---|
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>   | <i>Provider</i>  | <i>Location</i> | <i>Data source</i> | <i>Additional documentation</i>   |
| 1.10E-08                    | kg          | acrylonitrile-butadiene-styrene copolymer                              | market for acrylonitrile-butadiene-styrene copolymer   acrylonitrile-butadiene-styrene copolymer   Cutoff, U - GLO   | GLO             |                    | Maintenance of lid clip hook. Assumed to be replaced once every seven years.            |
| 1.83E-03                    | kWh         | electricity, low voltage   | market for electricity, low voltage   electricity, low voltage   Cutoff, U - NL  | NL              | UV Smart           | One disinfection cycle consumes 0.011 kWh.  |
| 1.10E-06                    | kg          | flat glass, coated   | market for flat glass, coated   flat glass, coated   Cutoff, U - RoW   | RoW             |                    | Maintenance of transmissive glass plate. Assumed to be replaced once every seven years. |
| 2.16E-07                    | m2          | printed wiring board, for through-hole mounting, Pb containing surface | market for printed wiring board, for through-hole mounting, Pb containing surface   printed wiring board, for through-hole mounting, Pb containing surface   Cutoff, U - GLO | GLO             |                    | Maintenance of PCBA. Replaced once every three years.                                   |
| 4.02E-06                    | Item(s)     | ultraviolet lamp   | market for ultraviolet lamp   ultraviolet lamp   Cutoff, U - GLO   | GLO             |                    | Maintenance of UV-C lamps. Assumed to be replaced annually.                             |
| 1.54E-05                    | Item(s)     | UV-C device  | production of UV-C device  | NL              | UV Smart           |   |
| 1                           | Item(s)     | vacutainer   | production of vacutainer   | NL              |                    | Six vacutinners can be disinfected simultaneously.                                      |
| <b>Economic flows, out:</b> |             |  |  |                 |                    |   |
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>   | <i>Provider</i>  | <i>Location</i> | <i>Data source</i> | <i>Additional documentation</i>   |
| 1                           | Item(s)     | <b>use of vacutainer</b>   | vacutainer use, disinfection   | NL              |                    |   |
| 6.00E-03                    | kg          | discarded plastic medical consumable                                   | end-of-life plastic medical materia;   | NL              |                    |   |
| 7.00E-03                    | kg          | discarded plastic packaging  | end-of-life plastic packaging  | NL              |                    |   |
| 1.54E-05                    | Item(s)     | discarded UV-C device  | end-of-life UV-C device  | NL              |                    |   |
| 1.54E-06                    | kg          | used fluorescent lamp  | treatment of used fluorescent lamp   used fluorescent lamp   Cutoff, U - GLO   | GLO             |                    | Proxy for waste ultraviolet lamp.   |
| 6.65E-07                    | kg          | used printed wiring boards   | treatment of scrap printed wiring boards, shredding and separation   used printed wiring boards   Cutoff, U - RoW  | RoW             |                    | PCBA waste.   |
| 1.10E-08                    | kg          | waste acrylonitrile-butadiene-styrene copolymer                        | end-of-life acrylonitrile-butadiene-styrene copolymer  | NL              |                    | Waste of the lid clip hook.   |
| 1.10E-06                    | kg          | waste glass  | treatment of waste glass, municipal incineration FAE   waste glass   Cutoff, U - CH  | NL              |                    | Provider data from Switzerland but assumed for the Netherlands.                         |
| 1.00E-03                    | kg          | waste graphical paper  | treatment of waste graphical paper, municipal incineration FAE   waste graphical paper   Cutoff, U - CH  | NL              |                    |   |
| 7.42E-05                    | kg          | waste steel  | treatment of waste steel, municipal incineration FAE   waste steel   Cutoff, U - CH  | NL              |                    | Provider data is from Switzerland but assumed for the Netherlands.                      |

**Table 14.29:** Use of a bedside cart with a 50% inventory, disposal.

**Unit process: use of bedside cart, 50% inventory, disposal**

| <b>Economic flows, in:</b>  |             |   |   |                 |                    |  |
|-----------------------------|-------------|---|---|-----------------|--------------------|--|
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>                                    | <i>Provider</i>   | <i>Location</i> | <i>Data source</i> | <i>Additional documentation</i>  |
| 6.88E+03                    | Item(s)     | blood gas syringe                                   | production of blood gas syringe   | NL              |                    | A full bedside cart inventory contains 15 blood gas syringe, 2 CO2 filter lines, 2 SpO2 sensors, and 2 vacutainer. Assume the full bedside cart as blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer in a 15:2:2:2 ratio, respectively. A bedside cart has 292 suitable medical consumables for disinfection. A 50% bedside cart inventory is assumed. For disposal, an output of one used medical consumable requires the input of two medical consumables. |
| 9.18E+02                    | Item(s)     | CO2 filter line                                     | production of CO2 filter line   | NL              |                    |  |
| 9.18E+02                    | Item(s)     | SpO2 sensor   | production of SpO2 sensor   | NL              |                    |  |
| 9.18E+02                    | Item(s)     | vacutainer  | production of vacutainer  | NL              |                    |  |
| <b>Economic flows, out:</b> |             |   |   |                 |                    |  |
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>                                    | <i>Provider</i>   | <i>Location</i> | <i>Data source</i> | <i>Additional documentation</i>  |
| 1                           | Item(s)     | <b>use of bedside cart inventory, 50% inventory</b> | use of bedside cart inventory, 50%, disposal  | NL              |                    |  |
| 6.66E+01                    | kg          | discarded plastic medical consumable                | end-of-life plastic medical consumable  | NL              |                    | Waste of blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer.  |
| 2.57E+01                    | kg          | discarded plastic packaging                         | end-of-life plastic packaging   | NL              |                    | Plastic packaging waste of blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer.  |
| 7.80                        | kg          | waste graphical paper                               | treatment of waste graphical paper, municipal incineration FAE   waste graphical paper   Cutoff, U - CH   | NL              |                    | Paper packaging waste of blood gas syringe and vacutainer. Provider data is from Switzerland but assumed for the Netherlands.  |
| 1.22                        | kg          | waste plastic, mixture                              | treatment of waste plastic, mixture, municipal incineration FAE   waste plastic, mixture   Cutoff, U - CH | NL              |                    | Waste of the LED sensor of the SpO2 sensor. Provider data is from Switzerland but assumed for the Netherlands.   |
| 6.81E-02                    | kg          | waste steel   | treatment of waste steel, municipal incineration FAE   waste steel   Cutoff, U - CH                       | NL              |                    | Waste of the needle of the vacutainer. Provider data is from Switzerland but assumed for the Netherlands.  |

