

**Université Libre de Bruxelles**  
**Institut de Gestion de l'Environnement et d'Aménagement du Territoire**  
**Faculté des Sciences**  
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**“Is there an alternative? Challenges and Solutions to Medical Single-Use  
Plastics. Insights from Brussels Hospital Personnel”**

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## **Abstract**

*Plastic pollution has emerged as a critical global issue, leading the United Nations Environment Assembly to adopt a resolution in March 2022, to create a legally binding agreement to end plastic pollution. The widespread use of Single-Use Plastics (SUPs) in medical settings, driven by their versatility and cost-effectiveness, has severe environmental and health repercussions. The healthcare sector alone accounts for 3% of global emissions, with the problem compounded by an increased reliance on disposable items post-COVID-19.*

*This thesis investigates the complex challenges of managing SUPs in healthcare. The environmental and health risks of plastics, including links to cancers, respiratory disorders, and the presence of microplastics in human blood and placentas, highlight the urgency for sustainable solutions. Despite significant research on plastic waste management, healthcare's recycling and disposal practices remain inadequate, necessitating a holistic approach to sustainability.*

*The study explores the perspectives of medical personnel in Brussels hospitals regarding SUPs, including their potential for reuse and alternative materials. Findings from this research qualitative survey reveal that while healthcare professionals are highly aware of the detrimental impacts of SUPs, they face substantial barriers to adopting sustainable practices. Key challenges include high costs, concerns about patient safety, and infrastructural deficiencies, such as inadequate sterilization equipment and trained personnel. Despite these hurdles, there is a strong consensus on the potential for viable alternatives to certain SUPs, though their implementation requires careful assessment to avoid unintended consequences.*

*The thesis is structured to review literature on the environmental and health impacts of plastic pollution, analyze current healthcare plastic waste management practices, and evaluate potential sustainable strategies and alternatives. It presents the research methodology, details the survey results, and compares these findings with existing literature. The discussion identifies common challenges and gaps, emphasizing the need for improved policy integration and infrastructure enhancement.*

*This research contributes valuable insights into the management of SUPs in healthcare settings, aiming to inform strategies that reduce plastic reliance and align with global sustainability goals. The findings highlight the urgent need for comprehensive sustainability practices, integrating sustainable procurement and waste management processes, to mitigate the environmental and health impacts of medical plastics.*

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*Lastly, I dedicate this thesis to my little son, Léo. Since his birth, he has taught me that miracles do happen and that they are indeed amazingly beautiful.*

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## 1. INTRODUCTION

The increasing global concern over plastic pollution has catalyzed significant international efforts to address this pervasive environmental issue. In March 2022, the United Nations Environment Assembly (UNEA-5.2) passed a resolution to end plastic pollution through a unified global approach. This resolution reflects the severity of plastic pollution as an environmental threat that transcends borders and affects multiple facets of life, including health, economic stability, and social well-being. Addressing this crisis requires a holistic strategy that emphasizes prevention, reduction, and the redesign of problematic plastics.

Plastics are widely employed in various sectors due to their versatility and cost-effectiveness. In the healthcare sector, their use is particularly prevalent because of their functionality and low cost. However, the production, use, and disposal of plastics present significant challenges, particularly concerning Single-Use Plastics (SUP) in medical contexts.

The healthcare sector contributes approximately 3% to the global climate footprint, making it the fifth-largest emitter if it were considered a country. The transition from reusable to disposable items, intensified by the COVID-19 pandemic, has exacerbated this issue, highlighting the urgent need for alternatives to fossil-fuel-based plastics.

The environmental and health impacts of plastic waste are substantial. Plastics, especially SUPs, contribute to pollution and present recycling challenges. Recent research has increasingly focused on the health risks associated with plastics, including their links to various cancers and respiratory disorders. Microplastics, a growing concern, have been found in the food chain, human blood, and placentas, underscoring their pervasive and harmful effects. Managing plastic waste, particularly in medical SUP in healthcare settings, necessitates a comprehensive approach that includes life-cycle management, sustainable alternatives, and shifts in production and consumption patterns.

The concept of the circular economy offers potential solutions by emphasizing the need for prevention, reuse, and innovative waste recovery methods. However, despite its promise, the management of plastic waste, particularly medical plastics, remains complex and requires coordinated efforts across various sectors and actors. Plastic recycling, promoted since the 1990s did not bring the improvements hoped, as less than 10% of the plastics ever produced has been recycled. With plastic production projected to triple by 2060, solely focusing on recycling is not a sustainable long-term solution.

At the hospital level, although plastic waste management is a well-researched topic, recycling and disposal challenges—especially with medical plastics—demand a life-cycle approach. Hospitals often lack detailed insights into the environmental impacts of raw material extraction and manufacturing, which can be understood through life-cycle assessments (LCAs).

This thesis aims to address the gap in understanding the perspectives of medical personnel on medical SUPs, their potential for reuse, and available alternatives. The research question guiding this study is: How do medical personnel in Brussels hospitals perceive the use of single-use plastics (SUP), their potential for reuse, and available alternatives? What are the primary challenges they face in implementing more sustainable practices, and how do these perceptions and challenges align with existing literature on the environmental impact of medical plastics and alternatives?

The focus of this research is on exploring the practical experiences of hospital staff regarding medical SUPs and their perspectives on sustainability within healthcare operations. By examining these perspectives, the study seeks to contribute to the broader discourse on integrating sustainability into healthcare practices. The structure of the thesis includes a review of the literature on the environmental and health impacts of plastic pollution, followed by an analysis of current practices and challenges in managing plastic waste within healthcare settings. The thesis then evaluates potential sustainable strategies and alternatives. It details the research methodology, including the research question and underlying hypothesis, while also addressing the study's relevance and potential limitations. Following this, the results of the survey are presented and compared with existing literature. The discussion identifies recurring themes and challenges, aligns findings with the literature review, and provides recommendations to hospital management and elements for further research. This framework aims to provide a comprehensive understanding of the issues at hand and inform strategies for reducing plastic use in healthcare settings.

## 2. Literature Review

The healthcare sector is a significant contributor to environmental pollution. Globally, healthcare contributes 4.4% of global net emissions<sup>1</sup>, making it the fifth-largest emitter if it were a country. The sector is a major purchaser of goods and services in Europe, including single-use plastics, whose use surged during the COVID-19 pandemic, resulting in increased waste and pollution<sup>2</sup>.

Hospitals are major users of single-use plastics due to the necessity of maintaining high hygiene standards, ensuring patient safety, and managing costs effectively. However, this *modus operandi* of the healthcare sector clashes with its primary mission of safeguarding human's health. In fact, plastic pollution has a negative impact on the environment and consequently on human health, and the healthcare plastic pollution reinforces this vicious circle.

This literature review explores the concerns on the environment and health linked to single-use plastics in medical settings, investigate strategies and solutions for reducing their impact and the challenges that prevent the adoption of sustainable practices and alternatives to single-use plastics for medical use.

Plastic is an integral part of the structure of our society. Once a crucial ally in simplifying daily tasks, it has now become an omnipresent, useful but problematic guest. Despite our heavy dependence on it, plastic poses a significant threat to both the environment and our health.

The literature universally acknowledges the advantageous qualities of plastic and extensively examines the factors contributing to its prevalence and ubiquity in our society. These include its physical attributes such as versatility, durability, lightweight nature, and cost-effectiveness. The latter is closely tied to the affordability of oil, a primary feedstock for plastic production.<sup>3</sup>

Historical literature on plastic reveals some curious paradoxes. Initially, plastic was embraced as a cost-effective and manageable alternative to natural resources, replacing fur, ivory, and tortoiseshell. Plastics have played a crucial role in the growth and development of the 'minority developed world' and have more recently extended their influence on the 'majority developing world'<sup>4</sup>. However, plastic has now become a major threat, contributing significantly to the triple planetary crisis of habitat loss, plastic

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<sup>1</sup> Health Care Without Harm, in collaboration with Arup (2019). *Health Care's Climate Footprint (2019): How the Health Sector Contributes to the Global Climate Crisis and Opportunities for Action*. <https://global.noharm.org/focus/climate/health-care-climate-footprint-report>.

<sup>2</sup> University of Gent. (2021). *The Healthcare Paradox*, Over de thesis van Justine Hanssens, Waste management in Flemish hospitals: a case study. <https://futureproof.ugent.be/thesis/the-healthcare-paradox/>

<sup>3</sup> Germantown News & Shelby-Sun Times, 9 August 2021, "Reasons Plastic Is So Cheap to Manufacture.". <https://shelby-news.com/reasons-plastic-is-so-cheap-to-manufacture/>, consulted on 3d June 2024.

<sup>4</sup> Cowan E, Booth AM, Misund A, Klun K, Rotter A, Tiller R. (2021) *Single-Use Plastic Bans: Exploring Stakeholder Perspectives on Best Practices for Reducing Plastic Pollution*. *Environments*. 8(8):81. <https://www.mdpi.com/2076-3298/8/8/81>

pollution, and greenhouse gas (GHG) emissions<sup>5</sup>. Today research is focusing more and more on finding alternatives to fossil fuel plastics<sup>6</sup>.

Although it was invented in the mid-19th century, its popularity didn't soar until the 1970s. Its use began to increase during World War I in the United States, where it served as a suitable material for mechanical mass production and helped preserve natural resources. Gradually, plastic replaced paper for packaging, glass for storage, and steel in automotive vehicles, especially in the post-World War II era marked by mass production and consumption, and increase of the linear economy model of make-take-throw away<sup>7</sup>. Under different angles, the literature, points to the reinforcing interplay between plastics benefits in our society, the impact on the environment, and consequent health risks. This interplay is even more visible in the healthcare sector, where plastic has held a prominent role since the mid-20th century<sup>8</sup>.

Within the healthcare sector, the focus is on hospitals as they are particularly resource-intensive due to their daily operations, which involve a combination of diagnostics, treatment procedures, and inpatient care<sup>9</sup>.

## 2.1. Single-Use Plastics: From Healthcare Dependency to Global Pollution Crisis

Single-use plastics (SUP) pose a significant problem for environmental pollution as they are made entirely or partially of plastic and are designed to be used once or for a short duration before being discarded.<sup>10</sup> The healthcare sector relies heavily on SUP, particularly for medical applications. In recent decades, the healthcare sector has increasingly shifted from reusable items to disposable ones<sup>11</sup>, and this dependence and trend intensified after COVID-19, which led to a surge in the use of SUP, especially personal protective equipment (PPE) such as face masks and gloves, by medical personnel and the general public. Additionally, the increase in home delivery and e-commerce, following the closure of many commercial activities, has led to a rise in SUP packaging<sup>12</sup>. SUP in general is treated extensively in the literature, especially after COVID-19, both addressing challenges and potential solutions. In particular literature focuses on plastic pollution of oceans, as 45% of total marine litter is SUP<sup>13</sup>, on

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<sup>5</sup> Bachmann, M., Zibunas, C., Hartmann, J., et al. (2023). *Towards circular plastics within planetary boundaries*. Nature Sustainability, 6, 599–610. <https://doi.org/10.1038/s41893-022-01054-9>

<sup>6</sup> European Commission. (2022). *Biobased, biodegradable and compostable plastics*. *Biobased, biodegradable and compostable plastics, Biobased, biodegradable and compostable plastics - European Commission (europa.eu)* consulted in May 2024 and Narendra Singh, Oladele A. Ogunseitan, Ming Hung Wong, Yuanyuan Tang (2022), *Sustainable materials alternative to petrochemical plastics pollution: A review analysis*, Sustainable Horizons, Volume 2, 2022, <https://www.sciencedirect.com/science/article/pii/S2772737822000116>

<sup>7</sup> Ellen MacArthur Foundation, *What is the Linear Economy?*, <https://tinyurl.com/hxm6mhxt>, consulted on 21 July 2024.

<sup>8</sup> Hodges, Sarah (2017), *Hospitals as factories of medical garbage*, Anthropology & Medicine, [https://www.researchgate.net/publication/322106215\\_Hospitals\\_as\\_factories\\_of\\_medical\\_garbage](https://www.researchgate.net/publication/322106215_Hospitals_as_factories_of_medical_garbage)

<sup>9</sup> Schneider, F., & Rau, S. (2022). *Material flow analysis of single-use plastics in healthcare: A case study of a surgical hospital in Germany*. *Journal of Cleaner Production*, 245, 118703. <https://www.sciencedirect.com/science/article/pii/S0921344922002683>

<sup>10</sup> European Commission (2022), *Single-Use Plastics*, [https://environment.ec.europa.eu/topics/plastics/single-use-plastics\\_en](https://environment.ec.europa.eu/topics/plastics/single-use-plastics_en), consulted on 17 July 2024.

<sup>11</sup> Healthcare without Harm Europe, Arianna Gamba & co. (2021). *Measuring and reducing plastics in the healthcare sector*. <https://europe.noharm.org/resources/measuring-and-reducing-plastics-healthcare-sector>, 35.

<sup>12</sup> Abu-qudais, H. and co (2020). *The Single-Use Plastic Pandemic in the COVID-19 Era*, Chapter 4 from Statistical analysis and characteristics of hospital medical waste under novel coronavirus outbreak. *Global Journal of Environmental Science and Management* 6, <https://onlinelibrary.wiley.com/doi/abs/10.1002/9781119879534.ch4>

<sup>13</sup> European Parliament (2023), *Plastic in the ocean: the facts, effects and new EU rules*,

<https://tinyurl.com/yjff7tpx>, consulted on 23 June 2024 / Jambeck, J. R., Geyer, R., Wilcox, C., et al. (2015). *Plastic waste inputs from land into the ocean*. *Science*, 347(6223), 768-771. <https://www.science.org/doi/10.1126/science.1260352>, 25 and Cressey, D. Bottles,

waste management<sup>14</sup> (or some define it ‘mismanagement’<sup>15</sup>), and microplastics, which contaminate soil, water, and enters the food chain, affecting wildlife and human health<sup>16</sup>. The surge in single-use plastics are challenging the recycle and frequently end up in landfills, particularly medical SUP. Consequently, despite often being used only once and for just a few minutes, single-use plastics can persist in landfills or the environment for hundreds of years.<sup>17</sup>

Single-use plastics in healthcare are valued for their versatility and affordability, yet they pose significant environmental and health risks. These specially designed materials ensure sterility and minimize contamination, playing vital roles in patient care, from transparent tubing for fluid administration to surgical gloves<sup>18</sup>. However, managing medical plastic waste is highly complex, with less than 10% of plastics ever produced being recycled globally, and a significant portion ending up incinerated (14%), landfilled (76%), or polluting the environment. In Europe, only about 30% of plastic material is recycled<sup>19</sup>; in Belgium in 2021, 80% of packaging waste was recycled, up from 71% in 2001. Plastic remains the least recycled category of waste, both now and 20 years ago. However, its recycling rate has significantly increased from 28% in 2001 to 49% in 2021<sup>20</sup>.

Additionally, China, which used to import 45% of the world’s plastic waste, has stopped accepting it, leaving wealthy countries at a crossroads<sup>21</sup>. Microplastics, resulting from plastic degradation, have pervasive environmental and health impacts, contaminating human bodies through various pathways<sup>22</sup>.

## 2.2.2. Plastic and the Environment: Beyond the Surface of Waste

Focusing on environmental concerns, there is a vast amount of literature on plastic pollution—180 million results appear in less than a second on Google<sup>23</sup>. This indicates that the issues surrounding plastics and single-use plastics (SUP) have been thoroughly examined, especially at the end-of-life cycle stage.

The exact quantity of plastics used in healthcare remains uncertain. However, various studies conducted across different countries and settings suggest that plastics constitute approximately 30% of total healthcare waste, with an even higher proportion observed in settings such as intensive care or

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bags, ropes and toothbrushes: the struggle to track ocean plastics. *Nature* 536, 263–265 (2016). <https://www.nature.com/articles/536263a> / Tosca Ballerini and co., *Plastic pollution in the ocean : what we know and what we don't know about*. Plastic and Ocean Platform; The camp. 2018, 1-27 p. fihal-04187123f - <https://hal.science/hal-04187123/> / Why is the global governance of plastic failing the oceans? - plastic failing the oceans? - <https://www.sciencedirect.com/science/article/abs/pii/S0959378017314140> Peter Dauvergne (2018), Why is the global governance of plastic failing the oceans?, *Global Environmental Change*, Volume 51, 22-31.

<sup>14</sup> Shin, Sun-Kyoung, Namil Um, Yong-Jun Kim, Na-Hyeon Cho, and Tae-Wan Jeon. 2020. "New Policy Framework with Plastic Waste Control Plan for Effective Plastic Waste Management" *Sustainability* 12, no. 15: 6049. <https://www.mdpi.com/2071-1050/12/15/6049>

<sup>15</sup> European Parliament Agency (2023), *Mismanaged waste — a key source*, <https://www.eea.europa.eu/publications/european-marine-litter-assessment/mismanaged-waste-a-key-source>, consulted on 17 May 2024.

<sup>16</sup> Rist, S. and co., (2018). *Microplastics: A Real Global Threat for Environment and Food Safety: A State of the Art Review*. *Science of the Total Environment*, 613-614, 812

<sup>17</sup> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9920460/#:~:text=Microplastics%20are%20small%20plastic%20particles,salt%2C%20honey%20and%20marine%20organisms>

<sup>18</sup> Kim Borg and co. (2022) Curbing plastic consumption: A review of single-use plastic behaviour change interventions, *Journal of Cleaner Production*, Volume 344, 25; - <https://www.sciencedirect.com/science/article/abs/pii/S0959652622007107>

<sup>19</sup> Midwest Rubber Company (2024), *The Pros and Cons of Single-Use Plastics in Medical Manufacturing*, [The Pros and Cons of Single-Use Plastics in Medical Manufacturing](https://www.mwrc.com) (mwrc.com), consulted 25 June 2024.

<sup>20</sup> National Center for Biotechnology Information (NCBI), (2021). *From plastics to microplastics and organisms*, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8016121/>, consulted on 19 May 2024.

<sup>21</sup> Stabel (November 2023). *Half of all plastic waste is not recycled in Belgium*. <https://statbel.fgov.be/en/news/half-all-plastic-waste-not-recycled-belgium#:~:text=In%202021%2C%2080%25%20oP%20packaging,2001%20to%2049%25%20in%202021>, consulted on 13 June 2024.

<sup>22</sup> Stone, R. (2018, November 16). *China's ban on trash imports shifts waste crisis to Southeast Asia*, National Geographic. <https://www.nationalgeographic.com/environment/article/china-ban-plastic-trash-imports-shifts-waste-crisis-southeast-asia-malaysia>, consulted on 20 May 2024

<sup>23</sup> Carrington, D. (2024). *Microplastics found in every human semen sample tested in study*. *The Guardian*. <https://www.theguardian.com/environment/article/2024/jun/10/microplastics-found-in-every-human-semen-sample-tested-in-chinese-study>, consulted on 25 May 2024.

<sup>24</sup> Woolven J., Ellen MacArthur Foundation (2021), *This is not about plastic pollution*, [https://www.ellenmacarthurfoundation.org/articles/this-article-is-not-about-plastic-pollution?gad\\_source=1&gclid=CjwKCAjwvdSzBhBOEiwAj0XN4BkxFT6Ls7JEiNINjmt34jouxHMhDx0bbTk\\_Ytztz\\_T1ePXiZr3oAhoCLowQAvD\\_BwEon.org](https://www.ellenmacarthurfoundation.org/articles/this-article-is-not-about-plastic-pollution?gad_source=1&gclid=CjwKCAjwvdSzBhBOEiwAj0XN4BkxFT6Ls7JEiNINjmt34jouxHMhDx0bbTk_Ytztz_T1ePXiZr3oAhoCLowQAvD_BwEon.org) , consulted on 8 May 2024.

anaesthetics, where they may comprise around one-third of the waste generated,<sup>24</sup> this is both environmentally damaging and expensive to clean up.

Single-use plastics in healthcare are valued for their versatility and affordability, yet they pose significant environmental and health risks. These specially designed materials ensure sterility and minimize contamination, playing vital roles in patient care, from transparent tubing for fluid administration to surgical gloves<sup>25</sup>. However, managing medical plastic waste is highly complex, with less than 10% of plastics ever produced being recycled globally, and a significant portion ending up incinerated (14%), landfilled (76%), or polluting the environment.

An increasing amount of literature now examines the problem throughout the entire plastic lifecycle, beginning from its conception<sup>26</sup>. These studies also consider the actors involved and the necessary regulatory framework. In essence, scientists have concluded that a holistic approach is essential—one that emphasizes prevention, reduction, and redesigning problematic plastics out of the global economy.<sup>27</sup>

The literature also highlights the necessity of assessing multiple impacts, ranging from health to economic effects, at each phase of the plastic lifecycle<sup>28</sup>. These phases can be summarized as follows: i. extraction of raw materials and transport; ii. design and production; iii. packaging and distribution; iv. use and maintenance; v. recycling, reuse, recovery, or final disposal.

In discussions about plastic, we inevitably touch on fossil fuels. Plastic is derived from organic polymers composed of long chains of monomers, primarily sourced from oil rigs, coal mines, or natural gas extraction sites. Most of the plastics (99%) are produced from chemicals sourced from fossil fuels (crude oil and natural gas)<sup>29</sup>, and primarily produced from petrochemistry and petroleum products, with approximately 5% to 8% of global oil production being used to manufacture plastic materials<sup>30</sup>.

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<sup>24</sup> Rizan C, Mortimer F, Stancliffe R, Bhutta MF. Plastics in healthcare: time for a re-evaluation. *J R Soc Med*. 2020 Feb;113(2):49-53. doi: 10.1177/0141076819890554. Erratum in: *J R Soc Med*. 2020 Jul;113(7):288. doi: 10.1177/0141076820942469. PMID: 32031491; PMCID: PMC7068768. [Plastics in healthcare: time for a re-evaluation - PMC \(nih.gov\)](https://pubmed.ncbi.nlm.nih.gov/32031491/)

<sup>25</sup> Midwest Rubber Company (2024), *The Pros and Cons of Single-Use Plastics in Medical Manufacturing*. [The Pros and Cons of Single-Use Plastics in Medical Manufacturing \(mwrc.com\)](https://www.mwrc.com/), consulted 25 June 2024.

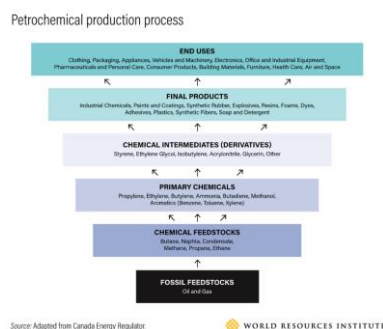
<sup>26</sup> Nielsen, Tobias D., *WIREs Energy and Environment* published by Wiley Periodicals, 2019, Politics and the plastic crisis: A review throughout the plastic life cycle, [Politics and the plastic crisis: A review throughout the plastic life cycle - Nielsen - 2020 - WIREs Energy and Environment - Wiley Online Library](https://onlinelibrary.wiley.com/doi/10.1002/anie.201901000), 12-18.

<sup>27</sup> **Plastics Treaty**. (2021). *A new global treaty on plastic pollution, Scientists' Declaration on the Need for Governance of Plastics Throughout their Lifecycles*. <https://www.plasticstreaty.org/scientists-declaration/>

<sup>28</sup> European Environment Agency, (19 June 2024), *Plastics*, [Plastics | European Environment Agency's home page \(europa.eu\)](https://www.eea.europa.eu/en/themes/water/plastics), consulted on 23 June 24

<sup>29</sup> **Center for International Environmental Law (CIEL)**. (2017). *Fueling Plastics*. <https://www.ciel.org/wp-content/uploads/2017/09/Fueling-Plastics-Fossils-Plastics-Petrochemical-Feedstocks.pdf>

<sup>30</sup> Ahsan Ali, Ali Bahadar, Afrasyab Khan, Khairuddin Sanaullah, 8 - Role of agricultural waste in recycled plastic biocomposites, Editor(s): Md Rezaur Rahman, Muhammad Khusairy Bin Bakri, In *Woodhead Publishing Series in Composites Science and Engineering, Recycled Plastic Biocomposites*, Woodhead Publishing, 2022, Pages 165-194, ISBN 9780323886536, <https://doi.org/10.1016/B978-0-323-88653-6.00002-X>



Source: World Resource Institute<sup>31</sup>

There are various types and a wide range of plastics, almost 30 types of primary plastics, with the most common including Acrylic or Polymethyl Methacrylate (PMMA), Polycarbonate (PC), Polyethylene (PE), Polypropylene (PP), Polyethylene Terephthalate (PETE or PET), Polyvinyl Chloride (PVC), and Acrylonitrile-Butadiene-Styrene (ABS). This diversity complicates the management of plastic waste even further. Three quarters of the plastic produced is used by four sectors: containers and packaging, infrastructure (construction), automobiles, and electrical and electronic equipment.<sup>32</sup>

According to the literature, during the COVID-19 pandemic, there was an observed improvement of air quality in the 50 most polluted capital cities, with an average reduction of 12% in PM<sub>2.5</sub> levels<sup>33</sup>. The most significant decrease in PM<sub>2.5</sub> in any capital city was 57%<sup>34</sup>. Considering the World Health Organization (WHO) estimates that about seven million people die each year from exposure to PM<sub>2.5</sub> particles, reducing pollution is clearly crucial<sup>35</sup>. However, plastic pollution surged during COVID-19 due to an increase in the production, use, and disposal of single-use plastics (SUP)<sup>36</sup>. An OECD report indicates a 2.2% decrease in plastics use in 2020 due to the slowdown in economic activity, yet there was an increase in waste, particularly from food takeaway packaging and plastic medical equipment such as masks. As economic activity picked up again in 2021, plastic consumption returned to usual levels. This highlights the need for a drastic cultural shift<sup>37</sup>.

<sup>31</sup> World Resources Institute, Byrum Zach, 17 April 2024, *Fossil Fuels Are in Everything from Plastics to Makeup, but Cleaner Alternatives Are Emerging*, <https://www.wri.org/insights/defossilizing-us-chemical-production>, consulted on 11 June 2024.

<sup>32</sup> Panuvatvanich, Atitaya & Limphitakphong, Nantamol. (2023). Business development from plastic wastes toward circular economy. 10.2166/9781789063448\_0339.

[https://www.researchgate.net/publication/367209646\\_Business\\_development\\_from\\_plastic\\_wastes\\_toward\\_circular\\_economy](https://www.researchgate.net/publication/367209646_Business_development_from_plastic_wastes_toward_circular_economy)

<sup>33</sup> UNEP (2022). Fine particles 2.5 microns or less in diameter —shortened as PM<sub>2.5</sub>. <https://www.unep.org/interactives/air-pollution-note/>, consulted on 18 May 2024

Fine particles 2.5 microns or less in diameter —shortened as PM<sub>2.5</sub> (<https://www.unep.org/interactives/air-pollution-note/>)

<sup>34</sup> National Library of Medicine, Rodríguez-Urrego D and co, (Nov.2020), *Air quality during the COVID-19: PM<sub>2.5</sub> analysis in the 50 most polluted capital cities in the world.*, Environ Pollut., [Air quality during the COVID-19: PM<sub>2.5</sub> analysis in the 50 most polluted capital cities in the world - PMC \(nih.gov\)](https://doi.org/10.1016/j.envpol.2020.106683)

<sup>35</sup> World Health Organization (WHO). (2022). Ambient (outdoor) air pollution. [https://www.who.int/news-room/fact-sheets/detail/ambient-\(outdoor\)-air-quality-and-health](https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health), consulted on 18 May 2024

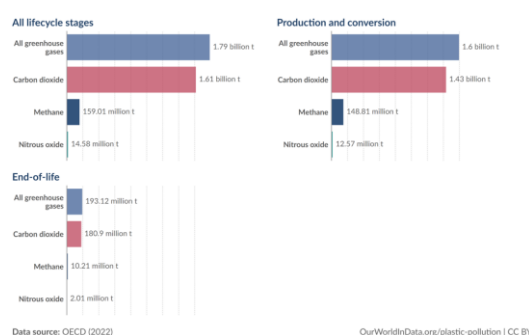
<sup>36</sup> Ana L. Patrício Silva, Joana C. Prata, Tony R. Walker, Armando C. Duarte, Wei Ouyang, Damià Barcelò, Teresa Rocha-Santos, Increased plastic pollution due to COVID-19 pandemic: Challenges and recommendations, Chemical Engineering Journal, Volume 405, 2021, 126683, ISSN 1385-8947, <https://doi.org/10.1016/j.cej.2020.126683>. (<https://www.sciencedirect.com/science/article/pii/S1385894720328114>)

<sup>37</sup> OECD. (2022). *Plastic pollution is growing relentlessly as waste management and recycling fall short.* <https://www.oecd.org/environment/plastic-pollution-is-growing-relentlessly-as-waste-management-and-recycling-fall-short.htm>, consulted on 10 July 2024

In 2019, greenhouse gas emissions from all stages of the plastic lifecycle totaled 1.79 billion tonnes of CO<sub>2</sub> equivalent (t CO<sub>2</sub> eq), primarily in the form of CO<sub>2</sub><sup>38</sup>. It is estimated that 90% of these emissions originated from the production and conversion of fossil fuels into plastics.<sup>39</sup>

Plastics lifecycle stage	All lifecycle stages				
Time	2015	2016	2017	2018	2019
<b>Greenhouse gases</b>					
All greenhouse gases	1664,68	1676,59	1702,06	1746,73	1788,51
CH <sub>4</sub>	148,15	148,98	151,24	155,13	159,01
CO <sub>2</sub>	1503,09	1514,01	1536,98	1577,4	1614,91
N <sub>2</sub> O	13,44	13,59	13,84	14,2	14,58

Data extracted on 22 Jun 2024 11:29 UTC (GMT) from  
 OECD.Stat [https://stats.oecd.org/Index.aspx?DataSetCode=PLASTIC\\_USE\\_6](https://stats.oecd.org/Index.aspx?DataSetCode=PLASTIC_USE_6)



Source graph: One World in Data. How much of global greenhouse gas emissions come from plastics?<sup>40</sup>

Plastic pollution issues transcend borders and generations, impacting all aspects of life, including health, economic, and social dimensions<sup>41</sup>. Nevertheless, plastic production and consumption continue to rise, partly due to the rapid growth of the global population. In 2019, plastic production hit 460 million tonnes (Mt) and is expected to surge to 1231 Mt by 2060, effectively tripling<sup>42</sup>.

Awareness of the negative environmental impacts of plastics grew already since the 1960s when the first plastics were found in the oceans and oil spills polluted the Cuyahoga River in Ohio<sup>43</sup> followed by

<sup>38</sup> OECD. (2022). Plastic Use Data Set. [https://stats.oecd.org/Index.aspx?DataSetCode=PLASTIC\\_USE\\_6](https://stats.oecd.org/Index.aspx?DataSetCode=PLASTIC_USE_6), consulted on 5 July 2024.

<sup>39</sup> OECD. (2022). *Increased plastic leakage and greenhouse gas emissions*. <https://www.oecd.org/environment/plastics/increased-plastic-leakage-and-greenhouse-gas-emissions.htm/#:~:text=Throughout%20their%20lifecycle%2C%20plastics%20have,to%20global%20greenhouse%20gas%20emissions,> consulted on 20 May 2024.

<sup>40</sup> Ritchie Hannah (2023) published in Our World in Data, “How much of global greenhouse gas emissions come from plastics?”, <https://ourworldindata.org/ghg-emissions-plastics>, consulted on 11 June 2024.

<sup>41</sup> Ana L. Patrício Silva, Joana C. Prata, Tony R. Walker, Armando C. Duarte, Wei Ouyang, Damià Barcelò, Teresa Rocha-Santos, Increased plastic pollution due to COVID-19 pandemic: Challenges and recommendations, Chemical Engineering Journal, Volume 405, 2021, 126683, ISSN 1385-8947, <https://doi.org/10.1016/j.cej.2020.126683>. (<https://www.sciencedirect.com/science/article/pii/S1385894720328114>)

<sup>42</sup> OECD. (2022). Plastics lifecycle is far from circular. <https://web.archive.oecd.org/2022-08-18/620573-plastics-lifecycle-is-far-from-circular.htm>, consulted on 10 June 2024

<sup>43</sup> Science History Institute, *History and Future of Plastics*, <https://tinyurl.com/3n3psxhc>, consulted on 24 May 2024.

other devastating incidents<sup>44</sup>. Despite the estimations indicating that plastics may take up to 500 years to degrade, in 2022, plastic production reached record of 400.3 million metric tons<sup>45</sup>.

According to the United Nations, if current growth trends persist, global production of primary plastic is expected to reach 1,100 million tonnes by 2050<sup>46</sup>. These statistics demonstrate that, despite the alarming impact of plastic pollution and related health concerns, plastic usage remains prevalent and is expected to continue in the long term.

### 2.2.3. Plastic and Health: A Yin-Yang Dependency

Focusing on health concerns, plastic is essential and present in all medical procedures. Plastic polymers are considered biochemically inert, meaning that they do not undergo chemical reactions or interactions that would alter biological processes or cause biological harm when in contact with living organisms. This characteristic is desirable when used for medical devices, food packaging, and various consumer products.

Suppliers and proponents of plastic medical devices and products emphasize their benefits in the healthcare sector, such as reducing cross-contamination and infections, ensuring safety for patients and health workers, and offering versatility and affordability. This is especially relevant for the use of PVC, as the majority of single-use medical devices, such as oxygen masks, medical tubing, and blood bags, are made from this material.<sup>47</sup> Although, some research argues that the initial adoption of medical plastics was not primarily motivated by hygiene concerns. Plastic originally emerged as a mid-century technology valued for its convenience and durability.<sup>48</sup>

However, the overlooked downside is the toxicity of plastics, which arises from several factors. During polymerization, monomers (small molecules) link together to form polymers (long chains), but the reaction often leaves some monomers unconverted. These unreacted monomers can remain in the final polymer material.<sup>49</sup>

These residual monomers can pose risks to human health and the environment because some of them are known to be hazardous. Additionally, the presence of unreacted monomers can affect the properties

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<sup>44</sup> Markleen-Marine Environmental Solutions (2020), *Major oil spill disasters at sea*, [Major Oil Spill Disasters At Sea | Markleen](#) , consulted on 12 June 2024.

<sup>45</sup> Statista. (2022). Annual production of plastics worldwide from 1950 to 2022. <https://www.statista.com/statistics/282732/global-production-of-plastics-since-1950/>, consulted on 11 June 2024

<sup>46</sup> UNEP. (2022). Our Planet is choking on plastics. <https://bit.ly/4b8LgGu> consulted 20 June 2024.

<sup>47</sup> PVCMed. Sept 2020, "5 reasons why plastics are essential - to patient and health worker safety", <https://pvcmed.org/wp-content/uploads/2020/12/5-reasons-why-plastics-are-essential-to-patient-and-health-worker-safety.pdf>

<sup>48</sup> Ana L. Patrício Silva, Joana C. Prata, Tony R. Walker, Armando C. Duarte, Wei Ouyang, Damià Barcelò, Teresa Rocha-Santos, Increased plastic pollution due to COVID-19 pandemic: Challenges and recommendations, *Chemical Engineering Journal*, Volume 405, 2021, 126683, ISSN 1385-8947, <https://doi.org/10.1016/j.cej.2020.126683>. (<https://www.sciencedirect.com/science/article/pii/S1385894720328114>)

<sup>49</sup> Till Tiso, Benedikt Winter, Ren Wei, Johann Hee, Jan de Witt, Nick Wierckx, Peter Quicker, Uwe T. Bornscheuer, André Bardow, Juan Nogales, Lars M. Blank, The metabolic potential of plastics as biotechnological carbon sources – Review and targets for the future, *Metabolic Engineering*, Volume 71, 2022, Pages 77-98, ISSN 1096-7176, <https://doi.org/10.1016/j.ymben.2021.12.006>. (<https://www.sciencedirect.com/science/article/pii/S1096717621001920>)

of the polymer, such as its stability, durability, or other performance characteristics. Therefore, even though polymerization is intended to transform monomers into inert polymer materials, the incomplete nature of these reactions means that precaution must be taken to assess and manage any potential risks associated with residual monomers.<sup>50</sup>

Moreover, plastic depends on additives, employed to improve its properties.<sup>51</sup> When plastics starts to degrade, these additives may be potentially hazardous for the environment and for human health. A study evaluating the harmfulness of plastic polymers based on their chemical composition found that 29% of the 55 polymer types examined were partly or entirely composed of monomers classified as carcinogenic, mutagenic, or toxic for reproduction.<sup>52</sup>

Over the years, a growing body of literature has recognized the direct and indirect impacts of plastics on human health, including potential links to various cancers, respiratory disorders, and other inflammatory diseases<sup>53</sup>. Notably, recent research increasingly focuses on nano and microplastics<sup>54</sup>, which were less prevalent in studies before 2019 and primarily associated with ocean pollution.<sup>55</sup>

The European Chemicals Agency's (ECHA)'s report<sup>56</sup> confirms that '*some substances added to polyvinyl chloride (PVC) plastic, like plasticisers, may pose risks to people and the environment*'. A recent report<sup>57</sup> calls the EU to phase out PVC by 2030.

Single-use plastics (SUPs) that are not recycled or incinerated end up in landfills and oceans. As these plastics degrade, they form microplastics, which can enter the food chain, and may move from the environment to living organisms. Recent studies have even detected microplastics in human blood<sup>58</sup> and placentas.<sup>59</sup>

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<sup>50</sup> Delilah Lithner, Åke Larsson, Göran Dave, Environmental and health hazard ranking and assessment of plastic polymers based on chemical composition, *Science of The Total Environment*, Volume 409, Issue 18, 2011, Pages 3309-3324, ISSN 0048-9697, <https://doi.org/10.1016/j.scitotenv.2011.04.038>. (<https://www.sciencedirect.com/science/article/pii/S0048969711004268>)

<sup>51</sup> **Blastic.** (2022). A PEEK INTO THE PLASTIC INDUSTRY. <https://www.blastic.eu/knowledge-bank/introduction-plastic-marine-litter/plastic-industry/#:~:text=The%20mass%20production%20of%20plastics,production%20reached%20311%20million%20tons,> consulted on 25 June 2024.

<sup>52</sup> **Blastic.** (2022). TOXICITY OF PLASTICS. <https://www.blastic.eu/knowledge-bank/impacts/toxicity-plastics/>, consulted on 11 May 2024. Awuchi Chinaza Godswill, Awuchi Chibueze Godspel. Physiological Effects of Plastic Wastes on the Endocrine System (Bisphenol A, Phthalates, Bisphenol S, PBDEs, TBBPA). *International Journal of Bioinformatics and Computational Biology*. Vol. 4, No. 2, 2019, pp. 11-29.

<sup>53</sup> Nielsen, Tobias D., *WIREs Energy and Environment* published by Wiley Periodicals, 2019, *Politics and the plastic crisis: A review throughout the plastic life cycle*, [Politics and the plastic crisis: A review throughout the plastic life cycle - Nielsen - 2020 - WIREs Energy and Environment - Wiley Online Library](https://onlinelibrary.wiley.com/doi/10.1002/ene.2020.12181), 12-18.

<sup>54</sup> Anthony L. Andrady, The plastic in microplastics: A review, *Marine Pollution Bulletin*, Volume 119, Issue 1, 2017, Pages 12-22, ISSN 0025-326X, <https://doi.org/10.1016/j.marpolbul.2017.01.082>. (<https://www.sciencedirect.com/science/article/pii/S0025326X1730111X>)

<sup>55</sup> Atsuhiko Isobe, Kaori Uchiyama-Matsumoto, Keiichi Uchida, Tadashi Tokai, Microplastics in the Southern Ocean, *Marine Pollution Bulletin*, Volume 114, Issue 1, 2017, Pages 623-626, ISSN 0025-326X, <https://doi.org/10.1016/j.marpolbul.2016.09.037>. (<https://www.sciencedirect.com/science/article/pii/S0025326X16307755>)

<sup>56</sup> European Chemicals Agency, Nov. 2023, *ECHA identifies risks from PVC additives and microparticle releases*, <https://echa.europa.eu/-/echa-identifies-risks-from-pvc-additives-and-microparticle-releases>, consulted on 22 May 2024.

<sup>57</sup> Health Care without Harm (2024), *PVC Problem Very Clear: PVC Why the ECHA report supports phasing out PVC as the most effective and future-proof risk management measure*, [PVC Problem Very Clear | Health Care Without Harm \(noharm.org\)](https://www.noharm.org/), 25-32.

<sup>58</sup> Heather A. Leslie, Martin J.M. van Velzen, Sico H. Brandsma, A. Dick Vethaak, Juan J. Garcia-Vallejo, Marja H. Lamoree, Discovery and quantification of plastic particle pollution in human blood, *Environment International*, Volume 163, 2022, 107199, ISSN 0160-4120, <https://doi.org/10.1016/j.envint.2022.107199>. (<https://www.sciencedirect.com/science/article/pii/S0160412022001258>)

<sup>59</sup> Antonio Ragusa, Alessandro Svelato, Criselda Santacroce, Piera Catalano, Valentina Notarstefano, Oliana Carnevali, Fabrizio Papa, Mauro Ciro Antonio Rongioletti, Federico Baiocco, Simonetta Draghi, Elisabetta D'Amore, Denise Rinaldo, Maria Matta, Elisabetta Giorgini, Plasticenta: First evidence of microplastics in human placenta, *Environment International*, Volume 146, 2021, 106274, ISSN 0160-4120, <https://doi.org/10.1016/j.envint.2020.106274>. (<https://www.sciencedirect.com/science/article/pii/S0160412020322297>)

However, health concerns related to plastics should be considered throughout the entire plastic lifecycle. For instance, the extraction of raw materials and their transport to refineries or markets is associated with the release of hundreds of toxins, which are harmful to humans. These toxins can cause skin and eye injuries and impair organs such as the liver and brain.<sup>60</sup>

During the refining and manufacturing process of plastics, the emissions released can harm the nervous system, cause reproductive and developmental issues, cancer, leukemia, and genetic impacts like low birth weight.

Once plastic products reach consumers, they may contain chemical substances used during manufacturing such as solvents. Humans are particularly exposed to these substances, especially through plastic packaging, which accounts for 60% of its use in food and beverages.<sup>61</sup> The mixture of chemicals of plastics contains suspected carcinogens, that have the potential to impact development, fertility, and the endocrine system.<sup>62</sup> Of particular concern for human health was the exposure to bisphenol A (BPA) considered an endocrine disruptor;<sup>63</sup> BPA was present in medical devices, bottles, toys and food containers. The EU has been leading the way and in 2018 banned BPA in plastic bottles and packaging containing food for babies and children under three years old.<sup>64</sup>

A less explored paradox in the literature is that environmental degradation, driven by plastic production and pollution, is occurring alongside overall improvements in global human health and well-being<sup>65</sup>. This 'apparent paradox' is addressed in another article<sup>66</sup>, which states, '*we have been mortgaging the health of future generations to realize economic and development gains in the present.*' This conclusion underscores a significant existential concern: the exploitation of natural resources, including those used to produce plastic goods, has facilitated societal development, innovation, and health improvements, but it is now jeopardizing our health and the ability of future generations to access these resources.

Overall, the relationship between the benefits of plastic, its environmental and health impacts, and the societal challenge in reducing these impacts is intricate. This necessitates the exploration of sustainable alternatives and more efficient practices, such as re-evaluating current production and consumption patterns, to mitigate plastic pollution and protect both environmental and human health.

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<sup>60</sup> Center for International Environmental Law (CIEL). (2019). *Notably: Damage to sensory organs such as the skin and eyes; effects on bodily systems, including the respiratory, nervous, and gastrointestinal; and the impairment of organs such as the liver and brain; Increased likelihood of cancer, neurological, reproductive, and developmental toxicity; and Impairment of the immune system.*

<sup>61</sup> Ksenia J. Groh, Thomas Backhaus, Bethanie Carney-Almroth, Birgit Geueke, Pedro A. Inostroza, Anna Lenquist, Heather A. Leslie, Maricel Maffini, Daniel Slunge, Leonardo Trasande, A. Michael Warhurst, Jane Muncke, Overview of known plastic packaging-associated chemicals and their hazards, *Science of The Total Environment*, Volume 651, Part 2, 2019, Pages 3253-3268.