**Table 14.30:** Use of a bedside cart with a 30% inventory, disposal.

**Unit process: use of bedside cart, 30% inventory, disposal**

| <b>Economic flows, in:</b>  |             |   |   |                 |                    |  |
|-----------------------------|-------------|---|---|-----------------|--------------------|--|
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>                                    | <i>Provider</i>   | <i>Location</i> | <i>Data source</i> | <i>Additional documentation</i>  |
| 4.13E+03                    | Item(s)     | blood gas syringe                                   | production of blood gas syringe   | NL              |                    | A full bedside cart inventory contains 15 blood gas syringe, 2 CO2 filter lines, 2 SpO2 sensors, and 2 vacutainer. Assume the full bedside cart as blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer in a 15:2:2:2 ratio, respectively. A bedside cart has 292 suitable medical consumables for disinfection. A 50% bedside cart inventory is assumed. For disposal, an output of one used medical consumable requires the input of two medical consumables. |
| 5.51E+02                    | Item(s)     | CO2 filter line                                     | production of CO2 filter line   | NL              |                    |  |
| 5.51E+02                    | Item(s)     | SpO2 sensor   | production of SpO2 sensor   | NL              |                    |  |
| 5.51E+02                    | Item(s)     | vacutainer  | production of vacutainer  | NL              |                    |  |
| <b>Economic flows, out:</b> |             |   |   |                 |                    |  |
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>                                    | <i>Provider</i>   | <i>Location</i> | <i>Data source</i> | <i>Additional documentation</i>  |
| 1                           | Item(s)     | <b>use of bedside cart inventory, 30% inventory</b> | use of bedside cart inventory, 30%, disposal  | NL              |                    |  |
| 4.00E+01                    | kg          | discarded plastic medical consumable                | end-of-life plastic medical consumable  | NL              |                    | Waste of blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer.  |
| 1.54E+01                    | kg          | discarded plastic packaging                         | end-of-life plastic packaging   | NL              |                    | Plastic packaging waste of blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer.  |
| 4.68                        | kg          | waste graphical paper                               | treatment of waste graphical paper, municipal incineration FAE   waste graphical paper   Cutoff, U - CH   | NL              |                    | Paper packaging waste of blood gas syringe and vacutainer. Provider data is from Switzerland but assumed for the Netherlands.  |
| 7.35E-01                    | kg          | waste plastic, mixture                              | treatment of waste plastic, mixture, municipal incineration FAE   waste plastic, mixture   Cutoff, U - CH | NL              |                    | Waste of the LED sensor of the SpO2 sensor. Provider data is from Switzerland but assumed for the Netherlands.   |
| 4.09E-02                    | kg          | waste steel   | treatment of waste steel, municipal incineration FAE   waste steel   Cutoff, U - CH                       | NL              |                    | Waste of the needle of the vacutainer. Provider data is from Switzerland but assumed for the Netherlands.  |

**Table 14.31:** Use of a bedside cart with a 10% inventory, disposal.

**Unit process: use of bedside cart, 10% inventory, disposal**

| <b>Economic flows, in:</b>  |         |   |   |          |             |  |
|-----------------------------|---------|---|---|----------|-------------|--|
| Amount                      | Unit    | Flow Name   | Provider  | Location | Data source | Additional documentation   |
| 1.38E+03                    | Item(s) | blood gas syringe                                   | production of blood gas syringe   | NL       |             | A full bedside cart inventory contains 15 blood gas syringe, 2 CO2 filter lines, 2 SpO2 sensors, and 2 vacutainer. Assume the full bedside cart as blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer in a 15:2:2:2 ratio, respectively. A bedside cart has 292 suitable medical consumables for disinfection. A 50% bedside cart inventory is assumed. For disposal, an output of one used medical consumable requires the input of two medical consumables. |
| 1.84E+02                    | Item(s) | CO2 filter line                                     | production of CO2 filter line   | NL       |             |  |
| 1.84E+02                    | Item(s) | SpO2 sensor   | production of SpO2 sensor   | NL       |             |  |
| 1.84E+02                    | Item(s) | vacutainer  | production of vacutainer  | NL       |             |  |
| <b>Economic flows, out:</b> |         |   |   |          |             |  |
| Amount                      | Unit    | Flow Name   | Provider  | Location | Data source | Additional documentation   |
| 1                           | Item(s) | <b>use of bedside cart inventory, 10% inventory</b> | use of bedside cart inventory, 10%, disposal  | NL       |             |  |
| 1.33E+01                    | kg      | discarded plastic medical consumable                | end-of-life plastic medical consumable  | NL       |             | Waste of blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer.  |
| 5.14                        | kg      | discarded plastic packaging                         | end-of-life plastic packaging   | NL       |             | Plastic packaging waste of blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer.  |
| 1.56                        | kg      | waste graphical paper                               | treatment of waste graphical paper, municipal incineration FAE   waste graphical paper   Cutoff, U - CH   | NL       |             | Paper packaging waste of blood gas syringe and vacutainer. Provider data is from Switzerland but assumed for the Netherlands.  |
| 2.45E-01                    | kg      | waste plastic, mixture                              | treatment of waste plastic, mixture, municipal incineration FAE   waste plastic, mixture   Cutoff, U - CH | NL       |             | Waste of the LED sensor of the SpO2 sensor. Provider data is from Switzerland but assumed for the Netherlands.   |
| 1.36E-02                    | kg      | waste steel   | treatment of waste steel, municipal incineration FAE   waste steel   Cutoff, U - CH                       | NL       |             | Waste of the needle of the vacutainer. Provider data is from Switzerland but assumed for the Netherlands.  |