ISSN 0048-9697, <https://doi.org/10.1016/j.scitotenv.2018.10.015>. (<https://www.sciencedirect.com/science/article/pii/S0048969718338828>)

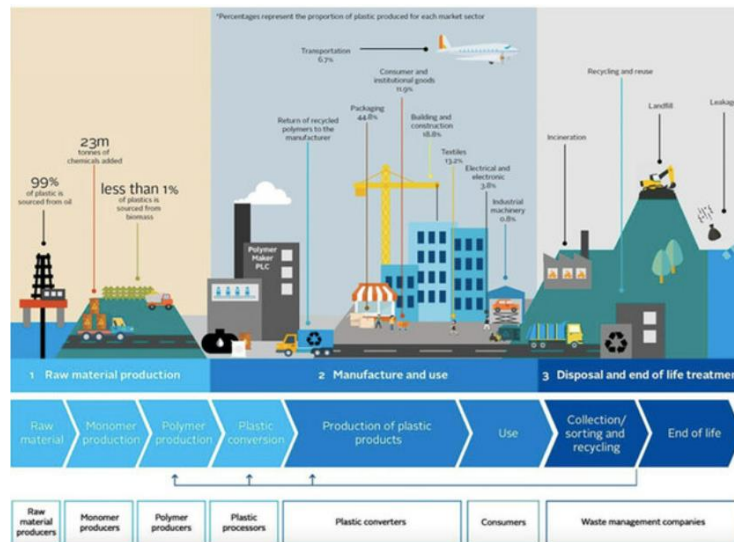
<sup>62</sup> Center for International Environmental Law (CIEL). <https://www.ciel.org/the-toxic-impacts-of-plastic-across-its-lifecycle/>, consulted on 10 May 2024. Endocrine disruptor = chemical substance of natural or artificial origin foreign to the organism which can interfere with the functioning of the endocrine system and thus induce deleterious effects on this organism or on its descendants. (Source: WHO) <https://www.cancer-environnement.fr/fiches/expositions-environnementales/bisphenol-a/>

<sup>63</sup> European Food Safety Authority (2023), Bisphenol A, [Bisphenol A | EFSA \(europa.eu\)](https://www.efsa.europa.eu), consulted on 23 June 24.

<sup>64</sup> World Health Organization (WHO). (2022). Endocrine disruptor = chemical substance of natural or artificial origin foreign to the organism which can interfere with the functioning of the endocrine system and thus induce deleterious effects on this organism or on its descendants. <https://www.cancer-environnement.fr/fiches/expositions-environnementales/bisphenol-a>, consulted on 11 May 2024.

<sup>65</sup> Filippelli, G. M. (2018). Exploring the paradox of increased global health and degraded global environment: How much borrowed time is humanity living on? *GeoHealth*, 2, 226–228. 10.1029/2018GH000155 [PMC free article] [PubMed] [CrossRef] [Google Scholar]/ Planetary Health Alliance meeting held in Edinburgh in May 2018 (<https://planetaryhealthannualmeeting.org/>)

<sup>66</sup> Rockefeller Foundation–Lancet Commission on planetary health. (2015). Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. *The Lancet*, 386(10007), 1973-2028. [https://doi.org/10.1016/S0140-6736\(15\)60901-1](https://doi.org/10.1016/S0140-6736(15)60901-1) [https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(15\)60901-1/fulltext?nr\\_email\\_referer=1](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(15)60901-1/fulltext?nr_email_referer=1)



Source: Plastic value chain<sup>67</sup>

## 2.2. Addressing the Problem of Medical Single-Use Plastics: Strategies and Challenges

In response to the increasing global concern over plastic pollution, the United Nations Environment Assembly (UNEA-5.2)<sup>68</sup> unanimously endorsed a resolution to end plastic pollution (resolution 5/14)<sup>69</sup> in March 2022. This historic resolution aims to create an internationally binding agreement by 2024 to prevent and reduce global plastic pollution. The push from the international community comes at the aftermath of the COVID-19 pandemic that affected the entire world on all fronts. The COVID emergency unveiled the extent to which society and the environment are intertwined, and the human dependence on the natural support system. Due to the strict lockdown and the halt to the business as usual of our economies and societies, it was observed short-term positive impact on the environment.

At the time of this research, negotiations are ongoing, and the 'High-Ambition Coalition' countries and the plastic and petrochemical-producing 'Like-Minded Countries' have not yet reached an agreement. This impasse is partly due to treaty language proposing production caps and chemical disclosures, which the Like-Minded Countries oppose, citing concerns about potential price increases for consumers. Additionally, these countries advocate for the reuse or recycling of plastics and the use of technology to convert plastic into fuel, which has not yet proven successful<sup>70</sup>.

<sup>67</sup> Panuvatvanich, Atitaya & Limphitakphong, Nantamol. (2023). Business development from plastic wastes toward circular economy. 10.2166/9781789063448\_0339.

[https://www.researchgate.net/publication/367209646\\_Business\\_development\\_from\\_plastic\\_wastes\\_toward\\_circular\\_economy](https://www.researchgate.net/publication/367209646_Business_development_from_plastic_wastes_toward_circular_economy)

<sup>68</sup> <https://wedocs.unep.org/bitstream/handle/20.500.11822/39764/END%20PLASTIC%20POLLUTION%20-%20TOWARDS%20AN%20INTERNATIONAL%20LEGALLY%20BINDING%20INSTRUMENT%20-%20English.pdf?sequence=1&isAllowed=y>

<sup>69</sup> [https://wedocs.unep.org/bitstream/handle/20.500.11822/39812/OEWG\\_PP\\_1\\_INF\\_1\\_UNEA%20resolution.pdf](https://wedocs.unep.org/bitstream/handle/20.500.11822/39812/OEWG_PP_1_INF_1_UNEA%20resolution.pdf)

<sup>70</sup> <https://www.reuters.com/sustainability/climate-energy/what-do-countries-companies-want-global-plastic-treaty-talks-2024-04-22/>

The proposed treaty seeks to address plastic pollution comprehensively by considering the entire life cycle of plastics. It focuses on promoting sustainable production and consumption, from product design to environmentally sound waste management, through resource efficiency and circular economy approaches.

Addressing these issues requires a shift from linear to alternative models, prioritizing product redesign, consumption patterns, and safer, reusable alternatives. However, with plastic production expected to triple by 2060, comprehensive life-cycle management strategies are essential to mitigate environmental degradation and safeguard public health, particularly in the challenging context of medical single-use plastics.<sup>71</sup> Medical plastic recycling is limited primarily due to the challenges of sorting and cleaning. Effective recycling of medical plastic waste requires close collaboration between the healthcare sector, recycling industries<sup>72</sup>, healthcare procurement, local and national regulations, as well as medical personnel.

Solutions to SUP are not straightforward, also considering that plastic embodies the core characteristics of ‘wicked problems’, characterized by scientific, political, and societal complexity and uncertainty, and it touches several actors with their own interpretation of the issue.<sup>73</sup>

Prevention through sustainable practices must be paramount in shaping future policies and practices. In healthcare, efforts are underway to make plastic use more sustainable by reprocessing medical equipment, using safer plastics, and reducing waste.

Since the 1970, one of the most adopted umbrellas of strategies by both the private and public sector is the circular economy (CE). The CE concept tries to offer a set of solutions to plastic pollution, from innovative recovery processes of plastic waste, bio-based alternatives and reuse and reduce solutions<sup>74</sup>.

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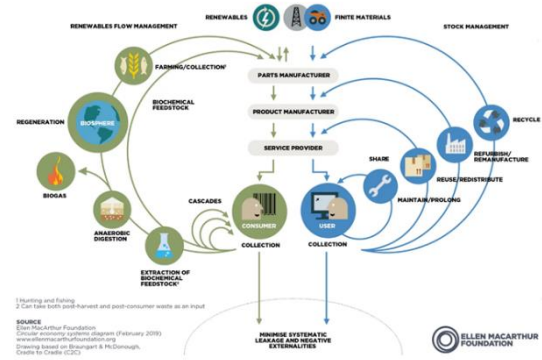
<sup>71</sup> Healthcare without Harm Europe, Arianna Gamba & co. , Measuring and reducing plastics in the healthcare sector, 2021 ([https://noharm-europe.org/sites/default/files/documents-files/6886/2021-09-23\\_Measuring-and-reducing-plastics-in-the-healthcare-sector.pdf](https://noharm-europe.org/sites/default/files/documents-files/6886/2021-09-23_Measuring-and-reducing-plastics-in-the-healthcare-sector.pdf))

<sup>72</sup> Blessy Joseph, Jemy James, Nandakumar Kalarikkal, Sabu Thomas, Recycling of medical plastics, *Advanced Industrial and Engineering Polymer Research*, Volume 4, Issue 3, 2021, Pages 199-208, ISSN 2542-5048, <https://doi.org/10.1016/j.aiepr.2021.06.003>. (<https://www.sciencedirect.com/science/article/pii/S2542504821000348>) Recycling of medical plastics - <https://www.sciencedirect.com/science/article/pii/S2542504821000348?via%3Dihub>

<sup>73</sup> Solutions to Plastic Pollution: A Conceptual Framework to Tackle a Wicked Problem - [https://link.springer.com/chapter/10.1007/978-3-030-78627-4\\_11](https://link.springer.com/chapter/10.1007/978-3-030-78627-4_11)

<sup>74</sup> Calisto Friant, Martin, Dirkjan Lakerveld, Walter J. V. Vermeulen, and Roberta Salomone. 2022. "Transition to a Sustainable Circular Plastics Economy in The Netherlands: Discourse and Policy Analysis" *Sustainability* 14, no. 1: 190. <https://doi.org/10.3390/su14010190>.

According to the Ellen MacArthur Foundation<sup>75</sup>, a circular economy is designed to keep products and materials in circulation through processes such as maintenance, reuse, refurbishment, remanufacturing, recycling, and composting. This approach is based on principles that aim to eliminate waste and pollution, circulate products and materials at their highest value, and regenerate nature. The Ellen MacArthur



Foundation proposed an effective visual representation, the Butterfly Diagram.<sup>76</sup> This shows two different cycles in which material circulates: The Biological Cycle (left side) based on materials which are biodegradable – the objective is to allow materials such as food and wood, to enter the biosphere as compost or other organic nutrients; and the Technical Cycle (right side), focused on materials which are non-biodegradable, such as plastics products, to keep them in the system as much as possible. The key difference from the linear to the circular economy is that the material’s cycles tend to close.

Parts of the CE concepts existed even before the '70 in many sub-disciplines of research such as industrial symbiosis where waste becomes raw material/input for another product, and environmentally sustainable design (for products and services).

The circular economy concepts have shifted the waste management strategies of linear disposal to recycling and recovery of materials that have the potential to re-enter the production and consumption chain.

The technical cycle applied to plastic packages for example that re-enter the market can be a mechanical recycling in closed loops, in this case polymers are kept intact preserving its value (i.e., from PET bottle to PET bottle); can occur through ‘cascading’, called mechanical recycling in open loops, where even though polymers are intact, they lose part of their quality or properties; or it is done via chemical recycling where polymers are broken into monomers or other hydrocarbon products that can be used as feedstock for other products. However, this process is less value-preserving than mechanical recycling and currently not widespread or economically viable for most common plastics<sup>77</sup>.

These options can work with most common plastics, however, in Belgium, as in other countries, most plastic waste that is used in the healthcare sector must be disposed and most medical waste incinerated, causing carbon emissions and toxic gases, and when they are landfilled can either remain decades and/or

<sup>75</sup> Ellen MacArthur Foundation. What is a circular economy? <https://shorturl.at/EpSCG>

<sup>76</sup> Ellen MacArthur Foundation. The butterfly diagram: visualising the circular economy -<https://www.ellenmacarthurfoundation.org/circular-economy-diagram>

<sup>77</sup> Panuvatvanich, Atitaya & Limphitakphong, Nantamol. (2023). Business development from plastic wastes toward circular economy. 10.2166/9781789063448\_0339. [https://www.researchgate.net/publication/367209646\\_Business\\_development\\_from\\_plastic\\_wastes\\_toward\\_circular\\_economy](https://www.researchgate.net/publication/367209646_Business_development_from_plastic_wastes_toward_circular_economy) (14-15)

leach in microplastics and toxic chemicals that affect the environment and health.<sup>78</sup> This means that other strategies have to be prioritized to reduce plastic pollution and negative externalities.

The Waste hierarchy concept provides a guidance for managing waste more meaningfully. In the EU this concept was introduced in 2008 via the EU Waste Framework Directive<sup>79</sup> encouraging Member States to prevent and manage waste in the following order: 1. Prevent, 2. preparing for re-use; 3. recycling; 4. other recovery, e.g. energy recovery; and, only at the end 5. disposal. This Directive was updated in 2018<sup>80</sup> adding additional requirements on prevention, explicitly mentioning that Member States should consider environmental protection principles, including precaution, sustainability, feasibility, viability, resource protection, and overall impacts on the environment, health, economy, and society.

Given the projected increase in plastic products and their detrimental impact on the environment and health, particularly the challenges in eliminating single-use plastics (SUP) in the medical field, preventive measures appear to be promising to reduce plastic pollution, especially in healthcare.

More ambitious versions of the waste hierarchy have been studied, strengthening further the prevention aspect, and going beyond the environmental concerns of waste, including social and health aspects. An example is the zero-waste hierarchy for Europe<sup>81</sup>. This model is constituted by the following layers: 1. Refuse, Rethink, Redesign, 2. Reduce and Reuse, 3. Preparation for Reuse, 4. Recycling, Composting, Anaerobic Digestion, 5. Material and Chemical Recovery, 6. Residuals Management, 7. Unacceptable.



Source: Zero waste Europe<sup>82</sup>.

<sup>78</sup> Liesbet Demarré & Co. (2023). REDUCING SINGLE-USE MATERIALS IN MEDICINE AND HEALTHCARE An exploratory study on sustainability of commonly used materials in hospitals.

[https://www.health.belgium.be/sites/default/files/uploads/fields/fpshealth\\_theme\\_file/reducing\\_sup\\_in\\_medicine\\_and\\_healthcare.pdf](https://www.health.belgium.be/sites/default/files/uploads/fields/fpshealth_theme_file/reducing_sup_in_medicine_and_healthcare.pdf)

<sup>79</sup> Directive 2008/98/EC. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02008L0098-20180705>

<sup>80</sup> EC, 2018a. Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste (Text with EEA relevance) [WWW document], URL [https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02008L0098-20180705\\_2018.150.01.0109.01.ENG](https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02008L0098-20180705_2018.150.01.0109.01.ENG) (accessed 5.12.20).

<sup>81</sup> <https://zerowasteurope.eu/2019/05/a-zero-waste-hierarchy-for-europe/>

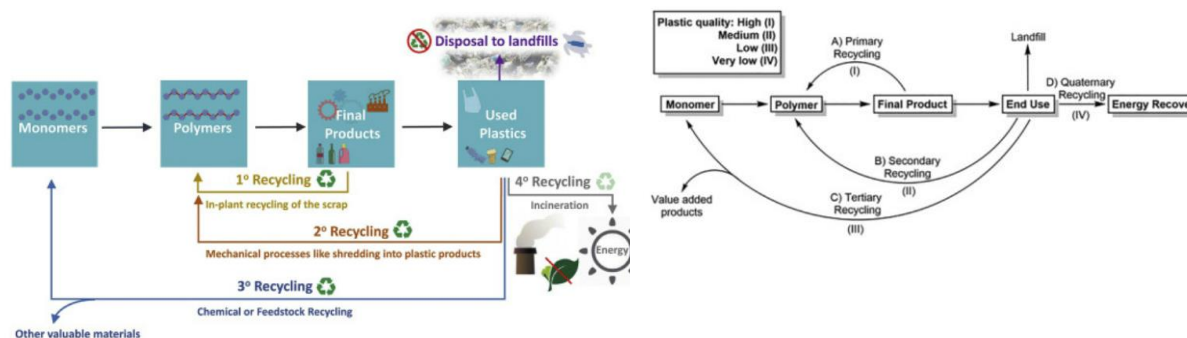
<sup>82</sup> Zero waste Europe (2019). A zero waste hierarchy for Europe. <https://zerowasteurope.eu/2019/05/a-zero-waste-hierarchy-for-europe/>

Prevention involves actions taken before a product is produced or purchased to ensure it doesn't become waste, and forces actors to ask key questions like "is it really needed?" or "is there an alternative?". Innovative strategies such as refusing, rethinking, and redesigning can be employed. The University of Minnesota Medical Center (US) identified items that were never used in the IV port kits reducing waste and costs<sup>83</sup>. If these strategies are not feasible and a product is already produced or purchased, other measures can be taken, such as reducing waste.

To apply this new waste hierarchy requires a paradigm shift that move from safe disposal of waste to 'ensure that the value of our resources is preserved in the economy for the new generations' as well as changing production and consumption habits, making products rethinking products as waste-free by design.<sup>84</sup> Indeed, another innovative element of this inverted pyramid is to extracting valuable materials from mixed waste and sorting discards as a higher priority, before recycling.

The challenges identified with recycling medical plastic waste are the difficulty in sorting and the risk of infection transmission. However, the scarcity of landfills and increasing environmental concerns make recycling crucial.

Recycling begins with identifying and sorting materials, either manually or using automated methods. Manual sorting is labor-intensive, while automated techniques like Near Infra-Red (NIR) and X-ray fluorescence are efficient for certain plastics. Other methods include density separation, froth flotation, electrostatic, and air sorting. Once plastic waste is collected, sorted, and cleaned, it can be processed through one of four recycling methods: primary, secondary, tertiary, or quaternary recycling<sup>85</sup>.



Source: Blessy & Co. Recycling of medical plastics (2021)

However, cost is one of the limitations with recycling, followed by limited efficiency of sorting plastic waste considering that not all plastic can be recycled in medical settings, and the complexities associated

<sup>83</sup> Healthcare without Harm Europe, Arianna Gamba & co. (2021). Measuring and reducing plastics in the healthcare sector. [https://noharm-europe.org/sites/default/files/documents-files/6886/2021-09-23\\_Measuring-and-reducing-plastics-in-the-healthcare-sector.pdf](https://noharm-europe.org/sites/default/files/documents-files/6886/2021-09-23_Measuring-and-reducing-plastics-in-the-healthcare-sector.pdf) (51)

<sup>84</sup> Zero waste Europe (2019). A zero waste hierarchy for Europe. <https://zerowasteurope.eu/2019/05/a-zero-waste-hierarchy-for-europe/>

<sup>85</sup> Blessy Joseph, Jemy James, Nandakumar Kalarikkal, Sabu Thomas, Recycling of medical plastics, *Advanced Industrial and Engineering Polymer Research*, Volume 4, Issue 3, 2021, Pages 199-208, ISSN 2542-5048, <https://doi.org/10.1016/j.aiepr.2021.06.003>. (<https://www.sciencedirect.com/science/article/pii/S2542504821000348>)

in identifying quality of recycled plastics. The risk is that mixed plastics result in final products that are structural weak and instable.<sup>86</sup>

Considering the difficulties in managing plastic waste, the EU introduced restrictions on certain single-use plastics products. The EU directive 2019/904<sup>87</sup> defines Single-use plastic products (SUPs) as those that are made either wholly or partly of plastic used once, or for a short period of time, before being thrown away. SUP can be found in all hospital departments and for any use such as in the cafeteria and waiting rooms. The directive tackles plastic pollution imposing measures to prevent and reduce plastic waste, particularly marine pollution, and on human health. According to the European Commission, 70% of all marine litter in the EU are made of the 10 most found single-use plastic items on European beaches, such as plastic bags, straws, cups among others. This directive explicitly mentions the need to consider plastic products entire life span, and take into account the production, use phase and the reusability and recyclability of the product. However, the EU directive explicitly excludes medical waste.

In Belgian hospitals 84% of the 40,000 tonnes of non-risk medical waste generated each year is incinerated as residual waste.<sup>88</sup> Belgium is also working to implement the European Single-Use Plastics Directive (SUP)<sup>89</sup> which has resulted in a Royal Decree<sup>90</sup> banning certain SUP items, such as cotton buds and plastic tableware, and promoting reusable alternatives. The management of SUP, including medical waste, falls under the jurisdiction of regional governments.

When looking at the European Environment Agency country profile for Belgium<sup>91</sup>, the word Single use plastic only appears two times and only in relation to the adoption of the EU SUP Directive.

In recent years several Belgian hospitals have been involved more and more in projects at all levels to reduce plastic waste, such as Greening the Brussels healthcare sector<sup>92</sup> and Global Green and Healthy Hospitals (GGHH) network.<sup>93</sup>

The Circular Economy (CE) model, particularly the one adopted by the EU, has faced criticism in the literature. While the circular economy aims to achieve green growth by decoupling economic growth from environmental impact, this decoupling is contested. Circular material flows are seen as a means to this end, not the ultimate goal. The CE encompasses various strategies and concepts, resulting in

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<sup>86</sup> Blessy Joseph, Jemy James, Nandakumar Kalarikkal, Sabu Thomas, Recycling of medical plastics, *Advanced Industrial and Engineering Polymer Research*, Volume 4, Issue 3, 2021, Pages 199-208, ISSN 2542-5048, <https://doi.org/10.1016/j.aiepr.2021.06.003>. (<https://www.sciencedirect.com/science/article/pii/S2542504821000348>)

<sup>87</sup> EURLEX. EU directive 2019/904. <https://eur-lex.europa.eu/eli/dir/2019/904/oj>

<sup>88</sup> Circular Flanders. Plastics in Healthcare - <https://vlaanderen-circulair.be/en/cases/detail/plastics-in-healthcare>

<sup>89</sup> EURLEX. COM/2018/028. <https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1516265440535&uri=COM:2018:28:FIN>

<sup>90</sup> Service Public Fédéral Justice. 9 DECEMBRE 2021. - Arrêté royal relatif aux produits à usage unique et à la promotion des produits réutilisables - [https://www.ejustice.just.fgov.be/cgi\\_loi/change\\_lg.pl?language=fr&la=F&cn=2021120932&table\\_name=loi](https://www.ejustice.just.fgov.be/cgi_loi/change_lg.pl?language=fr&la=F&cn=2021120932&table_name=loi)

<sup>91</sup> European Environmental Agency. Country Profile, Belgium. <https://shorturl.at/v30UW>

<sup>92</sup> HCWH. Greening the Brussels healthcare sector. <https://europe.noharm.org/climate-smart-healthcare/greening-brussels-healthcare-sector>

<sup>93</sup> Global Green and Healthy Hospitals. Acting together for environmental health. <https://greenhospitals.org/>

multiple definitions in the literature. This broad range of strategies makes measuring its true effectiveness challenging. Additionally, the concept oversimplifies the issue by framing it as a choice between linear and circular products, ignoring the physical limitations of materials and the complexity of waste management. Another critic is that the circular economy often ignores thermodynamic principles, which state that matter cannot be created or destroyed, only transformed and dissipated. A future without waste or endlessly recycled materials is practically impossible. Each cycle leads to material and quality losses, and new materials and energy are needed to offset these losses.<sup>94</sup>

In a nutshell, plastics can be disposed of through landfilling, incineration, recycling, or biodegradation. However, landfilling requires space and results in the loss of plastic's chemical energy, and incineration recovers some energy but has adverse environmental and health effects. Recycling can recover materials but is hindered by challenges in waste collection and sorting.

At the hospital level, plastic waste management has been extensively studied in the literature (about 101,000 results searching via google scholar). However, the challenges of recycling plastic, particularly medical plastics, and the issues related to disposal and incineration highlight the need to address the problem across the entire life cycle of plastic items. Although hospitals may struggle to fully understand the environmental and health impacts of raw material extraction and manufacturing—something that life-cycle assessments (LCAs) may be able to provide—sustainable procurement practices may offer solutions to reduce single-use plastics (SUP) and propose alternatives.

Sustainable procurement can also be called environmentally preferable purchasing (EPP), which considers social and economic aspects when purchasing products. This approach promises to reduce unnecessary plastic items and where possible to substitute these items with less harmful products. The supply chain emissions fall mostly under Scope 3 which includes purchases, products and services, transportation and distribution.<sup>95</sup>

Research suggests that the procurement process should include criteria that consider the environment and health impacts when purchasing products. A project managed by Towards Plastic-free Healthcare in Europe presents a case in which improper packaging in the Skåne Region in Sweden, that observed multiple gloves being removed and subsequently thrown away just after taking one, corresponded to almost 6% of their gloves wasted. These types of cases led some research to adapting procurement criteria and discussion with suppliers as strategy to help improve packaging to avoid these issues and minimise waste.<sup>96</sup>

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<sup>94</sup> Hervé Corvellec & Co. (2021). Critiques of the circular economy. *Journal of Industrial Ecology*  
<https://onlinelibrary.wiley.com/doi/full/10.1111/jiec.13187>

<sup>95</sup> ilburn, Susan & Jharia, Ishika & Prabhakaran, Poornima. (2021). Sustainable procurement in healthcare.  
10.4324/9781003190516-22.

[https://www.researchgate.net/publication/356269504\\_Sustainable\\_procurement\\_in\\_healthcare/references](https://www.researchgate.net/publication/356269504_Sustainable_procurement_in_healthcare/references)

<sup>96</sup> Healthcare without Harm Europe, Arianna Gamba & co. (2021). Measuring and reducing plastics in the healthcare sector. [https://noharm-europe.org/sites/default/files/documents-files/6886/2021-09-23\\_Measuring-and-reducing-plastics-in-the-healthcare-sector.pdf](https://noharm-europe.org/sites/default/files/documents-files/6886/2021-09-23_Measuring-and-reducing-plastics-in-the-healthcare-sector.pdf) (52)

Public organizations use sustainable public procurement (SPP) to tackle societal and environmental issues. However, having an SPP policy does not ensure its implementation, as barriers like financial constraints, lack of knowledge, and low motivation hinder public procurers. This raises the question of how much SPP is actually practiced. Existing studies often emphasize the environmental aspects of SPP and rely on interviews or surveys, which can be biased and have low response rates. Consequently, little is known about the practical implementation and frequency of SPP.<sup>97</sup>

Moreover, Healthcare accounts for 14% of annual EU GDP, approximately half of public spending in the EU, and 11% in Belgium – hospital account for around 45%.<sup>98</sup>

EU Member States need to introduce environmental criteria into their purchasing decisions following the EU green public procurement (GPP) criteria<sup>99</sup>

In principle, public procurement has the potential to contribute to the ‘greening’ of the economy by changing consumption and production patterns. However, there is limited data on the extent of green public procurement (GPP) in EU countries. The Tenders Electronic Daily (TED) database<sup>100</sup>, that records all tenders above EU thresholds noting if environmental considerations are included, can only provide estimates due to missing values and the lack of a standardized format. It currently shows significant differences between countries, with GPP ranging from less than 0.5% in Malta to over 15% in Denmark and France. Most countries apply GPP to less than 5% of their contracts. However, it is uncertain whether life cycle assessment, emission standards, carbon footprint concepts were taken into consideration when defining these public procurements ‘green’.

Alternative plastics, including biobased, biodegradable, and compostable options could offer a potentially more sustainable choice compared to fossil based. Nonetheless, these alternatives also come with their own sustainability challenges and trade-offs that need thorough evaluation and consideration<sup>101</sup>.

Biodegradable plastics for example are designed to reduce environmental damage, but they may not decompose quickly enough and can disrupt recycling processes due to their similar appearance but

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<sup>97</sup> J. (Jolien) Grandia, P.M. (Peter) Kruijven, Assessing the implementation of sustainable public procurement using quantitative text-analysis tools: A large-scale analysis of Belgian public procurement notices, *Journal of Purchasing and Supply Management*, Volume 26, Issue 4, 2020, 100627, ISSN 1478-4092, <https://doi.org/10.1016/j.pursup.2020.100627>. (<https://www.sciencedirect.com/science/article/pii/S1478409220300807>)

<sup>98</sup> HCWH (Strategic Procurement In European Healthcare (2019). [https://europe.noharm.org/sites/default/files/documents-files/6171/2019-12-17\\_HCWHEurope\\_Strategic\\_Procurement\\_Web.pdf](https://europe.noharm.org/sites/default/files/documents-files/6171/2019-12-17_HCWHEurope_Strategic_Procurement_Web.pdf) And Eurostat. Healthcare expenditure statistics. [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Healthcare\\_expenditure\\_statistics](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Healthcare_expenditure_statistics) Healthcare expenditure on major providers, 2020 (% of current healthcare expenditure) Health2022. [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Healthcare\\_expenditure\\_on\\_major\\_providers,\\_2020\\_\(%25\\_of\\_current\\_healthcare\\_expenditure\)\\_Health2022.png](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Healthcare_expenditure_on_major_providers,_2020_(%25_of_current_healthcare_expenditure)_Health2022.png)

<sup>99</sup> European Commission. Green Public Procurement. [https://green-business.ec.europa.eu/green-public-procurement\\_en](https://green-business.ec.europa.eu/green-public-procurement_en)

<sup>100</sup> EU Tenders. <https://ted.europa.eu/en/>

<sup>101</sup> European commission. Biobased, biodegradable and compostable plastics [https://environment.ec.europa.eu/topics/plastics/biobased-biodegradable-and-compostable-plastics\\_en](https://environment.ec.europa.eu/topics/plastics/biobased-biodegradable-and-compostable-plastics_en)

different composition.<sup>102</sup> Some research explains that not all biodegradable plastics fully degrade in natural conditions; they also break down into microplastics but faster than conventional plastics, potentially harming soil environments. These biodegradable microplastics may have even greater negative effects on soil species compared to oil-based microplastics. With the growing shift toward biodegradable plastics, it is crucial to assess their ecological safety before widespread commercial adoption.<sup>103</sup> A plastic can be labeled as "bioplastic" if it contains just 30% biomass by mass, meaning a plastic made from 70% petroleum can still be called a bioplastic.<sup>104</sup>

They can be biosourced, derived from natural or synthetic biomass, or petrosourced, derived from fossil resources like petroleum. Bioplastics can be either biodegradable or non-biodegradable, depending on their properties and environmental conditions. Therefore, a bioplastic can be biosourced and biodegradable, biosourced and non-biodegradable, or petrosourced and biodegradable. It is more accurate to refer to them as biosourced, biodegradable, or compostable plastics.

The surge in hazardous and infectious healthcare waste, intensified by COVID-19, has highlighted the healthcare sector's heavy reliance on single-use plastics. This presents a significant 21st-century dilemma: balancing environmental concerns with health needs, particularly regarding hard-to-reduce medical plastics, and finding viable alternatives or improved usage methods. While existing literature often focuses on businesses, academics, and policymakers, it frequently neglects the role of hospital staff in identifying effective strategies and alternatives based on their practical experience. Recent studies and projects led by Healthcare Without Harm (HCWH)<sup>105</sup> have involved hospital personnel, underscoring the importance of integrating their insights with scientific evidence to address the plastic issue in a sustainable manner.

### 3. Methodology

This preliminary research aims to guide the transition towards sustainable practices in healthcare by exploring the perspectives of hospital medical personnel. The study focuses on identifying sustainable alternatives to single-use plastics in medical applications through the examination of hospital staff practices. It also aims to understand how these practices influence decision-making processes throughout the supply chain, including procurement strategies and policymaking.

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<sup>102</sup> North EJ, Halden RU. Plastics and environmental health: the road ahead. *Rev Environ Health*. 2013;28(1):1-8. doi: 10.1515/reveh-2012-0030. PMID: 23337043; PMCID: PMC3791860. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3791860/>

<sup>103</sup> Meng Qin, Changya Chen, Biao Song, Maocai Shen, Weicheng Cao, Hailan Yang, Guangming Zeng, Jilai Gong, A review of biodegradable plastics to biodegradable microplastics: Another ecological threat to soil environments?, *Journal of Cleaner Production*, Volume 312, 2021, 127816, ISSN 0959-6526, <https://doi.org/10.1016/j.jclepro.2021.127816>. (<https://www.sciencedirect.com/science/article/pii/S0959652621020345>)

<sup>104</sup> Bruxelles environnement. « BIOPLASTIQUES » Plastiques biosourcés, biodégradables ou compostables Une alternative (in)soutenable ? [https://document.environnement.brussels/opac\\_css/electfile/BIOPLASTIQUESNOT\\_20200929\\_FR.pdf](https://document.environnement.brussels/opac_css/electfile/BIOPLASTIQUESNOT_20200929_FR.pdf)

<sup>105</sup> HCWH. Leading the global movement for sustainable health care. <https://noharm.org/> (Consulted on 3 August 2024).

The research identifies the challenges associated with adopting sustainable alternatives and assesses their potential to reduce the environmental impact of plastics. Furthermore, it develops recommendations for hospitals, regulators, and governments to support the adoption of sustainable practices.

By improving our understanding of sustainable practices related to single-use plastics, this research lays the foundation for further studies and actions in healthcare sustainability. Emphasizing the role of hospital personnel in driving change, the study addresses broader implications for policy and practice. Additionally, the research explores patterns and commonalities across different hospitals and departments regarding the use of single-use plastics and identifies discrepancies between hospital regulations and the actual practices of personnel. This comprehensive approach highlights the potential for systemic change within the healthcare sector.

The environmental and health impacts of plastic pollution have been extensively studied in the literature. Existing research often emphasizes scientific, institutional, and policy-level approaches to sustainability in healthcare, frequently overlooking the role of individual hospital personnel in shaping sustainable practices. Although there is a growing body of literature on alternatives to single-use plastics, practical implementation in healthcare settings remains underexplored. Specifically, studies focusing on medical single-use plastics are scarce due to the complexities of balancing environmental concerns with health safety requirements.

Current literature heavily addresses waste management practices but fails to provide a comprehensive view of how sustainable practices influence upstream procurement and downstream policy-making decisions. Additionally, there is a lack of research on the alignment between hospital policies and the actual practices of hospital staff concerning single-use plastics. Variability in practices across different hospitals and departments often leads to inconsistent application of sustainable practices within the same region.

Empirical data on the effectiveness of sustainable alternatives in reducing the environmental impact of plastics in healthcare is limited. While many studies underscore the need for change, they often lack concrete recommendations for hospitals, regulators, and governments.

This preliminary study sets the stage for further research in the field of healthcare sustainability. Future investigations could involve quantitative analyses comparing the environmental impacts of identified alternatives to single-use plastics in medical settings. This could be achieved through Life Cycle Assessments (LCAs) of both the current single-use plastic products and the proposed alternatives. LCA is a comprehensive method for evaluating the environmental impacts associated with all stages of a product's life cycle.

Subsequent research could focus on specific departments within hospitals in Brussels or broaden the scope to include hospitals across Belgium. Additionally, a material flow analysis of single-use medical plastics could be conducted to gain insights into their usage patterns and environmental footprint.

### **3.1. Research Question and Hypotheses**

The use of medical single-use plastic products in hospitals presents a significant environmental challenge. While hospitals and healthcare facilities depend on these products for their convenience, sterility, and cost-effectiveness, their environmental impact—including pollution and waste—demands a thorough re-evaluation of their use.

Despite increasing awareness of environmental issues, many hospitals face difficulties in finding viable alternatives to single-use plastics, particularly in medical applications. The challenge is further complicated by the need to uphold hygiene standards, ensure patient safety, and manage costs. There is an urgent need to investigate how hospitals can reduce their environmental impact while maintaining high-quality care.

#### **Research Question:**

Following the literature review findings, the initial research question, *‘What are the views of medical personnel in Brussels hospitals regarding the use, potential for reuse, and alternatives to medical single-use plastic products, and how do these perspectives align with the existing literature findings?’* Has been refined as follows:

- "How do medical personnel in Brussels hospitals perceive the use of single-use plastics (SUP), their potential for reuse, and available alternatives?"
- "What are the primary challenges they face in implementing more sustainable practices, and how do these perceptions and challenges align with existing literature on the environmental impact of medical plastics and alternatives?"

This research question is crucial because it delves into the views and practical experience of key actors such as medical personnel, who use daily single-use plastics in hospitals. It aims to uncover practical and actionable strategies that could be integrated into existing healthcare frameworks. The insights gained could guide policy changes, enhance sustainability efforts within hospitals, and potentially lead to cost savings and improved patient care over time. The study is based on the following overarching hypothesis:

1. Role of Medical Personnel: Medical personnel are aware of the health and environmental risks associated with single-use plastics in medical settings and understand their crucial role in promoting healthcare sustainability.
2. Influence on Decision-Making: The daily practices of hospital medical personnel have the potential to affect both upstream (procurement) and downstream (waste management) decisions, thereby influencing overall consumption of medical single-use plastics and the adoption of viable alternatives.
3. Solutions: While alternatives to certain medical single-use plastics exist, they require thorough examination within their specific contexts and a comprehensive approach to assess their effectiveness.

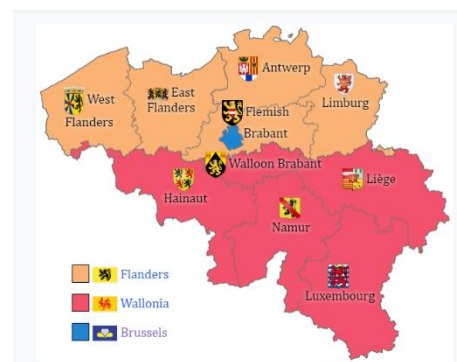
### 3.2. Significance of the Study

This preliminary research is both timely and pertinent for several key reasons. As awareness about plastic pollution and its detrimental environmental effects continues to rise, exploring ways for hospitals to reduce their plastic usage directly aligns with global, european, and national sustainability objectives. Hospitals, being major consumers of single-use plastics due to stringent hygiene and safety requirements, stand to benefit significantly from understanding how to transition towards more sustainable practices. This study is crucial as it explores the practicalities of this shift within the healthcare sector, addressing an urgent need to integrate sustainability into hospital operations.

Furthermore, the research offers valuable insights at the intersection of policy and practice, potentially informing administrative decisions and practical interventions in healthcare management. By focusing on hospitals in Brussels, the study provides context-specific findings that are particularly relevant to local policymakers and healthcare administrators. The interdisciplinary approach of combining environmental science, healthcare management, and policy studies enhances the research's appeal to a broad academic audience and promotes cross-disciplinary collaboration.

### 3.3. Scope and Limitations

The study focuses on hospitals within the Brussels-Capital region in Belgium, allowing for an analysis of practices in a specific healthcare environment. This may highlight differences in practices for the same single-use plastics products for medical use in different hospitals, it may highlight commonalities in practices, and common challenges.



This study focuses on plastic items/products that are considered single-use and are for medical use in hospitals. We refer to these in the study as medical single-use plastic products/items or single-use-plastic(s) for medical use to distinguish it to general single use plastic(s) products/items in hospitals.

In this study, 'medical use' refers to plastic objects that encounter patients for medical purposes. This excludes single-use products commonly found in hospital cafeterias, restaurants, or administrative departments, such as plastic bottles, plastic cups, and general plastic packaging, as these items are already widely studied in existing literature. Various departments were taken into consideration to provide a comprehensive understanding of single-use plastic usage across different medical procedures, identify the commonalities in SUP products, and pinpoint the departments with the most problematic use of SUP, as well as the common practices adopted across departments. The study examined practices related to the use, reuse, and reduction of single-use plastics by medical professionals including examples of more sustainable alternatives. The medical professionals targeted in this study include generalist and specialized doctors, nurses, and midwives, among others involved in conventional medical practices.<sup>106</sup> Administrative and cleaning personnel are excluded.

### 3.4. Data Collection Methods

Data was collected using an online survey created with Google Forms (refer to the survey in Annex I and II). This survey was distributed both directly to medical and professional personnel matching the targeted professions and indirectly through community and personal networks. The survey was available in both French and English and included several sections: i. Introduction, ii. Demographic Information, iii. Current Practices, iv. Policies and Training, v. Success Stories and Additional Comments.

The survey consisted of 17 questions, employing a variety of response formats including multiple-choice, short and long answers, linear scale, and yes/no/I don't know options.

1. **Introductory part:** this section explained the scope of the survey and the boundaries in terms of focus region and personnel type. It specified the answers were collected anonymously. Participants were advised that the survey would take about 5-10 minutes to complete. An automatic thank-you message was sent after each response, and participants were given my email address for any additional clarifications needed. These measures were implemented to minimize ambiguities and ensure clear and accurate responses.

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<sup>106</sup> Health food chain Safety Environnement. LIST OF ALL REGULATED HEALTHCARE PROFESSIONS\* IN BELGIUM <https://www.health.belgium.be/en/health/taking-care-yourself/patient-related-themes/cross-border-health-care/healthcare-providers#overview>

- II. **Demographic information:** in this section participants were asked to indicate their sex, age range, profession, years of experience, hospital name and department. It was specified the information was collected anonymously and would have been used solely for research and statistical purposes.
- III. **Current practices:** It was composed of nine (9) questions aimed at understanding hospital's current practices for single-use plastic products for medical use.
- IV. **Policies and Training:** This section explored existing guidelines or policies in place for the responsible use of single-use plastic products and trainings. It was composed of six (6) questions:
- V. **Success stories and additional comments :** this section aimed at identifying whether any success stories or positive initiatives in participants' hospitals on the reduction of single-use plastic products. It was composed of two (2) questions with a long answer, one of which was not compulsory.

### 3.5. Potential Limitations and Challenges

Among the limitations and challenges the study may encounter, the following have been identified:

**Response Bias:** The voluntary nature of the survey can lead to response bias, as individuals with strong views on environmental sustainability are more likely to participate, while others may not. There was also a risk of receiving responses from non-targeted professionals, such as cleaning and administrative staff. To address this issue, the online survey was primarily sent directly to the intended participants or known environmental/hospital networks, with clear explanations regarding the survey's focus and target audience to minimize such discrepancies.

**Time Constraints of the Target Audience:** Medical personnel often have limited time available for individual surveys outside of hospital projects or those required by their supervisors, which can lead to a lower response rate.

**Variability in Practices:** Practices related to single-use plastics can vary significantly between hospitals and departments, making it difficult to generalize findings across the entire healthcare sector.

**Language Constraints:** The survey was available only in French and English, excluding the Flemish language and the Flanders region. Hospitals in the Brussels-Capital Region can be monolingual in Dutch or French, or bilingual, based on their type. University hospitals, tied to specific linguistic communities, must be either monolingual Dutch or French. Public hospitals run by a public authority

are required by law to be bilingual. Private hospitals, which are not managed by a public authority, are not legally required to use any specific language, though most serve both Dutch and French speakers.<sup>107</sup>

**Hospitals regulatory and practices differences:** hospitals may adhere to regional and national regulations in a stricter or looser way, and personnel may find an environment that either encourage innovative practices or not at all. This may influence the comparison between hospitals practices, requiring careful consideration when comparing data from different hospitals.

#### 4. Survey Analysis and Literature Correlation

The following qualitative analysis aims to extract valuable insights that can contribute to understanding and addressing issues related to the use of single-use plastics in healthcare settings.

The survey received a total of 24 responses. Of these, 23 were deemed relevant for analysis, providing valuable insights into medical personnel perspectives in Brussels hospitals on the use, reuse potential, and alternatives to single-use plastic products for medical use.

It is acknowledged that due to the limited number of answers received, the data collected cannot be used for statistical purposes or to arrive to general conclusions. However, based on the answers provided the participants sample offered valuable insights and enough elements to undertake a qualitative analysis that could be compared with existing literature. The survey was composed of the following sections: **i. Introductory part, ii. Demographic information, iii. Current practices, iv. Policies and Training, v. Success stories and additional comments**

<b>Section I. Introductory part</b>	The introduction outlined the study’s purpose and target audience, clarified that the survey was anonymous to ensure confidentiality, and stated that data would be used only for research. Participants were informed it would take 5-10 minutes, with an automatic thank-you message and contact details for further questions.
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#### Section II. Demographic information

The demographic information provided insights into the general characteristics of the survey participants. It helped identify who the respondents were, their relevance to the survey topic, the target audience, and the context of the survey, while also allowing for the exclusion of irrelevant responses.