**Table 14.32: Use of a bedside cart with a 50% inventory, disinfection.**

**Unit process: use of bedside cart, 50% inventory, disinfection**

| <b>Economic flows, in:</b>  |             |  |  |                 |                    |  |
|-----------------------------|-------------|--|--|-----------------|--------------------|--|
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>   | <i>Provider</i>  | <i>Location</i> | <i>Data source</i> | <i>Additional documentation</i>  |
| 3.44E+03                    | Item(s)     | blood gas syringe  | production of blood gas syringe  | NL              |                    | A full bedside cart inventory contains 15 blood gas syringe, 2 CO2 filter lines, 2 SpO2 sensors, and 2 vacutainer. Assume the full bedside cart as blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer in a 15:2:2:2 ratio, respectively. A bedside cart has 292 suitable medical consumables for disinfection. A 50% bedside cart inventory is assumed. |
| 4.59E+02                    | Item(s)     | CO2 filter line  | production of CO2 filter line  | NL              |                    |  |
| 4.59E+02                    | Item(s)     | SpO2 sensor  | production of SpO2 sensor  | NL              |                    |  |
| 4.59E+02                    | Item(s)     | vacutainer   | production of vacutainer   | NL              |                    |  |
| 7.14E-04                    | kg          | acrylonitrile-butadiene-styrene copolymer                              | market for acrylonitrile-butadiene-styrene copolymer   acrylonitrile-butadiene-styrene copolymer   Cutoff, U - GLO   | GLO             |                    | Maintenance of lid clip hook. Assumed to be replaced once every seven years.   |
| 8.53                        | kWh         | electricity, low voltage   | market for electricity, low voltage   electricity, low voltage   Cutoff, U - NL  | NL              | UV Smart           | One disinfection cycle consumes 0.011 kWh. For 50% inventory, 775.5 cycles are required per year.  |
| 7.14E-02                    | kg          | flat glass, coated   | market for flat glass, coated   flat glass, coated   Cutoff, U - RoW   | RoW             |                    | Maintenance of transmissive glass plate. Assumed to be replaced once every seven years.  |
| 1.41E-02                    | m2          | printed wiring board, for through-hole mounting, Pb containing surface | market for printed wiring board, for through-hole mounting, Pb containing surface   printed wiring board, for through-hole mounting, Pb containing surface   Cutoff, U - GLO | GLO             |                    | Maintenance of PCBA. Replaced once every three years.  |
| 2.62E-01                    | Item(s)     | ultraviolet lamp   | market for ultraviolet lamp   ultraviolet lamp   Cutoff, U - GLO   | GLO             |                    | Maintenance of UV-C lamps. Assumed to be replaced annually.  |
| 1.43E-01                    | Item(s)     | UV-C device  | production of UV-C device  | NL              | UV Smart           | The UV-C device has a lifespan of 7 years. The functional unit covers one year of use.   |
| <b>Economic flows, out:</b> |             |  |  |                 |                    |  |
| <i>Amount</i>               | <i>Unit</i> | <i>Flow Name</i>   | <i>Provider</i>  | <i>Location</i> | <i>Data source</i> | <i>Additional documentation</i>  |
| 1                           | Item(s)     | <b>use of bedside cart inventory, 50% inventory</b>                    | use of bedside cart inventory, 50%, disinfection   | NL              |                    |  |
| 3.33E+01                    | kg          | discarded plastic medical consumable                                   | end-of-life plastic medical consumable   | NL              |                    | Waste of blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer.  |
| 1.28E+01                    | kg          | discarded plastic packaging  | end-of-life plastic packaging  | NL              |                    | Plastic packaging waste of blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer.  |
| 1.43E-01                    | Item(s)     | discarded UV-C device  | end-of-life UV-C device  | NL              |                    |  |
| 1.00E-01                    | kg          | used fluorescent lamp  | treatment of used fluorescent lamp   used fluorescent lamp   Cutoff, U - GLO   | GLO             |                    | Proxy for waste ultraviolet lamp.  |
| 4.33E-02                    | kg          | used printed wiring boards   | treatment of scrap printed wiring boards, shredding and separation   used printed wiring boards   Cutoff, U - RoW  | RoW             |                    | PCBA waste.  |
| 7.14E-04                    | kg          | waste acrylonitrile-butadiene-styrene copolymer                        | end-of-life acrylonitrile-butadiene-styrene copolymer  | NL              |                    | Waste of the lid clip hook.  |
| 7.14E-02                    | kg          | waste glass  | treatment of waste glass, municipal incineration FAE   waste glass   Cutoff, U - CH  | NL              |                    | Provider data from Switzerland but assumed for the Netherlands.  |
| 3.90                        | kg          | waste graphical paper  | treatment of waste graphical paper, municipal incineration FAE   waste graphical paper   Cutoff, U - CH  | NL              |                    | Paper packaging waste of blood gas syringe and vacutainer. Provider data is from Switzerland but assumed for the Netherlands.  |
| 6.12E-01                    | kg          | waste plastic, mixture   | treatment of waste plastic, mixture, municipal incineration FAE   waste plastic, mixture   Cutoff, U - CH  | NL              |                    | Waste of the LED sensor of the SpO2 sensor. Provider data is from Switzerland but assumed for the Netherlands.   |
| 3.41E-02                    | kg          | waste steel  | treatment of waste steel, municipal incineration FAE   waste steel   Cutoff, U - CH  | NL              |                    | Waste of the needle of the vacutainer. Provider data is from Switzerland but assumed for the Netherlands.  |