This section was composed of 6 questions: **A. Sex, B. Age range, C. Profession, D. Years of experience, E. Hospitals’ name, F. Departments.**

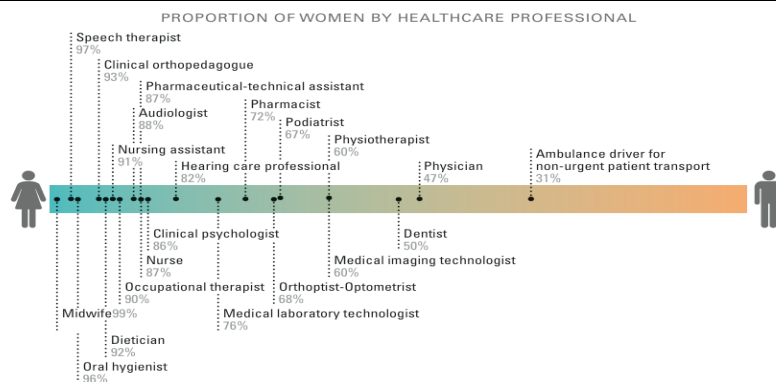
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<sup>107</sup> Wikipedia. List of hospitals in Belgium - [https://en.wikipedia.org/wiki/List\\_of\\_hospitals\\_in\\_Belgium#Brussels-Capital\\_Region](https://en.wikipedia.org/wiki/List_of_hospitals_in_Belgium#Brussels-Capital_Region) (Consulted on 5 august 2024).

### a. Sex

Sex (disaggregated data)	Number of total answers	% out of total answers	Number of relevant answers	% out of relevant answers
Male	8	33%	7	30%
Female	16	67%	16	70%
Prefer not to say	0	0	0	0
<b>Total</b>	<b>24</b>	<b>100%</b>	<b>23</b>	<b>100%</b>

The survey results show that 67% of respondents identify as female. Although the limited number of responses precludes statistical analysis, this aligns with a common pattern noted in the literature and official documents: significant female representation among healthcare professionals. According to the World Health Organization, women constitute 67% of the global health and social care workforce. This trend is also confirmed in Belgium (78.6%).<sup>108</sup>



Graph Source: Key data in health care (2022)<sup>109</sup>

### a. Age range

Age range	Total (out of all answers)	% (out of all answers)	Sex disaggregated data		Total (out of relevant answers)	% (out of relevant answers)	Sex disaggregated data	
			Female (out of all answers)	Male (out of all answers)			Female (out of the relevant answers)	Male (out of the relevant answers)
25-34	4	17%	3	1	4	17%	3	1
35-44	11	46%	8	3	11	48%	8	3
45-54	5	21%	4	1	5	22%	4	1
55-64	4	17%	1	3	3	13%	1	2
65 and above	0	0%	0	0	0	0%	0	0
Other	0	0%	0	0	0	0%	0	0
<b>Total</b>	<b>24</b>	<b>100%</b>	<b>16</b>	<b>8</b>	<b>23</b>	<b>100%</b>	<b>16</b>	<b>7</b>

Regarding the age range of respondents, almost half of the relevant answers are between **35 and 44 years old**. Followed by 22% among the 45-54 years old range. In 2020, the majority of physicians and

<sup>108</sup> For a Healthy Belgium. Key data: Healthcare professionals - <https://www.healthybelgium.be/en/key-data-in-healthcare/healthcare-professionals/download-the-full-report-in-pdf-here>

<sup>109</sup> Ibid.

caregivers in Belgium were between 25 and 34 years old, while most nurses fell within the 45 to 54 age range.<sup>110</sup>

## b. Profession

Sex disaggregated data				Sex disaggregated data		
Profession (English)	Number (out of all answers)	Female (out of all answers)	Male (out of all answers)	Number (out of relevant answers)	Female (out of the relevant answers)	Male (out of the relevant answers)
Medical technologist	1	0	1	1	0	1
Dentist	1	1	0	1	1	0
Nurse	4	4	0	4	4	0
Doctor	14	7	7	14	7	7
Midwife	3	3	0	3	3	0
Waste Manager	1	0	1	N/A	N/A	N/A
Total	24	15	9	23	15	8

Among the survey participants, the 23 relevant responses include a majority of doctors (14 - with an equal number of men and women) and nurses (4 - all women). In Belgium, 87% of nurses are women, and in 2020 they represented the largest group (40%) of paid healthcare professional.<sup>111</sup>

## c. Years of experience

Years of experience	Relevant #
Less than 1 year	0
1-3 years	1
4-6 years	2
7-10 years	3
More than 10	17
	<b>23</b>

- The majority of the relevant responses (17) come from individuals with 10 years or more of experience.
- This suggests that the answers are provided by seasoned professionals who may have witnessed changes in hospital environmental practices throughout their careers and are highly familiar with the items and products they use in their work.

*\*Plus 1 non-relevant*

## d. Hospitals' name

	Name of hospitals	#
1	CHIREC - Delta	6
2	Saint-Pierre University Hospital	6
3	Saint-Luc University Clinics	3
4	Saint-Jean Clinic	2
5	CHU - Brugmann University Hospital	2
6	Cliniques de l'Europe, Saint Michel	2
7	Brussels University Hospital - Jules Bordet Institute	1

- Respondents practice their profession in hospitals located in the Brussels-Capital Region, confirming the survey's targeted area.
- The survey includes representatives from 9 hospitals in Brussels, with a higher representation from CHIREC-Delta, Saint-Pierre University Hospital, and Saint-Luc

<sup>110</sup> Statista. Share of physicians, nurses, and caregivers in Belgium in 2020, by age group - <https://www.statista.com/statistics/1155278/health-providers-by-age-belgium/>

<sup>111</sup> Health Food Chain Safe Environnement (2023). Key data in healthcare General hospitals - [https://www.belgiqueenbonnesante.be/images/HEALTH/Algemene%20ziekenhuizen\\_2023/FOD%20Volksgesondheid%20-%20Blikvanger%2001%20-%20EN%20-%20Interactive%202%201.pdf](https://www.belgiqueenbonnesante.be/images/HEALTH/Algemene%20ziekenhuizen_2023/FOD%20Volksgesondheid%20-%20Blikvanger%2001%20-%20EN%20-%20Interactive%202%201.pdf)

8	Hôpitaux iris sud	1
	<b>Total</b>	<b>23</b>

University Clinics—the largest hospital in Brussels, employing over 6,000 staff<sup>112</sup>.

Some of the hospitals listed are engaged in ongoing sustainable initiatives and projects. In particular six of the hospitals that participated to the survey are part of the Greening the Brussels healthcare<sup>113</sup> sector managed by Health Care Without Harm.

### C. Departments

Among the 23 relevant responses, the top five departments represented are Neonatology (5), Anaesthesia (3), Cardiovascular, Maternity, Pediatrics, and Intensive Care (each with 2 responses).

The distribution of personnel across departments suggests potential biases stemming from the specific networks through which the survey was disseminated.

Nevertheless, the diversity of departments represented provides a solid foundation for conducting an informed qualitative analysis of the survey results.

Departments	Number of answers
<b>Neonatology</b>	<b>5</b>
<b>Anaesthesia</b>	<b>3</b>
Cardiovascular	2
Maternity	2
Paediatrics	2
Intensive care	2
Dentistry	1
Geriatrics	1
Gynaecology	1
Ophthalmology	1
Orthopaedics	1
Mother and child unit	1
Radiology	1
<b>Total</b>	<b>23</b>

### Section III. Current practices

This section aimed at understanding hospital's current practices for single-use plastic products intended for medical use.

#### Identification of Single-Use Plastics:

<p><b>Question: "Please name at least 5 'single use' plastic products for medical use that you encounter in your daily tasks."</b></p>	<p>The question received 23 answers that identified a total of 73 items of which 70 considered relevant for the analysis. The 3 excluded items (bin bag, plastic spoon, and straw) were considered out of the scope despite made of plastic material as they are commonly used outside of the hospital environment.</p> <p>The top five items mentioned by the survey respondents were: Syringe (10 times), feeding</p>
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<sup>112</sup> Saint Luc Hospital.

<https://www.saintluc.be/en#:~:text=Cliniques%20universitaires%20Saint%2DLuc%20is,employees%20and%20nearly%201000%20beds>

<sup>113</sup> HCWH. Greening the Brussels healthcare sector - <https://europe.noharm.org/climate-smart-healthcare/greening-brussels-healthcare-sector>

	bottle (six times), infusion (5 times), Gloves (4 times), and Oxygen spectacles, Sterile drapes, Catheters, Infusion tubing, all mentioned 3 times.
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Items	Recurrence	<b>Summary of Responses:</b>  ❖ Total Responses: 23 ❖ Total Items Identified: 73 ❖ Relevant Items for Analysis: 70
<b>Syringe</b>	10	
Feeding bottle	6	
<b>Infusion</b>	5	
<b>Gloves</b>	4	
Oxygen spectacles	3	
<b>Sterile drapes</b>	3	
<b>Catheters</b>	3	
Infusion tubing (including baxter infusion and infusion set)	3	

**Survey results:** the top five single-use plastic items mentioned by the survey sample.

### Analysis and literature comparison

These results highlighted the most encountered single-use plastic (SUP) items in daily medical tasks as reported by the survey respondents. Among the top five SUP products listed, **Syringe, Gloves, infusions, and catheters** are most present in hospitals as per the literature.

The graph presents the distinction between medical and non-medical items used in hospitals that are either fully or partially made of plastics. It also shows those that are considered consumable (disposable, single use) and those that are durable.

Gloves and syringe are the most present in the literature. These items are disposable after one use as they enter in contact with patients' body fluids including blood.



Graph Source<sup>114</sup>

### Gloves and Syringes

**Gloves** always present in the literature since the '80 as disposable material recommended to protect against bloodborne pathogens, like HIV, and particularly present during the COVID-19 pandemic when their use extended beyond hospitals. The Centers for Disease Control and Prevention (CDC) and the European Center for Disease Prevention and Control (ECDC) strongly recommended the use of disposable gloves. However, the World Health Organization cautioned that while gloves play a

**Gloves and syringe** are used in all hospital departments and are mostly disposable after one use in medical settings. Gloves even resulted the most purchased item in five surveyed European hospitals by research made in 2019, before COVID-19. The same research identified six product categories that make up more than 60% of the total annual plastic usage: intravenous administration systems (6.90%), **disposable gloves** (17.51%), IV solution bags (11.52%), disposable protective clothing (non-woven

<sup>114</sup> Tijana Ivanović, Hans-Jörg Meisel, Claudia Som, Bernd Nowack, Material flow analysis of single-use plastics in healthcare: A case study of a surgical hospital in Germany, Resources, Conservation and Recycling, Volume 185, 2022, 106425, ISSN 0921-3449, <https://doi.org/10.1016/j.resconrec.2022.106425>. (<https://www.sciencedirect.com/science/article/pii/S0921344922002683>)

crucial role in reducing contamination risks, their effectiveness can be compromised by improper use, such as healthcare professionals unintentionally touching their faces or using a cell phone after patient contact. There are various types of gloves designed to suit different medical procedures and accommodate the chemical allergies of medical personnel and patients, particularly to materials like latex. These gloves are typically made from materials that are either fully or partially plastic, or exhibit plastic-like properties, including nitrile, vinyl (polyvinyl chloride), polyethylene, synthetic materials, rubber (including neoprene), and latex. The choice of gloves may also be made on their cost, for example, Nitrile gloves (considered rubber) are the most expensive, while gloves made of polyvinyl chloride, polyethylene and synthetic materials are less expensive.

**Syringes** are widely used in medical settings to reduce the risk of infections, such as HIV and hepatitis. There are different types and measures, depending on their purpose, some to inject drugs, drawing liquids, intravenous therapy into the bloodstream or blood sampling. Although the first syringes were crafted from materials such as hollow reeds, glass tubes, and goose quills<sup>117</sup>, today they are made of plastic – the barrel in polypropylene (PP) and the plunger in polyethylene. Syringes are also used for non-medical uses.

fabrics) (9.75%), **syringes** (8.11%), and nappies, incontinence wear, and bed pads (8.06%)<sup>115</sup>.

Although single-use products play a crucial role in reducing contamination in medical settings, they also lead to significant negative externalities, such as increased waste from disposable items, environmental pollution, and potential health risks. This is corroborated by findings in the literature review. Waste audits in five European hospitals revealed that diapers, syringes, surgical gowns/aprons, and surgical gloves were the most prevalent items. Identifying the specific types of plastics proved challenging due to the lack of labels on most products. However, estimates based on labeling and assumptions indicated that polypropylene (PP) constituted about 12% of the waste, nitrile (mainly gloves) around 10%, low-density polyethylene (LDPE) 8.52%, high-density polyethylene (HDPE) 3.66%, and polyethylene terephthalate (PET) 3.38%. Additionally, polyvinyl chloride (PVC) was found in 1.52% of the items based on labeling<sup>116</sup>.

Although the top five items identified in the survey align with those confirmed by the literature as the most common single-use plastics in hospitals, the second most frequently mentioned item is '**feeding bottles**'. These are mainly used in neonatal intensive care, neonatology, maternity, and paediatrics departments. The prominence of feeding bottles in the survey results may reflect the fact that many respondents work in these departments. However, given that syringes, gloves, nappies, and disposable protective clothing were identified as the most purchased items in the aforementioned research, it is possible that the issue of baby feeding bottles as environmental issue has not been extensively explored in the literature. Moreover, the literature confirms the health risks of plastic baby bottles, notably through the presence of microparticles and chemical agents that can be ingested. A research estimates that babies may ingest on average 1.5 million particles of microplastics per day.<sup>118</sup>

<sup>115</sup> Healthcare without Harm Europe (2021). *Measuring and reducing plastics in the healthcare sector*. [https://noharm-europe.org/sites/default/files/documents-files/6886/2021-09-23\\_Measuring-and-reducing-plastics-in-the-healthcare-sector.pdf](https://noharm-europe.org/sites/default/files/documents-files/6886/2021-09-23_Measuring-and-reducing-plastics-in-the-healthcare-sector.pdf)  
<sup>116</sup> *Ibid.*  
<sup>117</sup> NMS. The story of Syringes. <https://www.nms.ac.uk/explore-our-collections/stories/science-and-technology/syringes/> (consulted on 6 August 2024)  
<sup>118</sup> NPR (2020). Study: Plastic Baby Bottles Shed Microplastics When Heated. Should You Be Worried? <https://www.npr.org/sections/goatsandsoda/2020/10/19/925525183/study-plastic-baby-bottles-shed-microplastics-when-heated-should-you-be-worried>

Feeding bottles are mostly made of polypropylene (PP) and they contain Bisphenol A (BPA), used since the 1960s. BPA is now known to be a toxic endocrine disruptor. It is associated with increased risks of cancer, immune issues, early puberty, obesity, diabetes, and hyperactivity.<sup>119</sup> In April 2024, the European Food Safety Authority (EFSA), concluded<sup>120</sup> that current levels of exposure to Bisphenol A (BPA) had “potential harmful effects on the immune system.” In 2011, the EU banned its use in polycarbonate baby bottles, introducing additional restrictions in 2018 and in 2024 EU member states agreed a proposal to ban Bisphenol A (BPA) in food and drink packaging.<sup>121</sup>

### Potential for Reuse:

<p><b>Question: "Among the mentioned plastic products labelled as ‘single use’ which ones have the potential to be reused at least once more as per your daily practices?"</b></p>	<p>The question received 21 answers that identified 19 single use items that, as per the respondents, have the potential to be used more than one time. Two items were excluded because considered commonly used items also outside of hospitals (plastic bags, parental bags). Among the items listed, <b>syringes</b> and <b>baby feeding bottles</b> were mentioned more often.</p>
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### Analysis and literature comparison

Items	Can be reused (as per respondents)	<p>The concept of waste hierarchy serves as a guide for prioritizing waste management strategies. Adopted by <b>the EU Waste Framework Directive</b><sup>122</sup>, this circular economy tool aims to: 1) reduce the negative effects of waste generation and management, and 2) enhance resource efficiency. The hierarchy is structured like an inverted pyramid, prioritizing <b>prevention (including reducing)</b> in terms of quantity, product type, alternatives, and both health and environmental concerns. Only after addressing prevention should efforts shift to <b>"preparing for reuse."</b></p>
Breast pump	X	
Dressing/bandage set	X	
Ear speculum	X	
Baby feeding bottle	X	
Liquid sampling needle	X	
Medicine cup (breast pump cups)	X	
NaCl bottle	X	
Needle guard/cover	X	
Nipples/dummies	X	
Operating rinsing bowl	X	
Oticurettes	X	
Otoscope tips	X	
Oxygen spectacles	X	
Patient breathing filter	X	

<sup>119</sup> Zhimin Xu, Jiemiao Shen, Lihong Lin, Jieting Chen, Lei Wang, Xingying Deng, Xinyue Wu, Zheng Lin, Yuxue Zhang, Renqiang Yu, Zhihao Xu, Jiexiang Zhang, Yi Zhang, Chao Wang, Exposure to irregular microplastic shed from baby bottles activates the ROS/NLRP3/Caspase-1 signaling pathway, causing intestinal inflammation, *Environment International*, Volume 181, 2023, 108296, ISSN 0160-4120, <https://doi.org/10.1016/j.envint.2023.108296>. (<https://www.sciencedirect.com/science/article/pii/S016041202300569X>)

<sup>120</sup> EFSA (2023). Bisphenol A in food is a health risk. <https://www.efsa.europa.eu/en/news/bisphenol-food-health-risk>

<sup>121</sup> Euractiv. EU countries endorse ban of Bisphenol A in food packaging <https://www.euractiv.com/section/agriculture-food/news/eu-countries-endorse-ban-of-bisphenol-a-in-food-packaging/> (Consulted on 3 August 2024).

<sup>122</sup> Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Text with EEA relevance), ELI: <http://data.europa.eu/eli/dir/2008/98/oj>. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32008L0098>.

Plugs	X	For medical personnel, patient health and safety are paramount, but they also need to consider their own safety. In their daily work, they often handle items, devices, and tools they did not purchase and may not have detailed information about their environmental impact or potential health risks.
Scalpel holder	X	
Sterile isolation gown	X	
Suction catheters	X	
<b>Syringe</b>	<b>X</b>	
<p><b>Summary of Responses:</b></p> <ul style="list-style-type: none"> <li>❖ Total Responses: 21</li> <li>❖ Total Items Identified: 21</li> <li>❖ Relevant Items for Analysis: 19</li> </ul>		Therefore, reviewing the literature and comparing it with the responses provided can offer insights into personnel's understanding of when it is appropriate to reuse a single-use plastic item.

**Syringes** and **feeding bottles** have been identified as single-use plastic items that respondents believe can be reused multiple times.

<p><b>Syringes:</b> most of the literature convenes that syringes in hospitals should be used once to prevent contamination, infections, and guarantee patients' safety. The World Health Organization estimates around 1.3 million people die worldwide every year, due to diseases contracted via the reuse of syringes.<sup>123</sup> Some syringes are conceived to prevent reuse, including features like a permanently attached needle or a plunger that locks after use (The K1 auto-disable syringe). In such cases, while reusing syringes may increase costs for hospitals due to additional cleaning and sterilization processes, it is generally considered more cost-effective than dealing with the long-term healthcare expenses associated with treating diseases that could result from improper syringe use. Reusable syringes of various sizes have been developed to safely deliver enteral feeds, medicines, and flushes to neonatal, pediatric, and adult patients at home, and they are also used in hospitals.</p> <p>Although some respondents believe syringes can be reused, the literature does not support this practice due to health security concerns. This belief among</p>	<p><b>Feeding bottles:</b> Limited literature addresses the environmental impact of baby feeding bottles in hospitals, but existing studies highlight health risks to babies from plastics and chemicals used in these bottles, as well as microplastics that may be ingested. One study indicates that baby bottles can be cleaned and sterilized in hospitals, but these processes must be meticulously performed. Poor hygiene and inadequate cleaning methods can lead to increased infant morbidity and mortality, as infections can be transmitted through improperly sanitized bottles. The study also emphasizes the importance of standard precautions to prevent hospital-acquired infections, such as hand washing or using alcohol rub before and after handling children and preparing food. Additionally, the study suggests that parents should be educated on the risks of disease transmission from contaminated bottles,</p>
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<sup>123</sup> WORLD HEALTH ORGANIZATION (2000). Injection safety. Report by the secretary. [https://apps.who.int/gb/ebwha/pdf\\_files/EB107/ee23.pdf](https://apps.who.int/gb/ebwha/pdf_files/EB107/ee23.pdf)

<p>respondents may indicate that syringe reuse occurs in less risky procedures, despite not being explicitly permitted by current regulations. A 2017 survey of medical personnel in the United States found that 12% of physicians and 3% of nurses reported syringe reuse in their workplaces<sup>124</sup>.</p> <p>Given the challenges associated with reusing syringes, medical personnel should carefully consider strategies to minimize their use, so to reduce SUP waste.</p>	<p>however, hospitals should implement clear policies and procedures for bottle feeding.<sup>125</sup></p>
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**Prevalence in Hospital Departments:**

<p><b>Question:</b> <i>"Are there specific areas or departments within the hospital where the use of 'single use' plastic products for medical use is more prevalent? Please specify."</i></p>	<p>The question received 22 answers, identifying 5 relevant departments. The <b>operating area</b> was identified as the department that, as per the respondents, single use plastic items are used the most. This was followed by the <b>intensive care units</b> and <b>emergency departments</b>.</p>
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Items	Number of responses	Summary of Responses:
Operating area/block/room/theatre	15	<ul style="list-style-type: none"> <li>❖ Total Responses: 22</li> <li>❖ Total departments Identified: 5</li> <li>❖ Relevant departments for Analysis: 5</li> </ul>
Intensive care units (ICU)	3	
Emergency Department	2	
Infectious diseases department	1	
Neonatology	1	

*Analysis and literature comparison*

Nearly 70% of respondents agreed that the **operating room** is the hospital department that uses the most single-use plastics. In sterile environments such as ORs and ICUs, maintaining strict hygiene is essential, and single-use items ensure that each patient receives uncontaminated, sterile equipment. These departments often function under high-pressure and time-sensitive conditions, and single-use plastics eliminate the need for time-consuming sterilization processes, ensuring that necessary supplies

<sup>124</sup> Rachel A. Kossover-Smith, Katelyn Coutts, Kelly M. Hatfield, Ronda Cochran, Hana Akselrod, Melissa K. Schaefer, Joseph F. Perz, Katherine Bruss, One needle, one syringe, only one time? A survey of physician and nurse knowledge, attitudes, and practices around injection safety, American Journal of Infection Control, Volume 45, Issue 9, 2017, Pages 1018-1023, ISSN 0196-6553, <https://doi.org/10.1016/j.ajic.2017.04.292>. (<https://www.sciencedirect.com/science/article/pii/S0196655317306806>)

<sup>125</sup> Mohamed, Huda and Tarhuni, Abdelmetab and Abbeid, Hager and Abdulati, Aiyor and Adel, Aisha and Saleh, Fatima and Abdullah, Wafa (2023) Microbial Contamination of Infant Feeding Bottles and Caregiver Compliance to Disinfection and Sterilization Techniques, Pediatric Hospital, Libya. International Journal of Pathogen Research, 12 (6). pp. 110-119. ISSN 2582-3876, Official URL: <https://doi.org/10.9734/ijpr/2023/v12i6259>. <http://publish.sub7journal.com/id/eprint/1907/>.

are always readily available. A recent study on waste management in Belgian operating rooms reveals that the operating theatre has a significantly larger carbon footprint compared to other hospital areas, primarily due to waste generation. It accounts for 40% of the total greenhouse gas emissions in healthcare, contributing 5.5% to Belgium's national emissions, higher than the global average of 4.4%.<sup>126</sup> As the core of a healthcare facility, reducing SUP in ORs could set an example and encourage other departments to engage in sustainable practices.