**Table 14.33:** Use of a bedside cart with a 30% inventory, disinfection.

**Unit process: use of bedside cart, 30% inventory, disinfection**

| Economic flows, in:  |         |  |  |          |             |  |
|----------------------|---------|--|--|----------|-------------|--|
| Amount               | Unit    | Flow Name  | Provider   | Location | Data source | Additional documentation   |
| 2.06E+03             | Item(s) | blood gas syringe  | production of blood gas syringe  | NL       |             | A full bedside cart inventory contains 15 blood gas syringe, 2 CO2 filter lines, 2 SpO2 sensors, and 2 vacutainer. Assume the full bedside cart as blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer in a 15:2:2:2 ratio, respectively. A bedside cart has 292 suitable medical consumables for disinfection. A 50% bedside cart inventory is assumed. |
| 2.75E+02             | Item(s) | CO2 filter line  | production of CO2 filter line  | NL       |             |  |
| 2.75E+02             | Item(s) | SpO2 sensor  | production of SpO2 sensor  | NL       |             |  |
| 2.75E+02             | Item(s) | vacutainer   | production of vacutainer   | NL       |             |  |
| 7.14E-04             | kg      | acrylonitrile-butadiene-styrene copolymer                              | market for acrylonitrile-butadiene-styrene copolymer   acrylonitrile-butadiene-styrene copolymer   Cutoff, U - GLO   | GLO      |             | Maintenance of lid clip hook. Assumed to be replaced once every seven years.   |
| 5.12                 | kWh     | electricity, low voltage   | market for electricity, low voltage   electricity, low voltage   Cutoff, U - NL  | NL       | UV Smart    | One disinfection cycle consumes 0.011 kWh. For 30% inventory, 465.3 cycles are required per year.  |
| 7.14E-02             | kg      | flat glass, coated   | market for flat glass, coated   flat glass, coated   Cutoff, U - RoW   | RoW      |             | Maintenance of transmissive glass plate. Assumed to be replaced once every seven years.  |
| 1.41E-02             | m2      | printed wiring board, for through-hole mounting, Pb containing surface | market for printed wiring board, for through-hole mounting, Pb containing surface   printed wiring board, for through-hole mounting, Pb containing surface   Cutoff, U - GLO | GLO      |             | Maintenance of PCBA. Replaced once every three years.  |
| 2.62E-01             | Item(s) | ultraviolet lamp   | market for ultraviolet lamp   ultraviolet lamp   Cutoff, U - GLO   | GLO      |             | Maintenance of UV-C lamps. Assumed to be replaced annually.  |
| 1.43E-01             | Item(s) | UV-C device  | production of UV-C device  | NL       | UV Smart    | The UV-C device has a lifespan of 7 years. The functional unit covers one year of use.   |
| Economic flows, out: |         |  |  |          |             |  |
| Amount               | Unit    | Flow Name  | Provider   | Location | Data source | Additional documentation   |
| 1                    | Item(s) | <b>use of bedside cart inventory, 30% inventory</b>                    | use of bedside cart inventory, 30%, disinfection   | NL       |             |  |
| 2.00E+01             | kg      | discarded plastic medical consumable                                   | end-of-life plastic medical consumable   | NL       |             | Waste of blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer.  |
| 7.71                 | kg      | discarded plastic packaging  | end-of-life plastic packaging  | NL       |             | Plastic packaging waste of blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer.  |
| 1.43E-01             | Item(s) | discarded UV-C device  | end-of-life UV-C device  | NL       |             |  |
| 1.00E-01             | kg      | used fluorescent lamp  | treatment of used fluorescent lamp   used fluorescent lamp   Cutoff, U - GLO   | GLO      |             | Proxy for waste ultraviolet lamp.  |
| 4.33E-02             | kg      | used printed wiring boards   | treatment of scrap printed wiring boards, shredding and separation   used printed wiring boards   Cutoff, U - RoW  | RoW      |             | PCBA waste.  |
| 7.14E-04             | kg      | waste acrylonitrile-butadiene-styrene copolymer                        | end-of-life acrylonitrile-butadiene-styrene copolymer  | NL       |             | Waste of the lid clip hook.  |
| 7.14E-02             | kg      | waste glass  | treatment of waste glass, municipal incineration FAE   waste glass   Cutoff, U - CH  | NL       |             | Provider data from Switzerland but assumed for the Netherlands.  |
| 2.34                 | kg      | waste graphical paper  | treatment of waste graphical paper, municipal incineration FAE   waste graphical paper   Cutoff, U - CH  | NL       |             | Paper packaging waste of blood gas syringe and vacutainer. Provider data is from Switzerland but assumed for the Netherlands.  |
| 3.67E-01             | kg      | waste plastic, mixture   | treatment of waste plastic, mixture, municipal incineration FAE   waste plastic, mixture   Cutoff, U - CH  | NL       |             | Waste of the LED sensor of the SpO2 sensor. Provider data is from Switzerland but assumed for the Netherlands.   |
| 2.04E-02             | kg      | waste steel  | treatment of waste steel, municipal incineration FAE   waste steel   Cutoff, U - CH  | NL       |             | Waste of the needle of the vacutainer. Provider data is from Switzerland but assumed for the Netherlands.  |

**Table 14.34:** Use of a bedside cart with a 10% inventory, disinfection.

**Unit process: use of bedside cart, 10% inventory, disinfection**

| Economic flows, in:  |         |  |  |          |             |  |
|----------------------|---------|--|--|----------|-------------|--|
| Amount               | Unit    | Flow Name  | Provider   | Location | Data source | Additional documentation   |
| 6.88E+02             | Item(s) | blood gas syringe  | production of blood gas syringe  | NL       |             | A full bedside cart inventory contains 15 blood gas syringe, 2 CO2 filter lines, 2 SpO2 sensors, and 2 vacutainer. Assume the full bedside cart as blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer in a 15:2:2:2 ratio, respectively. A bedside cart has 292 suitable medical consumables for disinfection. A 50% bedside cart inventory is assumed. |
| 9.18E+01             | Item(s) | CO2 filter line  | production of CO2 filter line  | NL       |             |  |
| 9.18E+01             | Item(s) | SpO2 sensor  | production of SpO2 sensor  | NL       |             |  |
| 9.18E+01             | Item(s) | vacutainer   | production of vacutainer   | NL       |             |  |
| 7.14E-04             | kg      | acrylonitrile-butadiene-styrene copolymer                              | market for acrylonitrile-butadiene-styrene copolymer   acrylonitrile-butadiene-styrene copolymer   Cutoff, U - GLO   | GLO      |             | Maintenance of lid clip hook. Assumed to be replaced once every seven years.   |
| 1.71                 | kWh     | electricity, low voltage   | market for electricity, low voltage   electricity, low voltage   Cutoff, U - NL  | NL       | UV Smart    | One disinfection cycle consumes 0.011 kWh. For 30% inventory, 465.3 cycles are required per year.  |
| 7.14E-02             | kg      | flat glass, coated   | market for flat glass, coated   flat glass, coated   Cutoff, U - RoW   | RoW      |             | Maintenance of transmissive glass plate. Assumed to be replaced once every seven years.  |
| 1.41E-02             | m2      | printed wiring board, for through-hole mounting, Pb containing surface | market for printed wiring board, for through-hole mounting, Pb containing surface   printed wiring board, for through-hole mounting, Pb containing surface   Cutoff, U - GLO | GLO      |             | Maintenance of PCBA. Replaced once every three years.  |
| 2.62E-01             | Item(s) | ultraviolet lamp   | market for ultraviolet lamp   ultraviolet lamp   Cutoff, U - GLO   | GLO      |             | Maintenance of UV-C lamps. Assumed to be replaced annually.  |
| 1.43E-01             | Item(s) | UV-C device  | production of UV-C device  | NL       | UV Smart    | The UV-C device has a lifespan of 7 years. The functional unit covers one year of use.   |
| Economic flows, out: |         |  |  |          |             |  |
| Amount               | Unit    | Flow Name  | Provider   | Location | Data source | Additional documentation   |
| 1                    | Item(s) | <b>use of bedside cart inventory, 10% inventory</b>                    | use of bedside cart inventory, 10%, disinfection   | NL       |             |  |
| 6.66                 | kg      | discarded plastic medical consumable                                   | end-of-life plastic medical consumable   | NL       |             | Waste of blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer.  |
| 2.57E+00             | kg      | discarded plastic packaging  | end-of-life plastic packaging  | NL       |             | Plastic packaging waste of blood gas syringe, CO2 filter line, SpO2 sensor, and vacutainer.  |
| 1.43E-01             | Item(s) | discarded UV-C device  | end-of-life UV-C device  | NL       |             |  |
| 1.00E-01             | kg      | used fluorescent lamp  | treatment of used fluorescent lamp   used fluorescent lamp   Cutoff, U - GLO   | GLO      |             | Proxy for waste ultraviolet lamp.  |
| 4.33E-02             | kg      | used printed wiring boards   | treatment of scrap printed wiring boards, shredding and separation   used printed wiring boards   Cutoff, U - RoW  | RoW      |             | PCBA waste.  |
| 7.14E-04             | kg      | waste acrylonitrile-butadiene-styrene copolymer                        | end-of-life acrylonitrile-butadiene-styrene copolymer  | NL       |             | Waste of the lid clip hook.  |
| 7.14E-02             | kg      | waste glass  | treatment of waste glass, municipal incineration FAE   waste glass   Cutoff, U - CH  | NL       |             | Provider data from Switzerland but assumed for the Netherlands.  |
| 7.80E-01             | kg      | waste graphical paper  | treatment of waste graphical paper, municipal incineration FAE   waste graphical paper   Cutoff, U - CH  | NL       |             | Paper packaging waste of blood gas syringe and vacutainer. Provider data is from Switzerland but assumed for the Netherlands.  |
| 1.22E-01             | kg      | waste plastic, mixture   | treatment of waste plastic, mixture, municipal incineration FAE   waste plastic, mixture   Cutoff, U - CH  | NL       |             | Waste of the LED sensor of the SpO2 sensor. Provider data is from Switzerland but assumed for the Netherlands.   |
| 6.81E-03             | kg      | waste steel  | treatment of waste steel, municipal incineration FAE   waste steel   Cutoff, U - CH  | NL       |             | Waste of the needle of the vacutainer. Provider data is from Switzerland but assumed for the Netherlands.  |