### Measures to Reduce Single-Use Plastics:

<p><b>Question: "What measures, if any, has your hospital implemented to reduce the consumption of single-use plastics for medical use in its facilities/your department?"</b></p>	<p>The question received 22 responses among which 2 were not relevant as mentioned items and departments out of the scope of the study. Three answered that there are either 'no measures adopted' or 'not many'.</p> <p>The measures more commonly identified were <b>recycling, waste sorting and presence of waste bins</b>. One answer explicitly mentioned the type of plastics part of the measures, Polyvinyl chloride (PVC).</p> <p><b>Summary of Responses:</b></p> <ul style="list-style-type: none"> <li>❖ Total Responses: 22</li> <li>❖ Total relevant responses: 17</li> <li>❖ Total relevant <b>measures</b> Identified: 19</li> </ul>
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### Analysis and literature comparison

Measures/strategies	
Recycling/waste recycling	<p>Most of the measures listed by respondents, based on their personal experience, focus on addressing single-use plastics at the end of their lifecycle, particularly in disposal and sorting. Recycling measures appears to be the most common measure adopted.</p> <p>Clinical waste that enters in contact with body fluids and blood is the most common waste in hospitals. However,</p>
Sorting of waste/sorting of staff waste	
Waste bins for sorting	
Bottle-feeding, asking parents to take their bottles home	
Disposable plastic laryngoscope blade replaced by sterilisable metal blades.	
Eco-responsible company	
Launch of a CSR programme	
Metal flask put on list of equipment to be brought in by parents to reduce plastic bottles	
More environmental criteria at the time of purchase	
PMC bags	

<sup>126</sup> N. Magasich-Airola1 , Q. Souberbielle1 , L. L'Hotel2 , M. Momeni1 , R. Tircoveanu1 (2024). Waste management in Belgian operating rooms: A narrative review. Acta Anaesth. Bel., 75 (2): 149-154, <https://doi.org/10.56126/75.2.47> . <http://www.actaanaesthesiologica.be/assets/302/ActaAnaesthBelg-75-149.pdf> .

PMC sorting	<p>this waste requires expensive treatment and disposal, when the regulations allow the hospital to recycle it.<sup>127</sup></p> <p><b>Scientists estimate that only 9% of all global plastic waste has been recycled</b>, and most of plastic waste (79%) ends up in landfill or in the nature<sup>128</sup>. Additionally, the quality of recycled plastic diminishes due to entropy and the mixing of other materials during the recycling process. As a result, some plastics can only be recycled once or twice before they ultimately need to be incinerated<sup>129</sup>.</p>
<b>PVC recycling programme</b>	
Search for alternatives	
Selective sorting of plastics and paper in the operating room.	
Separate bins for infusion sets	
Setting up of an environmental officer in each unit	
Sterilisable metal equipment for fitting central catheters	
Study on the reintroduction of sterilisable equipment	
Washing bottles and breast pump sets	

The design of a plastic product highly interferes with the material closed-loop recycling preventing higher recycling quality, in fact upstream approaches, such as ‘design for recycling’ should be preferred to reduce the plastic impact throughout its life-cycle.<sup>130</sup> Moreover, the elimination of hazardous medical waste in Europe has to be done mostly by incineration, which is up to ten times more expensive than the incineration of non-dangerous medical waste.<sup>131</sup> Consequently, disposal and recycling are considered the last resort in the waste hierarchy.<sup>132</sup> Collection and sorting are the second mentioned measure by respondents, and it is indeed a crucial step in waste management. The third measure mentioned, waste bins for sorting, is the inevitable enabler to implement the first two measures. The other measures identified may fall under the following categorizations:

- **Pre-requirements:** Awareness raising and trainings of hospitals and their personnel, such as Corporate Sustainability and Responsibility (CSR), and the certifications to assess a company ‘Eco-responsible’, these can be considered a part of the ‘pre-requirements’ needed to effectively manage SUP and general waste in hospitals.
- **Research:** the need to find viable alternatives that can meaningfully replace medical single use plastics without having other negative externalities on the environment.

<sup>127</sup>ECHAlliance. Hospitals produce tonnes of plastic waste annually – How can they reduce this?

<https://echalliance.com/news/hospitals-produce-tonnes-of-plastic-waste-annually-how-can-they-reduce-this/> (Consulted on 5 August 2024)

<sup>128</sup> UNDP (2023). How much plastic is recycled today? <https://stories.undp.org/why-arent-we-recycling-more-plastic#:~:text=Scientists%20estimate%20that%20only%20around.Some%2012%20percent%20is%20incinerated.>

<sup>129</sup> *ibid.*

<sup>130</sup> Alassali, Ayah, Caterina Picuno, Zhi Kai Chong, Jinyang Guo, Roman Maletz, and Kerstin Kuchta. 2021. "Towards Higher Quality of Recycled Plastics: Limitations from the Material's Perspective" *Sustainability* 13, no. 23: 13266.

<https://doi.org/10.3390/su132313266> . <https://www.mdpi.com/2071-1050/13/23/13266#B5-sustainability-13-13266>

<sup>131</sup> Liesbet Demarré & Co. (2023). REDUCING SINGLE-USE MATERIALS IN MEDICINE AND HEALTHCARE An exploratory study on sustainability of commonly used materials in hospitals.

[https://www.health.belgium.be/sites/default/files/uploads/fields/fpshealth\\_theme\\_file/reducing\\_sup\\_in\\_medicine\\_and\\_healthcare.pdf](https://www.health.belgium.be/sites/default/files/uploads/fields/fpshealth_theme_file/reducing_sup_in_medicine_and_healthcare.pdf)

<sup>132</sup> Healthcare without Harm Europe (2021). *Measuring and reducing plastics in the healthcare sector*. [https://noharm-europe.org/sites/default/files/documents-files/6886/2021-09-23\\_Measuring-and-reducing-plastics-in-the-healthcare-sector.pdf](https://noharm-europe.org/sites/default/files/documents-files/6886/2021-09-23_Measuring-and-reducing-plastics-in-the-healthcare-sector.pdf)

- **Structural/institutional:** ensuring a sustainability department or ‘**an environmental officer in each unit**’, to explore the right balance between environmental and health concerns.
- **Procurement:** Some of the measures, highlight the role of a **responsible procurement department**, suggesting ‘more environmental criteria at the time of purchase’. This aspect will be elaborated more in the following sections.
- **Replace:** Single use plastic products replaced with alternatives such as the non disposable plastic laryngoscope blade replaced by sterilisable metal blades (alternatives are discussed in the following sections).
- **Reuse:** ensuring some plastic products can be reused where possible, for example through the ‘**reintroduction of sterilisable equipment**’.

To effectively reduce single-use plastics, a comprehensive approach that incorporates all the discussed measures and strategies is essential. Some research suggests that adding '**Rethink**' and '**Research**' concepts to the waste hierarchy or 'green' practices could transform the healthcare sector and enhance its sustainability.<sup>133</sup> Moreover, a life-cycle approach should be considered to understand and measure all potential impacts on the environment and human health associated with the SUP, starting from the extraction and transportation, production, use, reuse, potential alternatives of medical SUP, including the end-of-life strategies (collection, sorting, recycling and disposal/incineration).<sup>134</sup>

### Viable Alternatives:

<p><b>Two Questions:</b> <i>"Do you believe there are viable alternatives to plastic products for medical use in your daily tasks?" and "If yes, please provide examples of the viable alternatives to plastic products for medical use in your daily tasks."</i></p>	<p>Out of the 23 answers received, <b>18 (78%) of respondents believe there are viable alternatives to plastic products for medical use</b>, as per their daily professional experience. Four respondents consider they do not know, and one belief that there are none.</p>											
	<table border="1"> <thead> <tr> <th>Response</th> <th>Number of Responses</th> </tr> </thead> <tbody> <tr> <td>Yes</td> <td>18</td> </tr> <tr> <td>No</td> <td>1</td> </tr> <tr> <td>I do not know</td> <td>4</td> </tr> <tr> <td><b>Total</b></td> <td><b>23</b></td> </tr> </tbody> </table>	Response	Number of Responses	Yes	18	No	1	I do not know	4	<b>Total</b>	<b>23</b>	
Response	Number of Responses											
Yes	18											
No	1											
I do not know	4											
<b>Total</b>	<b>23</b>											

<p><b>Potential Alternatives</b></p>	<p>On the second question, requesting to provide concrete examples of viable alternatives, respondents</p>
<p>Glass feeding bottles/Empty non-plastic feeding bottles/Sterile feeding bottle</p>	
<p><b>Sterilisable mask</b></p>	

<sup>133</sup> Kampman JM, Sperna Weiland NH. Anaesthesia and environment: impact of a green anaesthesia on economics. Curr Opin Anaesthesiol. 2023 Apr 1;36(2):188-195. doi: 10.1097/ACO.0000000000001243. Epub 2023 Jan 23. PMID: 36700462; PMCID: PMC9973446. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9973446/>.

<sup>134</sup> UNEP. Plastic – not so fantastic. <https://shorturl.at/5e9J8>

<b>Aprons/cloth isolation gown</b>	<p>identified <b>15 items as possible viable alternatives.</b></p> <p>Among the relevant items, non-plastic, glass and sterile feeding bottles were the most mentioned by respondents. This result may be due to the concentration of respondents in departments where baby feeding bottles are used the most (Neonatology, Maternity).</p> <p><b>Summary of Responses:</b></p> <ul style="list-style-type: none"> <li>❖ Total Responses: 23</li> <li>❖ Total relevant responses: 16</li> <li>❖ Total items Identified: 20</li> <li>❖ Total relevant single items: 15</li> </ul>
<b>Laryngoscope blades</b>	
Autoclavable metal instruments	
Sterilisable speculum	
Metal speculum to be sterilised at the CSSD	
Cloth drapes	
Sterile tray (kidney tray)	
Sterile instruments	
Non plastic needle boxes	
Metal otoscope tips	
Metal forceps	
Reusable laryngoscope	
Reusable masks	
The question received 23 answers of which 2 answers were not relevant, 2 did not provide an answer, 2 explicitly answered that there is no alternative, and 1 replied that did not know. Three of the items mentioned were considered not relevant (Cardboard straws, wooden spoons, cups).	

### *Analysis and literature comparison*

There is **insufficient scientific literature** to determine if glass or other materials are better **alternatives to plastic baby bottles**. In neonatal intensive care, baby bottles are essential for premature infants who need to start feeding due to their immaturity.<sup>135</sup> Mothers often use plastic bottles to express breast milk, but these bottles are typically single-use due to high contamination risks during use and feeding. Given that newborns feed every 2 to 3 hours in their first few months, this results in substantial plastic waste.

While some articles discuss the pros and cons of glass and other alternatives, glass bottles reduce the risk of chemical leaching compared to plastic but can be dangerous if broken and are generally not used in hospitals due to their weight and safety concerns. Stainless steel bottles are another option but are heavy and costly, while silicone bottles have limited research regarding their safety for infants.<sup>136</sup>

The comparison between plastic and glass water bottles has been extensively analysed and may provide valuable insights into the potential use of glass baby bottles. Polyvinyl chloride (PVC) is the most used plastics in Europe in healthcare settings (i.e., IV bags, tubing, examination gloves, catheters) but it also poses high risks to health and the environment throughout its life-cycle due to the use of toxic substances during its production. There are several innovative alternatives to traditional plastic products, including PVC; however, a thorough analysis is needed to determine their environmental and health impacts. This assessment is crucial for deciding whether these alternatives are preferable to plastics, especially when considering replacements for single-use medical items in complex hospital settings. In Latin America,

<sup>135</sup> Hill RR, Park J, Pados BF. Bottle-Feeding Challenges in Preterm-Born Infants in the First 7 Months of Life. *Glob Pediatr Health*. 2020 Sep 4;7:2333794X20952688. doi: 10.1177/2333794X20952688. PMID: 32953946; PMCID: PMC7479869. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7479869/>

<sup>136</sup> Glass vs. plastic baby bottles. [https://europe.noharm.org/sites/default/files/documents-files/7382/2023-05-Towards-PVC-free-healthcare\\_0.pdf](https://europe.noharm.org/sites/default/files/documents-files/7382/2023-05-Towards-PVC-free-healthcare_0.pdf). (Consulted on 4 August 2024).

**the Hospital Universitario Fundación Valle de Lili replaced disposable PVC face masks with 100% silicone-based alternatives, that can be reused 100 times<sup>137</sup>.** As per the literature, there is no guarantee that a bioplastic is biosourced or biodegradable. This is due to the lack of standards defining the amount of biobased material required in a product.<sup>138</sup> Life Cycle Assessment (LCA) of alternative feedstocks for plastics would help understand the advantages and disadvantages of each material or product, evaluating the effects that they have on the environment over the entire period of its life. The analysis of the following items in the respondents list was found in the literature:

<p><b>A. Isolation gown<sup>139</sup></b></p> <p>A review of six life cycle studies on reusable and <b>single-use perioperative textiles, such as surgical gowns and drapes, found that reusable textiles offer significant sustainability benefits.</b> They reduce natural resource energy use by 200-300%, water footprint by 250-330%, carbon footprint by 200-300%, volatile organic compounds and solid waste by 750%, and improve instrument recovery. <b>Recent studies have confirmed that reusable gowns are more environmentally friendly and have less impact than single-use gowns.</b> The environmental benefits of producing fewer gowns outweigh the additional impact of the laundry process.</p>	<p><b>B. Laryngoscope blades<sup>140</sup></b></p> <p>A review of two LCAs comparing single-use and reusable laryngoscopes revealed differing results. The first study, which included an LCA and Lifecycle Costing Assessment (LCC), found that reusable laryngoscopes produce fewer emissions and are cheaper. The second study indicated that switching to single-use laryngoscope blades would reduce emissions. Further analysis showed this discrepancy was due to the energy mix differences: the second study was conducted in coal-dependent Australia, while the first was in Europe and the US, where energy is primarily from renewables and natural gas, respectively. Switching to reusable equipment reduced CO2 emissions by 84% in the UK/Europe and by 48% in the USA.</p>
<p><b>C. Facial mask<sup>141</sup></b></p> <p>A life cycle assessment (LCA) study compared single-use surgical face masks with reusable face masks featuring an embedded filtration layer (EFL). It examined various environmental impacts and waste generation from production to disposal in Singapore. A University College London (UCL) study found that environmental impact varies based on the type of reusable mask. Reusable cloth masks without filters were the most</p>	

<sup>137</sup> *Ibid.*

<sup>138</sup> Bruxelles environnement. « BIOPLASTIQUES » Plastiques biosourcés, biodégradables ou compostables Une alternative (in)soutenable ? [https://document.environnement.brussels/opac\\_css/elecfile/BIOPLASTIQUESNOT\\_20200929\\_FR.pdf](https://document.environnement.brussels/opac_css/elecfile/BIOPLASTIQUESNOT_20200929_FR.pdf)

<sup>139</sup> Liesbet Demarré & Co. (2023). REDUCING SINGLE-USE MATERIALS IN MEDICINE AND HEALTHCARE. An exploratory study on sustainability of commonly used materials in hospitals. [https://www.health.belgium.be/sites/default/files/uploads/fields/fpshealth\\_theme\\_file/reducing\\_sup\\_in\\_medicine\\_and\\_healthcare.pdf](https://www.health.belgium.be/sites/default/files/uploads/fields/fpshealth_theme_file/reducing_sup_in_medicine_and_healthcare.pdf) (35-37)

<sup>140</sup> Liesbet Demarré & Co. (2023). REDUCING SINGLE-USE MATERIALS IN MEDICINE AND HEALTHCARE. An exploratory study on sustainability of commonly used materials in hospitals. [https://www.health.belgium.be/sites/default/files/uploads/fields/fpshealth\\_theme\\_file/reducing\\_sup\\_in\\_medicine\\_and\\_healthcare.pdf](https://www.health.belgium.be/sites/default/files/uploads/fields/fpshealth_theme_file/reducing_sup_in_medicine_and_healthcare.pdf) (19-20)

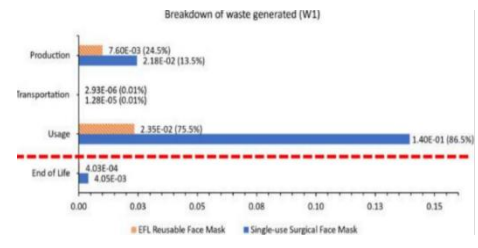
<sup>141</sup> Lee AWL, Neo ERK, Khoo ZY, Yeo Z, Tan YS, Chng S, Yan W, Lok BK, Low JSC. Life cycle assessment of single-use surgical and embedded filtration layer (EFL) reusable face mask. *Resour Conserv Recycl.* 2021 Jul;170:105580. doi: 10.1016/j.resconrec.2021.105580. Epub 2021 Mar 31. PMID: 33814723; PMCID: PMC8009732. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8009732/>

environmentally friendly, while those with filters were the least. This highlights the need to evaluate each type of reusable mask individually rather than assuming all are better than single-use masks.

The LCA results indicated that **EFL reusable masks generate 30% less waste and have lower environmental impacts** than single-use masks in most categories, except for **Freshwater eutrophication (FE), Marine eutrophication (ME), Water depletion (WD), and Human toxicity (HT)**. Emissions mainly occur during raw material acquisition, except for WD in EFL masks and FE in single-use masks. Including incineration in the LCA end-of-life stage results in net positive FE for single-use masks. The usage stage contributes most to cumulative waste in **Waste Generated (W1)** analysis.

Three scenarios analyzed different usage habits and waste management practices. Across all scenarios, EFL reusable masks remained greener, with lower **Climate change (CC)** and W1 values than single-use masks.

Overall, the study quantified the environmental impact of single-use and EFL reusable masks, finding that EFL reusable masks had lower emissions in most impact categories.



### Challenges in Adopting Alternatives:

**Question:** *"If yes, what challenges, if any, do you face in adopting these alternatives?" please select the top three among Cost, Availability, Quality, Training, Patient concern, Other.*

This question received 22 responses. The top three challenges identified were 1. Cost (16 choices), 2. Patient concern (7 choices), 3. Availability (6 choices).

Key Challenges (Multiple choice answer - top three challenges)	Number of choices
Cost	16
Patient concern/safety	7
Availability	6
Quality	3
Training	0
Other	9

Among 'other'
Re-sterilisable disposables are no longer sold. (Only disposables are available on the market).
<b>Sterilisation time</b>
<b>Patient comfort</b>
<b>Increased workload for steriliser</b>
<b>Cleaning</b>
<b>Shortage of staff in sterilisation unit</b>
<b>Staff safety</b>

### Analysis and literature comparison

The survey identified **cost** and **concerns over patient safety** as major challenges preventing hospitals from adopting alternatives to medical single-use plastics (SUP). However, literature presents mixed findings depending on the specific products being substituted. For example, as noted earlier, some reusable isolation gowns may have less environmental impact compared to disposable plastic ones. Additionally, some studies suggest that substituting some disposable gowns with reusable alternatives

can lead to a 30% reduction in costs in certain cases.<sup>142</sup> Another challenge highlighted in the literature, particularly regarding reusable gowns, is the necessity to account for the blue water used for washing and sterilizing the gowns after each use. However, a cradle-to-end-of-life evaluation of reusable and disposable isolation gowns revealed a 41% reduction in blue water consumption for reusable gowns.<sup>143</sup>

A 2022 study<sup>144</sup> conducted in Belgium evaluated the costs of various single-use items in hospitals. The findings indicated that, among the assessed medical single-use plastic items also identified by respondents, **reusable kidney trays** (Stainless steel / inox) are generally more expensive than their single-use counterparts. This cost disparity is primarily attributed to the expenses involved in disinfecting the reusable trays, to reduce concerns over patients' safety. The same research compared reusable and disposable (polystyrene) **vaginal specula** reveals that their costs can be similar, with the overall cost-effectiveness of each type depending largely on the competitive pricing of single-use specula. Disposable specula have a lower upfront cost per unit but can accumulate significant costs over time, especially in high-volume settings. In contrast, reusable specula, though initially more expensive, may be more cost-effective in the long term if the costs of sterilization and maintenance are efficiently managed.

Hospitals have increasingly adopted disposable items due to the belief that they are logistically simpler, being faster to purchase, use, and discard. Disposables are often perceived as more cost-effective compared to reusables. However, when evaluating the total cost of ownership, reusables often prove to be more economical over time than single-use items. A comprehensive cost comparison should include waste disposal fees, cleaning expenses, and the cost per use, rather than just the initial purchase price.

In fact, the authors acknowledge their conclusions lack strong evidence due to insufficient data on labor and time costs for re-sterilizing reusable items. In all cases, both **single-use and reusable devices are considered equally safe**.