## 14.6. Appendix VI: LCIA results

**Table 14.35:** LCIA results of the disposal and disinfection of bedside carts at the ICU of the LUMC in 2024. The results are calculated using the EF impact assessment method.

| Impact category                               | Unit                             | Disposal | Disinfection |
|---|----------------------------------|----------|--------------|
| Acidification                                 | mol H <sup>+</sup> -Eq           | 1.52E+01 | 7.89E+00     |
| Climate change                                | kg CO <sub>2</sub> -Eq           | 1.84E+03 | 9.56E+02     |
| Ecotoxicity: freshwater                       | CTUe                             | 1.59E+04 | 8.38E+03     |
| Energy resources: non-renewable               | MJ, net calorific value          | 2.45E+04 | 1.27E+04     |
| Eutrophication: freshwater                    | kg P-Eq                          | 1.16E+00 | 6.06E-01     |
| Eutrophication: marine                        | kg N-Eq                          | 1.99E+00 | 1.04E+00     |
| Eutrophication: terrestrial                   | mol N-Eq                         | 2.16E+01 | 1.13E+01     |
| Human toxicity: carcinogenic                  | CTUh                             | 1.28E-06 | 6.83E-07     |
| Human toxicity: non-carcinogenic              | CTUh                             | 9.74E-05 | 5.18E-05     |
| Ionising radiation: human health              | kBq U235-Eq                      | 1.26E+02 | 6.54E+01     |
| Land use                                      | dimensionless                    | 1.01E+04 | 5.20E+03     |
| Material resources: metals/minerals           | kg Sb-Eq                         | 1.17E-01 | 6.26E-02     |
| Ozone depletion                               | kg CFC-11-Eq                     | 2.41E-04 | 1.22E-04     |
| Particulate matter formation                  | disease incidence                | 8.75E-05 | 4.62E-05     |
| Photochemical oxidant formation: human health | kg NMVOC-Eq                      | 7.40E+00 | 3.85E+00     |
| Water use                                     | m <sup>3</sup> world Eq deprived | 6.04E+02 | 3.13E+02     |

## 14.7. Appendix VII: Sensitivity analysis results

**Table 14.36:** LCIA results of the disposal and disinfection of a blood gas syringe. The results are calculated using the EF impact assessment method.

| Impact category                               | Unit                             | Disposal | Disinfection |
|---|----------------------------------|----------|--------------|
| Acidification                                 | mol H <sup>+</sup> -Eq           | 2.56E-04 | 1.52E-04     |
| Climate change                                | kg CO <sub>2</sub> -Eq           | 8.31E-02 | 4.49E-02     |
| Ecotoxicity: freshwater                       | CTUe                             | 3.99E-01 | 2.38E-01     |
| Energy resources: non-renewable               | MJ, net calorific value          | 1.25E+00 | 6.64E-01     |
| Eutrophication: freshwater                    | kg P-Eq                          | 1.53E-05 | 9.84E-06     |
| Eutrophication: marine                        | kg N-Eq                          | 6.52E-05 | 3.68E-05     |
| Eutrophication: terrestrial                   | mol N-Eq                         | 6.73E-04 | 3.81E-04     |
| Human toxicity: carcinogenic                  | CTUh                             | 1.34E-11 | 9.16E-12     |
| Human toxicity: non-carcinogenic              | CTUh                             | 4.30E-10 | 3.56E-10     |
| Ionising radiation: human health              | kBq U235-Eq                      | 3.47E-03 | 1.97E-03     |
| Land use                                      | dimensionless                    | 6.46E-01 | 3.36E-01     |
| Material resources: metals/minerals           | kg Sb-Eq                         | 2.23E-07 | 4.91E-07     |
| Ozone depletion                               | kg CFC-11-Eq                     | 1.35E-09 | 7.47E-10     |
| Particulate matter formation                  | disease incidence                | 2.69E-09 | 1.56E-09     |
| Photochemical oxidant formation: human health | kg NMVOC-Eq                      | 2.99E-04 | 1.63E-04     |
| Water use                                     | m <sup>3</sup> world Eq deprived | 1.89E-02 | 1.05E-02     |

**Table 14.37:** LCIA results of the disposal and disinfection of a CO<sub>2</sub> filter line. The results are calculated using the EF impact assessment method.

| Impact category                               | Unit                             | Disposal | Disinfection |
|---|----------------------------------|----------|--------------|
| Acidification                                 | mol H <sup>+</sup> -Eq           | 7.36E-04 | 4.54E-04     |
| Climate change                                | kg CO <sub>2</sub> -Eq           | 2.45E-01 | 1.34E-01     |
| Ecotoxicity: freshwater                       | CTUe                             | 1.07E+00 | 6.71E-01     |
| Energy resources: non-renewable               | MJ, net calorific value          | 2.80E+00 | 1.54E+00     |
| Eutrophication: freshwater                    | kg P-Eq                          | 3.70E-05 | 2.61E-05     |
| Eutrophication: marine                        | kg N-Eq                          | 1.75E-04 | 1.02E-04     |
| Eutrophication: terrestrial                   | mol N-Eq                         | 1.80E-03 | 1.06E-03     |
| Human toxicity: carcinogenic                  | CTUh                             | 1.55E-10 | 8.61E-11     |
| Human toxicity: non-carcinogenic              | CTUh                             | 1.44E-09 | 1.21E-09     |
| Ionising radiation: human health              | kBq U235-Eq                      | 7.52E-03 | 4.57E-03     |
| Land use                                      | dimensionless                    | 4.32E-01 | 2.64E-01     |
| Material resources: metals/minerals           | kg Sb-Eq                         | 1.34E-06 | 2.00E-06     |
| Ozone depletion                               | kg CFC-11-Eq                     | 3.16E-08 | 1.60E-08     |
| Particulate matter formation                  | disease incidence                | 5.55E-09 | 3.51E-09     |
| Photochemical oxidant formation: human health | kg NMVOC-Eq                      | 7.27E-04 | 4.11E-04     |
| Water use                                     | m <sup>3</sup> world Eq deprived | 7.30E-02 | 4.00E-02     |

**Table 14.38:** LCIA results of the disposal and disinfection of a SpO<sub>2</sub> sensor. The results are calculated using the EF impact assessment method.

| Impact category                               | Unit                             | Disposal | Disinfection |
|---|----------------------------------|----------|--------------|
| Acidification                                 | mol H <sup>+</sup> -Eq           | 1.33E-02 | 6.71E-03     |
| Climate change                                | kg CO <sub>2</sub> -Eq           | 9.46E-01 | 4.79E-01     |
| Ecotoxicity: freshwater                       | CTUe                             | 1.25E+01 | 6.32E+00     |
| Energy resources: non-renewable               | MJ, net calorific value          | 1.18E+01 | 5.99E+00     |
| Eutrophication: freshwater                    | kg P-Eq                          | 1.08E-03 | 5.43E-04     |
| Eutrophication: marine                        | kg N-Eq                          | 1.37E-03 | 6.91E-04     |
| Eutrophication: terrestrial                   | mol N-Eq                         | 1.53E-02 | 7.72E-03     |
| Human toxicity: carcinogenic                  | CTUh                             | 1.11E-09 | 5.60E-10     |
| Human toxicity: non-carcinogenic              | CTUh                             | 1.00E-07 | 5.04E-08     |
| Ionising radiation: human health              | kBq U235-Eq                      | 9.43E-02 | 4.76E-02     |
| Land use                                      | dimensionless                    | 4.77E+00 | 2.41E+00     |
| Material resources: metals/minerals           | kg Sb-Eq                         | 1.24E-04 | 6.24E-05     |
| Ozone depletion                               | kg CFC-11-Eq                     | 2.27E-08 | 1.15E-08     |
| Particulate matter formation                  | disease incidence                | 6.35E-08 | 3.21E-08     |
| Photochemical oxidant formation: human health | kg NMVOC-Eq                      | 4.49E-03 | 2.27E-03     |
| Water use                                     | m <sup>3</sup> world Eq deprived | 4.04E-01 | 2.04E-01     |

**Table 14.39:** LCIA results of the disposal and disinfection of a vacutainer. The results are calculated using the EF impact assessment method.

| Impact category                               | Unit                             | Disposal | Disinfection |
|---|----------------------------------|----------|--------------|
| Acidification                                 | mol H <sup>+</sup> -Eq           | 5.88E-04 | 3.23E-04     |
| Climate change                                | kg CO <sub>2</sub> -Eq           | 1.87E-01 | 9.75E-02     |
| Ecotoxicity: freshwater                       | CTUe                             | 7.46E-01 | 4.18E-01     |
| Energy resources: non-renewable               | MJ, net calorific value          | 2.66E+00 | 1.37E+00     |
| Eutrophication: freshwater                    | kg P-Eq                          | 3.60E-05 | 2.05E-05     |
| Eutrophication: marine                        | kg N-Eq                          | 1.32E-04 | 7.12E-05     |
| Eutrophication: terrestrial                   | mol N-Eq                         | 1.36E-03 | 7.31E-04     |
| Human toxicity: carcinogenic                  | CTUh                             | 3.24E-11 | 1.90E-11     |
| Human toxicity: non-carcinogenic              | CTUh                             | 1.12E-09 | 7.26E-10     |
| Ionising radiation: human health              | kBq U235-Eq                      | 8.91E-03 | 4.72E-03     |
| Land use                                      | dimensionless                    | 9.44E-01 | 4.88E-01     |
| Material resources: metals/minerals           | kg Sb-Eq                         | 7.28E-07 | 8.07E-07     |
| Ozone depletion                               | kg CFC-11-Eq                     | 1.99E-07 | 9.94E-08     |
| Particulate matter formation                  | disease incidence                | 6.18E-09 | 3.34E-09     |
| Photochemical oxidant formation: human health | kg NMVOC-Eq                      | 5.96E-04 | 3.14E-04     |
| Water use                                     | m <sup>3</sup> world Eq deprived | 3.92E-02 | 2.08E-02     |

**Table 14.40:** LCIA results of the disposal and disinfection of bedside cart inventories of 50% at the ICU of the LUMC in 2024. The results are calculated using the EF impact assessment method.