The third challenge identified was **availability**. This issue can be understood in two ways: first, respondents might believe the alternative exists but is not available in the hospital; second, the alternative exists and is present in the hospital but there is not enough stock. Following the study on the **single-use kidney tray versus the reusable one**, there are pro and cons in both cases: the process of acquiring single-use kidney trays involves several administrative steps: ordering, receiving the order,

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<sup>142</sup> Amy B. Kressel, Jennie L. McVey, Joan M. Miller, Lauren L. Fish, Hospitals learn their collective power: An isolation gown success story, *American Journal of Infection Control*, Volume 39, Issue 1, 2011, Pages 76-78, ISSN 0196-6553, <https://doi.org/10.1016/j.ajic.2010.07.016>. (<https://www.sciencedirect.com/science/article/pii/S019665531000948X>)

<sup>143</sup> Eric Vozzola, Michael Overcash, Evan Griffing, Environmental considerations in the selection of isolation gowns: A life cycle assessment of reusable and disposable alternatives, *American Journal of Infection Control*, Volume 46, Issue 8, 2018, Pages 881-886, ISSN 0196-6553, <https://doi.org/10.1016/j.ajic.2018.02.002>. (<https://www.sciencedirect.com/science/article/pii/S0196655318300750>)

<sup>144</sup> Liesbet Demarré & Co. (2023). REDUCING SINGLE-USE MATERIALS IN MEDICINE AND HEALTHCARE. An exploratory study on sustainability of commonly used materials in hospitals. [https://www.health.belgium.be/sites/default/files/uploads/fields/fpshealth\\_theme\\_file/reducing\\_sup\\_in\\_medicine\\_and\\_healthcare.pdf](https://www.health.belgium.be/sites/default/files/uploads/fields/fpshealth_theme_file/reducing_sup_in_medicine_and_healthcare.pdf) (55-55)

transferring items to storage, placing orders for the ward, and finally delivering them. On the other hand, using reusable kidney trays bypasses the need for purchasing and inventory management but still requires adequate storage space. For reusable trays, it is essential to have either adequate disinfectant supplies or an automated washing machine. Five responses highlighted **sterilization** as a major challenge in adopting alternatives, citing issues such as the unavailability of necessary equipment or technology, the time required by personnel for the sterilization process, and insufficient staff to carry out these tasks. This factor is crucial to consider when evaluating whether an alternative to plastic is genuinely more environmentally friendly.

**Awareness of Environmental Impact:**

<p><b>Two Questions: "How aware are you of the environmental impact of single-use plastics for medical use in your work?" and "Do you think the environmental impact of plastics is a concern that should be addressed in hospital practices?"</b></p>	<p>Medical personnel that replied to the survey (23 answers) considered themselves either ‘very aware’ (12 answers) or ‘extremely aware’ (11 answers) about the environmental impact of single use plastics for medical use.</p>
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**Awareness**

Responses	1 Not at all aware	2 Slightly aware	3 Moderately aware	4 Very aware	5 Extremely aware
#	0	0	0	12	11

Answer	Number of answers
Yes	21
No	0
I do not know	2
<b>Total</b>	<b>23</b>

- ❖ Out of 23 responses, 21 expressed concerns about the environmental impact of plastics in hospital practices, believing it should be addressed in hospital practices.
- ❖ Two respondents indicated they were unsure.

Overall medical personnel are aware about the environmental impact of SUP, suggesting they may also be aware of the role they can play towards a more sustainable healthcare sector.

**Section IV. Policies and training**

**Training and Education:**

<p><b>Question: "Please mention any training or education that you have received as part of your work on the environmental impact of single-use medical plastics and the potential health risks associated with prolonged exposure to certain plastic materials."</b></p>	<p><b>Summary of Responses</b></p> <ul style="list-style-type: none"> <li>❖ Total Responses: 22</li> <li>❖ Total relevant responses: 21</li> <li>❖ Total respondents that have received a training/education: 11</li> <li>❖ Total respondents that <b>have not</b> received a training/education: 10</li> </ul> <table border="1" data-bbox="957 1937 1340 2024"> <thead> <tr> <th data-bbox="963 1946 1120 2002">Answer</th> <th data-bbox="1126 1946 1334 2002">Number of replies</th> </tr> </thead> <tbody> <tr> <td data-bbox="963 2011 1120 2024">Non</td> <td data-bbox="1126 2011 1334 2024">10</td> </tr> </tbody> </table>	Answer	Number of replies	Non	10
Answer	Number of replies				
Non	10				

	Yes	11
	No answer	1
	<b>Total</b>	<b>22</b>

Type of training/education received
Corporate Sustainability and Responsibility (CSR) seminars
Environmental medicine (5-day training courses offered by the ssmg).
Explanations received on the fact of using syringes of a suitable size and not larger than necessary.
HCWM training
Participate in the eco-responsible working group
Sorting training
Training in environmental health offered by Chirec and given by the SSMG 's environment unit (4 afternoons).
Training on endocrine disruptors by the SSMG
Training on endocrine disruptors in the hospital environment
Training on PVC recycling
Waste bin sorting explanation
Waste management training

Respondents mentioned 12 trainings/education they have received as part of their work on environmental or health impact of plastics. Among the training listed, 3 were identified as 'explanation' or 'participation to a working group'. The official trainings listed are 8.

Assessing the effectiveness of training programmes is not possible through the literature review as information such as the real application in personnel daily work and actual content and quality of the trainings may not be verified. From the list provided by respondents there are no targeted trainings specifically on the issue of single-use plastics for medical use. However, this does not exclude it may be part of a more comprehensive sustainability, health or environmental training.

### Hospital Guidelines and Policies:

#### Three Questions:

- ***"Are there any specific guidelines or policies in place at your hospital regarding the responsible use of single-use plastic products for medical use?"***

- Out of 22 answers, 7 respondents affirmed there are policies or guidelines on the responsible use of single-use plastic products for medical use.

Answer	Number of answers
No	9
Yes	7
I do not know	6
<b>Total</b>	<b>22</b>

- **"How often do you see discrepancies between hospital guidelines/policies regarding the responsible use of single-use medical plastic products and your daily practices that have the potential to be equally/more environmentally sustainable/viable?"**

1	2	3	4	5
Never	Rarely	Sometimes	Often	Very often
8	1	9	4	1

The survey asked participants how frequently they encounter discrepancies, if any, between existing policies/guidelines and their daily practices.

Out of 23 responses, 12 indicated they 'never' or 'rarely' notice inconsistencies between their practices and hospital policies. However, 14 reported observing discrepancies sometimes, often, or very often.

- **“If you find any discrepancies between hospital policy and practice in this regard, could you please provide an example?”**

Participants that affirmed to encounter some discrepancies were requested to provide concrete examples. Out of 23 answers, 13 provided an example, one person does not know, 3 did not provide an answer, and 6 re-affirmed they do not see discrepancies.

Answer	Number of answers
No answer	3
No	6
Answered (see details)	13
I do not know	1
<b>Total</b>	<b>23</b>

**The following discrepancies were identified:**

- The hospital's policy is one of disposability. In practice, it is all disposable.
- The hospital's CSR policy, developed less than 2 years ago, is not yet firmly established in every department.
- Sorting came very late.
- The request to use more sterilisable equipment and the introduction of single-use equipment through the provision of medical machines.
- Storing milk bottles in the fridge for 24 hours.
- The bordeaux gowns we wear have also been allocated to the PMA lab, but their gowns have to be wrapped in plastic when they come out of the laundry, ours do not. As they have the same colour, they are ALL wrapped in plastic, even ours! Why not give them another colour that is not yet available in the hospital?
- Policies were recently introduced, so there is not much work yet, and the sorting is not done.

### *Analysis and literature comparison*

Single-use plastics, in particular, have been recognized as obstacles to achieving climate goals.<sup>145</sup> The European Union has responded with the single-use plastics directive, targeting sea pollution caused by SUP (accounting for more than 80% of the total sea pollution). However, this directive primarily addresses single-use plastic items commonly found on European shores and in oceans, and exempts SUP for medical use.

The Brussels-Capital Region has set out to reduce direct GHG emissions by at least 90% by 2050 compared to 2005 levels (40% by 2030 and 67% by 2040).<sup>146</sup>

Every hospital in Brussels have publicly available their sustainability policies, however most are broad and finding internal guidelines on the use sustainable use and disposal of medical and non medical items is not straightforward. An example from the Saint-Luc hospital provides the hospital sustainability ambition, carbon footprint, their major actions and plans.<sup>147</sup>

<sup>145</sup> European Environment Agency (2021). Plastics, a growing environmental and climate concern: how can Europe revert that trend? (Consulted on 4 August 2024) <https://www.eea.europa.eu/highlights/plastics-environmental-concern>

<sup>146</sup> Belgium's Roadmap for the Net-Zero Government Initiative. <https://www.sustainability.gov/pdfs/belgium-nzgi-roadmap.pdf>

<sup>147</sup> Know Saint-Luc. <https://www.saintluc.be/fr/developpement-durable> (consulted on 20 July 2024).

### Criticisms of Procurement Practices:

<p><b>Question: "Are you aware of any criticisms related to the way plastic products are procured/bought that you can share? Please specify."</b></p>	6 respondents affirmed they are aware of some criticisms related to the purchase of plastics products.	
	Answer	Number of answers
	No	15
	No answer	1
	Yes	6
<b>Total</b>	<b>22</b>	

Among the criticisms respondents cited:

<ul style="list-style-type: none"> <li>• Aside from a few colleagues questioning whether we could revert to using sterilizable instead of disposable gowns, there was minimal criticism or debate. <b>The primary concern for caregivers remains the issue of healthcare funding.</b></li> <li>• Products out of stock.</li> <li>• Budget and ease of use are always at the top of the agenda for procurement.</li> <li>• They are expensive.</li> <li>• Cost.</li> <li>• We regularly ask for more sustainable investment, but our demands are not being met.</li> </ul>
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### Influence of Sustainable Practices on Procurement:

<p><b>Question: "How can the practices that have the potential to be more environmentally sustainable/viable influence the procurement and use of plastic products in the hospital?"</b></p>	<p>Out of 23 responses, 7 provided detailed replies. Most acknowledged the limited influence of personnel practices, attributing this to a lack of political support and minimal involvement of staff in decision-making processes. Two responses pointed out the high cost of alternative products or practices (such as sterilization) as likely considerations for procurement departments when purchasing plastic items. Another response emphasized that factors like cost and hospital hygiene should be prioritized over environmental sustainability.</p>
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#### Potential Influence

Not enough influence because of not enough political support

- Influence may come through contracts environmental clauses
- Personnel do not feel/take part on the decisions of products
- Some alternatives may be more expensive but certain practices make it possible to reduce costs by reusing certain products.

- I do not think it is a very important criterion when compared with price, hospital hygiene problems, etc.
- The only concern is cost and sterilisation is expensive for the manager.
- Waste sorting, fewer infusions and more oral treatments.

***Analysis ad literature comparison***

Literature indicates that procurement departments are increasingly expected to consider environmental criteria. However, challenges such as financial constraints, lack of knowledge, and low motivation impede public procurers, raising questions about the actual practice of sustainable procurement (SP). Existing research often focuses on the environmental aspects of SP and relies on interviews or surveys, which can be biased and have low response rates. As a result, there is limited insight into the practical implementation and frequency of SP, with cost still being a major deciding factor.

To evaluate the climate impact of procurement choices, the Belgian government funded research<sup>148</sup> on the environmental sustainability of common hospital materials. This study compared five single-use medical items (kidney trays, blankets, vessel sealing devices, thermometer covers, and vaginal specula) with their reusable alternatives, assessing them on environmental sustainability, safety, costs, and efficiency. The sustainability analysis covered raw materials, manufacturing, transport, (re)use, end-of-life waste, and carbon footprint. The study concluded that reusable items were generally more sustainable, though evidence was limited in some cases. The report provides recommendations for hospitals, companies, and regulatory bodies, including: 1. Integrating validated sustainability criteria into procurement processes., 2. Balancing sustainability with costs and logistics in procurement decisions, 3. Informing suppliers that sustainability will be a key factor in procurement.

**Section V. Success stories and additional comments**

**Success Stories and Initiatives:**

<p><b>Question: "Are there any success stories or initiatives within your hospital that you are aware of, where efforts have been made to reduce the reliance on plastic products? Please describe briefly."</b></p>	<p>Out of the 22 replies, 10 respondents reported an example of a success story or initiative to reduce the reliance on plastic products. Some of the answers were not specific to single use plastic for medical use, probably because the question did not explicitly mention it, despite the focus of the survey was clarified in the introduction and through the survey. Six of the answers were specific to medical single use plastic or general enough to include these products.</p>
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<sup>148</sup> University of Ghent & FPS (2023). Reducing Single-Use Materials In Medicine And Healthcare. An exploratory study on sustainability of commonly used materials in hospitals (online). Available at: [https://www.health.belgium.be/sites/default/files/uploads/fields/fpshealth\\_theme\\_file/reducing\\_sup\\_in\\_medicine\\_and\\_healthcare.pdf](https://www.health.belgium.be/sites/default/files/uploads/fields/fpshealth_theme_file/reducing_sup_in_medicine_and_healthcare.pdf)

Answer	Number of answers	Relevant success stories or initiatives
Yes	10	<ul style="list-style-type: none"> <li>• Obtaining the Ecolabel</li> <li>• The hospital is currently involved in a global approach to environmental health.</li> <li>• A working group on the subject has been set up, but not very active.</li> <li>• Disinfection of plastic ear specula.</li> <li>• PVC recycling.</li> <li>• Eco responsible label / sorting.</li> </ul>
No	7	
No answer	2	
I do not know	3	
<b>Total</b>	<b>22</b>	

The literature, there are some recent successful cases that could provide valuable lessons for Brussels hospitals. In Norway, for example, Norwegian Healthcare aims to eliminate harmful substances from 75% of hospital products by 2030. The Hospital Procurement Trust is crucial in this effort, managing hospital supplies. A 2021 survey found 25% of surveyed products contained PVC, with some suppliers unable to confirm. Many tenders now require PVC-free items, and major suppliers are increasingly offering these. Some PVC-free products have faced higher costs or quality issues, but most meet expectations, and some have earned the Nordic Swan label for being free of harmful substances.<sup>149</sup>

#### Additional Comments and Suggestions:

<p><b>Question:</b> <i>"Do you have any additional comments or suggestions regarding the reduction of single-use plastic for medical purposes in your hospital?"</i></p>	<p>Among the additional comments, respondents reiterated some criticism or concern, and provided some recommendations:</p> <ul style="list-style-type: none"> <li>• Make single-use products more expensive by imposing a pollution tax to encourage the purchase of reusable products. At the same time, reduce the cost of sterilisation products and train logistics assistants in sterilisation so that it is no longer carried out by nurses (who are more expensive) and who are sorely needed elsewhere.</li> <li>• Need to use sterilisable fabric products.</li> <li>• Personnel cannot choose the products they will use.</li> <li>• Everything is to be done.</li> </ul>
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## 5. Discussion and Recommendations

Due to the limited number of responses (24), the data cannot be used for statistical analysis or general conclusions. However, the responses provide valuable insights for a qualitative analysis, which was the intended purpose of this survey. The low rate of responses confirms some of the risks identified in the methodology section pertaining to the limited time of medical personnel to undertake individual surveys outside of hospital's initiatives.

The demographic section of the survey reveals key patterns consistent with existing data and literature. A notable 67% of respondents are female, aligning with the World Health Organization's finding that

<sup>149</sup> HCWH 52023). Towards Pvc-Free Healthcare Reducing the Environmental Impact And Exposure To Harmful Chemicals [https://europe.noharm.org/sites/default/files/documents-files/7382/2023-05-Towards-PVC-free-healthcare\\_0.pdf](https://europe.noharm.org/sites/default/files/documents-files/7382/2023-05-Towards-PVC-free-healthcare_0.pdf)

women constitute a significant portion of the global health and social care workforce, a trend mirrored in Belgium. Age-wise, nearly half of the respondents fall within the 35-44 age bracket, suggesting a slightly older demographic compared to national statistics, which indicate younger averages for physicians and older for nurses. Professionally, the survey comprises mainly doctors and nurses, reflecting the national gender distribution where a substantial majority of nurses are women. The predominant years of experience among respondents, with most having over a decade in the field, indicate seasoned professionals who are likely well-acquainted with shifts in hospital practices and product usage. Lastly, representation from nine Brussels hospitals, particularly from major institutions like Saint-Luc University Clinics, confirms the survey's focus on the Brussels-Capital Region, ensuring the survey reached the targeted institutions of this research.

Responses also reveals a high level of awareness among medical personnel regarding the environmental impact of single-use plastics (SUP), with 23 respondents expressing themselves as either 'very aware' (12) or 'extremely aware' (11). This indicates a strong recognition of the environmental issues associated with SUP and suggests that these professionals may be well-positioned to advocate for and implement more sustainable practices within their hospitals. However, the correlation between awareness and actionable change within hospital practices remains uncertain, as heightened awareness does not automatically translate into effective action or policy changes.

In contrast, the feedback on training and education related to the environmental impact of plastics is less encouraging. Out of the same group, only 12 respondents reported receiving relevant training or education. Of these, 3 were involved in informal explanations or working groups, while 8 participated in official training programs. Notably, none of the training sessions were specifically targeted at the issue of single-use plastics in medical settings. This lack of targeted training could limit the effectiveness of current educational efforts, as comprehensive and specific training is crucial for ensuring that staff are not only aware but also knowledgeable about how to mitigate the environmental impact of SUP.

Throughout the literature while awareness is seen a critical first step, there is a need to be complemented by robust and specific training programs to drive meaningful change reducing unintended negative practices. Effective training should include detailed information on the environmental and health impacts of specific plastic materials and practical strategies for reducing SUP use. The absence of targeted training in the responses suggests a potential gap in current educational approaches, which could impede efforts to address the environmental impact of plastics comprehensively. Additionally, without thorough evaluation of training programs—regarding their application in daily work and their content quality—it is challenging to assess their real-world impact. Therefore, enhancing and tailoring training initiatives to focus on single-use plastics and incorporating them into broader sustainability and

health training could improve both awareness and practical implementation of more sustainable practices.

**The analysis underscores the prominent role of single-use plastics (SUP) in hospital environments,** with syringes, feeding bottles, and gloves emerging as the most frequently identified items. Specifically, syringes were mentioned 10 times, gloves 4 times, and feeding bottles 6 times, highlighting their widespread use. This aligns with literature identifying syringes and gloves as critical for infection control, with gloves often cited as essential since the 1980s and extensively used during the COVID-19 pandemic. Notably, the high mention of feeding bottles suggests a significant presence of respondents from neonatal and pediatric units. Despite their frequent use, feeding bottles—primarily made of polypropylene and containing Bisphenol A (BPA)—are less covered in existing environmental research, although BPA's health risks are well-documented. The literature reports that disposable gloves and syringes are among the top contributors to hospital plastic waste, with gloves alone making up 17.51% of annual plastic usage in European hospitals. This finding reinforces the environmental impact of SUPs, which include increased waste and pollution. The survey data highlights areas for further exploration, such as the environmental footprint of specific SUPs and potential improvements in sustainable practices within healthcare settings.

**The survey results provide valuable insights into the potential for reusing single-use plastics (SUP) and their prevalence in hospital settings.** Among the 21 respondents, 19 items were identified as having potential for reuse, with syringes and feeding bottles mentioned most frequently. Syringes were cited by several respondents as potentially reusable, though literature overwhelmingly supports single use to mitigate contamination risks; the World Health Organization reports about 1.3 million annual deaths from diseases linked to reused syringes. Some syringes are specifically designed to prevent reuse, incorporating features such as auto-disable mechanisms, which add to their cost but reduce long-term healthcare expenses from infections. Additionally, while the potential for reusing feeding bottles exists, their environmental and health risks, including BPA and microplastics, are well-documented, requiring meticulous sterilization to avoid infections.

In terms of departmental usage, the survey highlighted that the operating room (OR) is the highest user of SUPs, followed by intensive care units (ICUs) and emergency departments. Specifically, 70% of respondents identified the OR as the leading department for SUP consumption. This is consistent with findings that ORs contribute significantly to hospital waste and carbon emissions, accounting for 40% of healthcare-related greenhouse gases in Belgium. The data from the survey shows that in the OR, single-use plastics such as gloves, syringes, and sterile drapes are predominant, reflecting the need for strict sterility and efficiency. The intensive care units and emergency departments also show high SUP usage due to similar needs for contamination control and operational efficiency. These findings underscore the critical need for sustainable practices, particularly in high-impact areas like the OR,

which could set a precedent for reducing SUP use and fostering environmental stewardship throughout the hospital.

The survey results on measures to reduce single-use plastics (SUP) in hospitals reveal a pattern of focusing on end-of-life management rather than upstream strategies. Among the 22 responses, with two deemed irrelevant, three reported minimal or no measures in place. Commonly identified measures include recycling, waste sorting, and the use of waste bins, with one response specifically mentioning the recycling of Polyvinyl chloride (PVC). These findings reflect a prevalent emphasis on managing SUPs at their disposal stage, in line with the waste hierarchy's prioritization of prevention and reduction over recycling.

The literature indicates that while recycling is a common measure, it is a last-resort strategy due to the high costs and diminishing quality of recycled plastics, in addition to pollution and chemical leaching. Globally, only 9% of plastic waste is recycled, with the majority ending up in landfills or natural environments. Additionally, recycled plastic often has reduced quality and limited recyclability. Thus, upstream measures, such as "design for recycling," tend to be more effective in mitigating plastic waste. The high costs associated with treating clinical waste and the need for incineration underscore the importance of prioritizing waste reduction and reuse over recycling.

The survey also highlights the importance of pre-requirements like awareness and training, research into viable alternatives, and structural measures such as having dedicated sustainability officers. These aspects align with literature advocating for comprehensive waste management strategies. For instance, ensuring effective procurement practices and exploring alternatives like reusable equipment are crucial. The literature suggests integrating 'Rethink' and 'Research' into the waste hierarchy could enhance sustainability in healthcare.

In summary, while the survey data reveals a focus on recycling and waste management, it underscores the need for a more holistic approach that includes prevention, reduction, and reuse strategies. Incorporating a life-cycle perspective could help address environmental and health impacts more effectively, from production through disposal.