| Impact category                               | Unit                             | Disposal | Disinfection |
|---|----------------------------------|----------|--------------|
| Acidification                                 | mol H <sup>+</sup> -Eq           | 7.60E+00 | 4.07E+00     |
| Climate change                                | kg CO <sub>2</sub> -Eq           | 9.18E+02 | 4.94E+02     |
| Ecotoxicity: freshwater                       | CTUe                             | 7.95E+03 | 4.40E+03     |
| Energy resources: non-renewable               | MJ, net calorific value          | 1.22E+04 | 6.52E+03     |
| Eutrophication: freshwater                    | kg P-Eq                          | 5.81E-01 | 3.14E-01     |
| Eutrophication: marine                        | kg N-Eq                          | 9.93E-01 | 5.42E-01     |
| Eutrophication: terrestrial                   | mol N-Eq                         | 1.08E+01 | 5.87E+00     |
| Human toxicity: carcinogenic                  | CTUh                             | 6.42E-07 | 3.61E-07     |
| Human toxicity: non-carcinogenic              | CTUh                             | 4.87E-05 | 2.74E-05     |
| Ionising radiation: human health              | kBq U235-Eq                      | 6.28E+01 | 3.36E+01     |
| Land use                                      | dimensionless                    | 5.04E+03 | 2.65E+03     |
| Material resources: metals/minerals           | kg Sb-Eq                         | 5.84E-02 | 3.34E-02     |
| Ozone depletion                               | kg CFC-11-Eq                     | 1.21E-04 | 6.11E-05     |
| Particulate matter formation                  | disease incidence                | 4.38E-05 | 2.43E-05     |
| Photochemical oxidant formation: human health | kg NMVOC-Eq                      | 3.70E+00 | 2.00E+00     |
| Water use                                     | m <sup>3</sup> world Eq deprived | 3.02E+02 | 1.61E+02     |

**Table 14.41:** LCIA results of the disposal and disinfection of bedside cart inventories of 30% at the ICU of the LUMC in 2024. The results are calculated using the EF impact assessment method.

| Impact category                               | Unit                             | Disposal | Disinfection |
|---|----------------------------------|----------|--------------|
| Acidification                                 | mol H <sup>+</sup> -Eq           | 4.56E+00 | 2.55E+00     |
| Climate change                                | kg CO <sub>2</sub> -Eq           | 5.51E+02 | 3.09E+02     |
| Ecotoxicity: freshwater                       | CTUe                             | 4.77E+03 | 2.81E+03     |
| Energy resources: non-renewable               | MJ, net calorific value          | 7.34E+03 | 4.06E+03     |
| Eutrophication: freshwater                    | kg P-Eq                          | 3.49E-01 | 1.97E-01     |
| Eutrophication: marine                        | kg N-Eq                          | 5.96E-01 | 3.43E-01     |
| Eutrophication: terrestrial                   | mol N-Eq                         | 6.47E+00 | 3.70E+00     |
| Human toxicity: carcinogenic                  | CTUh                             | 3.85E-07 | 2.32E-07     |
| Human toxicity: non-carcinogenic              | CTUh                             | 2.92E-05 | 1.76E-05     |
| Ionising radiation: human health              | kBq U235-Eq                      | 3.77E+01 | 2.08E+01     |
| Land use                                      | dimensionless                    | 3.02E+03 | 1.63E+03     |
| Material resources: metals/minerals           | kg Sb-Eq                         | 3.50E-02 | 2.17E-02     |
| Ozone depletion                               | kg CFC-11-Eq                     | 7.24E-05 | 3.69E-05     |
| Particulate matter formation                  | disease incidence                | 2.63E-05 | 1.55E-05     |
| Photochemical oxidant formation: human health | kg NMVOC-Eq                      | 2.22E+00 | 1.25E+00     |
| Water use                                     | m <sup>3</sup> world Eq deprived | 1.81E+02 | 1.01E+02     |

**Table 14.42:** LCIA results of the disposal and disinfection of bedside cart inventories of 10% at the ICU of the LUMC in 2024. The results are calculated using the EF impact assessment method.

| Impact category                               | Unit                             | Disposal | Disinfection |
|---|----------------------------------|----------|--------------|
| Acidification                                 | mol H <sup>+</sup> -Eq           | 1.52E+00 | 1.02E+00     |
| Climate change                                | kg CO <sub>2</sub> -Eq           | 1.84E+02 | 1.24E+02     |
| Ecotoxicity: freshwater                       | CTUe                             | 1.59E+03 | 1.21E+03     |
| Energy resources: non-renewable               | MJ, net calorific value          | 2.45E+03 | 1.59E+03     |
| Eutrophication: freshwater                    | kg P-Eq                          | 1.16E-01 | 8.01E-02     |
| Eutrophication: marine                        | kg N-Eq                          | 1.99E-01 | 1.43E-01     |
| Eutrophication: terrestrial                   | mol N-Eq                         | 2.16E+00 | 1.53E+00     |
| Human toxicity: carcinogenic                  | CTUh                             | 1.28E-07 | 1.04E-07     |
| Human toxicity: non-carcinogenic              | CTUh                             | 9.74E-06 | 7.88E-06     |
| Ionising radiation: human health              | kBq U235-Eq                      | 1.26E+01 | 8.11E+00     |
| Land use                                      | dimensionless                    | 1.01E+03 | 6.17E+02     |
| Material resources: metals/minerals           | kg Sb-Eq                         | 1.17E-02 | 9.99E-03     |
| Ozone depletion                               | kg CFC-11-Eq                     | 2.41E-05 | 1.27E-05     |
| Particulate matter formation                  | disease incidence                | 8.75E-06 | 6.74E-06     |
| Photochemical oxidant formation: human health | kg NMVOC-Eq                      | 7.40E-01 | 5.10E-01     |
| Water use                                     | m <sup>3</sup> world Eq deprived | 6.04E+01 | 3.98E+01     |