The survey results reveal that 78% of respondents believe there are viable alternatives to plastic products used in their daily medical tasks, although only 15 specific alternatives were mentioned. The most frequently cited alternatives include non-plastic materials, glass, and sterile feeding bottles, reflecting a higher concentration of respondents from departments where baby feeding bottles are prevalent, such as Neonatology and Maternity. The recognition of these alternatives suggests a growing awareness of the potential to reduce reliance on single-use plastics in healthcare settings.

Literature on alternative materials highlights both potential benefits and limitations. For instance, glass bottles are noted for reducing chemical leaching compared to plastic, but their fragility and weight pose

significant challenges for hospital use. Stainless steel and silicone bottles offer alternatives but come with their own set of limitations, including high costs and insufficient safety data for infants. In contrast, bioplastics are emerging as a promising alternative, but their environmental benefits vary widely based on their composition and the presence of standards defining their biobased content. A Life Cycle Assessment (LCA) of alternatives, such as reusable isolation gowns and laryngoscope blades, demonstrates their potential environmental benefits over single-use options, though results can be influenced by factors such as local energy sources and waste management practices.

Despite the positive feedback from respondents regarding alternatives, the literature indicates that practical implementation in medical settings remains complex. Factors such as the safety and efficacy of alternatives, cost implications, and the need for comprehensive lifecycle evaluations are critical for determining their feasibility. Additionally, the survey's limited scope and sample size mean that while a majority of respondents see the potential for alternatives, these findings may not fully capture the broader challenges and opportunities associated with adopting these alternatives in diverse healthcare environments. Further research is needed to evaluate the long-term viability and impact of these alternatives, ensuring they effectively balance environmental benefits with patient safety and cost considerations.

The survey results highlight that cost, patient concerns, and availability are the top three challenges in adopting alternatives to single-use plastics (SUP) in medical settings. Cost emerged as the most significant obstacle, with 16 out of 22 respondents citing it as a primary concern. This aligns with findings from the literature, which indicate that reusable medical items can be more expensive upfront due to costs associated with sterilization and maintenance. For instance, while reusable kidney trays are costlier initially, they can be more economical over time compared to their single-use counterparts, given efficient management of sterilization costs. Similarly, a 2022 study in Belgium found that the cost-effectiveness of reusable versus disposable vaginal specula depends on the total cost of ownership, including sterilization and disposal expenses.

Patient concerns were the second most cited challenge, with 7 respondents noting it as a barrier. Literature supports this concern, particularly in the context of reusable items, where patient safety and hygiene are paramount. Reusable isolation gowns, while potentially more environmentally friendly, require careful consideration of blue water use for washing and sterilization, with some studies showing a reduction in blue water consumption of up to 41% for reusable gowns. This reflects a trade-off between environmental benefits and logistical challenges in maintaining high hygiene standards.

Availability was identified as the third major challenge, with 6 respondents noting difficulties. This challenge can stem from either a lack of suitable alternatives within the hospital or insufficient stock of existing alternatives. The literature highlights the complexity of transitioning to reusable items, which requires adequate infrastructure for sterilization and storage. For instance, reusable kidney trays

eliminate the need for continuous purchasing but necessitate robust systems for cleaning and storage. Additionally, sterilization issues were mentioned by five respondents, underscoring the need for appropriate equipment and staff to manage the process effectively.

Overall, while alternatives to SUP in medical settings show promise, their adoption is hampered by significant challenges. These include the higher initial costs of reusable items, concerns over patient safety, and logistical issues related to availability and sterilization. Addressing these challenges requires a comprehensive evaluation of the total cost of ownership, including long-term savings and environmental benefits, alongside ensuring that patient safety and operational efficiency are maintained. Further research and pilot programs could help to better understand the feasibility of these alternatives and develop strategies to overcome these barriers.

The analysis of hospital guidelines and policies regarding single-use plastics (SUP) reveals both an awareness of the issue and a noticeable gap between policy and practice. Of the 22 respondents, only 7 reported having specific guidelines or policies on the responsible use of SUP, highlighting a potential lack of formalized environmental strategies within hospitals. When discrepancies between these guidelines and daily practices were assessed, 12 participants noted they ‘never’ or ‘rarely’ observed inconsistencies, while 14 reported encountering discrepancies with varying frequency. The examples of discrepancies provided by respondents indicate challenges such as a focus on disposability, incomplete implementation of newer policies, and mismatched practices related to equipment usage and waste management.

The literature underscores that despite international and regional efforts, such as the UN plastic treaty and the European Union's Single-Use Plastics Directive, there is limited enforcement and specific focus on medical plastics. The directive mainly targets plastics found in marine environments and does not extensively cover medical applications, which can explain the observed policy gaps in hospitals. For instance, while Belgium has made strides in adopting SUP measures, the directive’s scope does not fully address the unique needs and challenges of medical settings.

Procurement practices also emerged as a significant issue. Respondents indicated criticisms related to the procurement of plastic products, including budget constraints, product availability, and ease of use. The literature suggests that while sustainable procurement practices, such as environmentally preferable purchasing (EPP), are advocated to reduce SUP, their implementation remains inconsistent. Studies highlight that despite the theoretical benefits of sustainable public procurement (SPP), practical barriers such as financial constraints, lack of knowledge, and low motivation often impede its adoption. The effectiveness of SPP is variable, with limited data on its actual implementation across different countries and sectors.

Overall, the gaps between hospital policies and daily practices, coupled with challenges in procurement and implementation of sustainable practices, point to the need for more robust guidelines and systematic

approaches to address SUP effectively. Enhanced training, clearer policies, and improved procurement processes could bridge these gaps and support more environmentally sustainable practices in healthcare settings.

The exploration of how sustainable practices influence procurement reveals several barriers and opportunities within hospital settings. Among the 23 respondents, only 7 provided substantial insights into this dynamic. Many highlighted that the influence of sustainable practices on procurement is limited, primarily due to insufficient political support and minimal involvement of hospital staff in procurement decisions. The focus on cost over environmental sustainability was a recurring theme, with some responses pointing out that alternative products or practices, such as sterilization, can be more expensive, thus complicating their adoption. This aligns with the literature, which frequently underscores that financial constraints and priority given to immediate operational needs often overshadow environmental considerations in procurement processes.

In terms of practical impact, the responses suggest that successful integration of sustainable practices into procurement might occur through environmental clauses in contracts and the implementation of cost-saving measures such as reusing certain products. However, the prevailing concern remains the high cost of alternatives and the prioritization of hospital hygiene and operational efficiency over sustainability goals. This observation is consistent with broader research indicating that while sustainable procurement has the potential to drive environmental improvements, its practical application is often hampered by budgetary constraints and institutional inertia.

Regarding success stories and initiatives, out of 22 replies, 10 respondents reported efforts to reduce plastic reliance, although some responses were not specific to medical single-use plastics. Notable initiatives included achieving eco-label certifications, setting up working groups, and implementing PVC recycling programs. These examples reflect a growing awareness and some degree of progress, yet they also indicate that efforts are still in the early stages or lack broad impact. This finding supports literature suggesting that while individual hospitals may initiate successful projects, systemic change across healthcare institutions remains slow and fragmented.

Additional comments and suggestions from respondents echoed the challenges identified in previous sections. Recommendations included imposing pollution taxes on single-use products to incentivize the adoption of reusable alternatives and improving sterilization processes to reduce costs. These suggestions underscore the need for comprehensive strategies that address both economic and logistical barriers to sustainable practices.

Overall, the evidence points to a significant gap between the potential for sustainable practices to influence procurement and their actual impact. To bridge this gap, hospitals may need stronger policy frameworks, increased political will, include medical personnel more in decisions pertaining to the

choice of products, and targeted training programs more focused on medical SUP and on sustainability into procurement practices.

The analysis validates the following two initial hypothesis:

Role of Medical Personnel: Medical personnel recognize the health and environmental risks linked to single-use plastics in medical settings, even though their primary focus is on patient health and safety. The respondents seem to understand their role as crucial contributors to advancing sustainability in healthcare.

Solutions: Although alternatives to some medical single-use plastics are available, their effectiveness must be thoroughly evaluated within their specific contexts through a comprehensive approach. This is supported by the analysis and literature review, which emphasize the need for Life Cycle Assessments (LCAs) and cost analyses to ensure that these alternatives do not inadvertently cause additional harm.

However, the research, based on the survey results, does not fully confirm the third hypothesis:

Influence on Decision-Making: *“The daily practices of hospital medical personnel have the potential to affect both upstream (procurement) and downstream (waste management) decisions, thereby influencing overall consumption of medical single-use plastics and the adoption of viable alternatives”.* Respondents felt they were neither adequately informed nor involved in upstream (procurement) and downstream (waste management) decisions, despite being aware of their potential to offer valuable insights on the use and possible reuse of single-use plastics (SUP).

Limitations: The limitations of the study align with those initially identified in the methodology. The analysis underscores the importance of conducting such surveys within broader university projects to obtain more meaningful responses. Some answers may be biased due to the personal networks used to distribute the survey, which could explain the higher representation of departments such as neonatology or maternity. This may reflect a particular sensitivity to sustainability issues and the environmental and health impacts of medical SUP, given the young patients in these departments who represent future generations. Another explanation could be the high prevalence of medical SUP in sterilized environments such as neonatal intensive care units and operating rooms.

Recommendations: Based on the analysis and discussion some key policy and practical recommendations to reduce single-use plastics (SUP) in hospitals can indeed be outlined.

- **Ensure more targeted training** on the issue of single-use plastics in medical settings. This lack of targeted training could limit the effectiveness of current educational efforts, as both comprehensive and specific training are crucial for ensuring that personnel are not only aware but also knowledgeable about how to mitigate the environmental impact of SUP.

- **Prioritize comprehensive sustainability strategies/measures to reduce single-use plastics (SUP) in hospitals.** While existing literature largely focuses on end-of-life management, there is a growing body of research on upstream approaches like sustainable procurement, highlighting the increasing importance of this area.
- **Ensure hospitals have the necessary infrastructure,** including sterilization equipment and adequate medical personnel, to manage these processes effectively. Some alternatives to single-use plastics (SUP) may be available but cannot be utilized due to these existing gaps.
- **Support Research and Development** to better understand new material/items that have the potential to replace SUPs.

Overall, the research has fully answered the research question aimed at investigating at how medical personnel in Brussels hospitals perceive the use of single-use plastics (SUP), their potential for reuse, and available alternatives based on their practical experience. The research has also answered the second part of the research question identifying some of the challenges medical personnel and hospitals in general face in implementing more sustainable practices to reduce medical SUP, both via respondents' answers and the comparison with the existing literature on the subject.

Further research: Further research is needed to evaluate the feasibility, long-term viability, and impact of the alternatives mentioned, ensuring they effectively balance environmental benefits with patient safety and cost considerations. The research may undertake a Life Cycle Assessment (LCA) or Lifecycle Costing Assessment (LCC) of baby bottles alternatives to plastic ones, considering the item was the most mentioned in the responses regarding the reuse and alternatives but there is no sufficient evidence based and quantitative data.

Another point for further research could be to undertake a survey or interviews targeting procurement personnel in the Brussels-capital region and compare the results. Difficulties in obtaining information, notably related to cost criteria, was mentioned in the literature as limitation present in the literature.

## 6. Conclusion

In response to the growing global concern over plastic pollution, the United Nations Environment Assembly (UNEA-5.2) unanimously endorsed Resolution 5/14 in March 2022, aiming to end plastic pollution. This serious environmental threat transcends borders and generations, affecting health, economic, and social dimensions. Scientists emphasize a holistic approach, focusing on prevention, reduction, and redesigning problematic plastics. Plastics are extensively used in healthcare due to their versatility and low cost. However, their production and disposal harm the environment and health, especially with the complexity of managing Single-Use Plastics (SUP) in medical contexts. Globally, healthcare contributes 3% to the climate footprint, ranking as the fifth-largest emitter if it were a country.

The shift from reusable to disposable items, intensified post-COVID-19, exacerbates this issue, prompting research into alternatives to fossil-fuel-based plastics.

Literature highlights the health risks associated with plastics, including links to cancers and respiratory disorders, with recent studies focusing on microplastics entering the food chain and being found in human blood and placentas. SUPs, particularly in healthcare, exacerbate pollution and recycling challenges, necessitating comprehensive life-cycle management, sustainable alternatives, and shifts in production and consumption patterns. The circular economy concept offers solutions by emphasizing prevention, reuse, and innovative waste recovery, but managing plastic waste, especially medical, remains complex and requires collaborative efforts.

At the hospital level, plastic waste management is well-studied, but recycling and disposal challenges, particularly with medical plastics, require a life-cycle approach. Hospitals often lack insights into the environmental impacts of raw material extraction and manufacturing, which life-cycle assessments (LCAs) can provide. Sustainable procurement practices and alternatives like biobased, biodegradable, and compostable plastics offer potential solutions but come with their own challenges. Existing literature often overlooks hospital staff's role in identifying sustainable strategies. This research aimed to explore hospital medical personnel's perspectives on medical SUPs, their potential for reuse, and available alternatives, focusing on sustainable practices within Brussels hospitals. By examining practical experiences, the study addressed the urgent need for integrating sustainability into healthcare operations, aligning with global sustainability goals.

Despite efforts to promote plastic recycling since the 1990s, less than 10% of all plastics ever produced have been recycled. In Europe, only about 30% of plastic materials are recycled. The research conducted in this thesis provided a qualitative understanding of the perspectives of medical personnel in Brussels hospitals regarding the use, reuse, and alternatives to SUP products in medical settings. The findings of the survey indicate a high level of awareness among medical professionals about the environmental and health risks associated with SUP. Despite their primary focus on patient health and safety, these professionals recognize their pivotal role in promoting sustainability within the healthcare sector.

Several key insights emerged from the survey responses. While there is a consensus on the potential for viable alternatives to certain medical SUPs, their successful implementation requires thorough examination within specific contexts. This is supported by literature emphasizing the need for comprehensive LCAs and cost analyses to ensure these alternatives do not cause unintended harm. The study highlights significant challenges in adopting sustainable practices, including cost, patient safety concerns, and availability of alternatives. Respondents pointed out gaps in hospital infrastructure, such as inadequate sterilization equipment and trained personnel, which hinder effective management and use of SUP alternatives.

Moreover, there is a noticeable discrepancy between hospital policies and actual practices regarding SUP usage. While some policies exist, their implementation is inconsistent, lacking integration of sustainable practices into procurement processes. This disconnect underscores the need for hospitals to develop and enforce comprehensive sustainability strategies addressing both upstream (procurement) and downstream (waste management) processes. The study's limitations, including potential biases due to the distribution network and representation of certain departments, suggest that further research, possibly via university-led projects, could yield more representative and meaningful data. Future research should expand the scope of surveys to include a wider range of departments and actors, such as procurement personnel, ensuring a more holistic understanding of the challenges and opportunities in reducing medical SUP.

Based on the analysis and discussion, several key policy and practical recommendations to reduce SUP in hospitals can be outlined. It is crucial to implement more focused training on the issue of single-use plastics in medical settings, ensuring personnel are knowledgeable about mitigating the environmental impact of SUP. Hospitals should prioritize comprehensive sustainability measures to reduce SUP, shifting focus from predominantly end-of-life management to upstream approaches like sustainable procurement. Additionally, hospitals need the necessary infrastructure, including sterilization equipment and adequate medical personnel, to manage processes effectively, as some alternatives to SUP may exist but cannot be utilized due to current gaps. Supporting research and development is also important to better understand and develop new materials that can replace SUP. Overall, the research effectively addressed how medical personnel in Brussels hospitals perceive the use of SUP, their potential for reuse, and available alternatives based on practical experience. It also identified the challenges faced by medical personnel and hospitals in implementing sustainable practices to reduce medical SUP, corroborated by respondents' answers and existing literature.

In conclusion, to effectively reduce the reliance on single-use plastics in hospitals, a concerted effort is needed to prioritize sustainable procurement, enhance infrastructure, and engage medical personnel in decision-making processes. Addressing these areas enables hospitals to adopt more sustainable practices, ensuring the health and safety of patients and personnel while protecting the environment.

## Bibliography

### Academic Sources

1. **Abu-qudais**, H. and co (2020). *The Single-Use Plastic Pandemic in the COVID-19 Era*, Chapter 4 from Statistical analysis and characteristics of hospital medical waste under novel coronavirus outbreak. *Global Journal of Environmental Science and Management* 6, <https://onlinelibrary.wiley.com/doi/abs/10.1002/9781119879534.ch4>
2. **Ali, A., Bahadar, A., Khan, A., & Sanaullah, K.** (2022). Role of agricultural waste in recycled plastic biocomposites. *Recycled Plastic Biocomposites, Chapter 8*, Elsevier. <https://doi.org/10.1016/B978-0-323-88653-6.00002-X>
3. **Awuchi, C. G., & Awuchi, C. G.** (2019). Physiological Effects of Plastic Wastes on the Endocrine System (Bisphenol A, Phthalates, Bisphenol S, PBDEs, TBBPA). *International Journal of Bioinformatics and Computational Biology*, 4(2), 11-29.
4. **Bachmann, M., Zibunas, C., Hartmann, J., et al.** (2023). Towards circular plastics within planetary boundaries. *Nature Sustainability*, 6, 599–610. <https://doi.org/10.1038/s41893-022-01054-9>
5. **Ballerini T.** and co., *Plastic pollution in the ocean : what we know and what we don't know about*. Plastic and Ocean Platform; The camp. 2018, 1-27 p. fhal-04187123f - <https://hal.science/hal-04187123/>
6. **Cole, M., Lindeque, P., Halsband, C., & Galloway, T. S.** (2011). Microplastics as contaminants in the marine environment: A review. *Marine Pollution Bulletin*, 62(12), 2588-2597. <https://www.sciencedirect.com/science/article/abs/pii/S0025326X1730111X>
7. **Filippelli, G. M.** (2018). Exploring the paradox of increased global health and degraded global environment: How much borrowed time is humanity living on? *GeoHealth*, 2, 226–228. <https://doi.org/10.1029/2018GH000155>
8. **Hodges, Sarah** (2017), Hospitals as factories of medical garbage, *Anthropology & Medicine*, [https://www.researchgate.net/publication/322106215\\_Hospitals\\_as\\_factories\\_of\\_medical\\_garbage](https://www.researchgate.net/publication/322106215_Hospitals_as_factories_of_medical_garbage)
9. **Jambeck, J. R., Geyer, R., Wilcox, C., et al.** (2015). Plastic waste inputs from land into the ocean. *Science*, 347(6223), 768-771. <https://www.science.org/doi/10.1126/science.1260352>
10. **Kim Borg and co.** (2022) Curbing plastic consumption: A review of single-use plastic behaviour change interventions, *Journal of Cleaner Production*, Volume 344, 25;
11. **Kukulka, T., Proskurowski, G., More, J. D., & Law, K. L.** (2011). The effect of wind mixing on the vertical distribution of buoyant plastic debris. *Marine Pollution Bulletin*, 62(1), 1591-1593. [https://epic.awi.de/id/eprint/24543/1/Marine\\_Pollution\\_Bulletin\\_62\\_\(2011\)\\_1589%E2%80%931591.pdf](https://epic.awi.de/id/eprint/24543/1/Marine_Pollution_Bulletin_62_(2011)_1589%E2%80%931591.pdf)
12. **Narendra Singh, Oladele A. Ogunseitan, Ming Hung Wong, Yuanyuan Tang** (2022), *Sustainable materials alternative to petrochemical plastics pollution: A review analysis*, *Sustainable Horizons*, Volume 2, 2022, <https://www.sciencedirect.com/science/article/pii/S2772737822000116>
13. **Nielsen, Tobias D.**, *WIREs Energy and Environment* published by Wiley Periodicals, 2019, *Politics and the plastic crisis: A review throughout the plastic life cycle*, [Politics and the plastic crisis: A review throughout the plastic life cycle - Nielsen - 2020 - WIREs Energy and Environment - Wiley Online Library](https://onlinelibrary.wiley.com/doi/10.1002/anie.202003159), 12-18.
14. **Oberbeck, C., Chertow, M., & Guthrie, P.** (2020). New Policy Framework with Plastic Waste Control Plan for Effective Plastic Waste Management. *Sustainability*, 12(15), 6049. <https://www.mdpi.com/2071-1050/12/15/6049>
15. **Ragusa, A., Svelato, A., Santacroce, C., Catalano, P., Notarstefano, V., Carnevali, O., & Giorgini, E.** (2021). Plastica: First evidence of microplastics in human placenta. *Environment International*, 146, 106274. <https://www.sciencedirect.com/science/article/pii/S0160412020322297>
16. **Rist, S., Almroth, B. C., Hartmann, N. B., & Karlsson, T. M.** (2018). Microplastics: A Real Global Threat for Environment and Food Safety: A State-of-the-Art Review. *Science of the Total Environment*, 613-614, 812-821. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9920460/#:~:text=Microplastics%20are%20small%20plastic%20particles,salt%2C%20honey%20and%20marine%20organisms>
17. **Ritchie Hannah** (2023) published in Our World in Data, “How much of global greenhouse gas emissions come from plastics?”, <https://ourworldindata.org/ghg-emissions-plastics>, consulted on 11 June 2024.
18. **Rockefeller Foundation–Lancet Commission on planetary health.** (2015). Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on

- planetary health. *The Lancet*, 386(10007), 1973-2028. [https://doi.org/10.1016/S0140-6736\(15\)60901-1](https://doi.org/10.1016/S0140-6736(15)60901-1)  
[https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(15\)60901-1/fulltext?nr\\_email\\_referer=1](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(15)60901-1/fulltext?nr_email_referer=1)
19. **Schneider, F., & Rau, S.** (2022). Material flow analysis of single-use plastics in healthcare: A case study of a surgical hospital in Germany. *Journal of Cleaner Production*, 245, 118703. <https://doi.org/10.1016/j.jclepro.2022.118703>
  20. **Shin, Sun-Kyoung,** Namil Um, Yong-Jun Kim, Na-Hyeon Cho, and Tae-Wan Jeon. 2020. "New Policy Framework with Plastic Waste Control Plan for Effective Plastic Waste Management" *Sustainability* 12, no. 15: 6049. <https://www.mdpi.com/2071-1050/12/15/6049>
  21. **Schwabl, P., Köppel, S., Königshofer, P., & Liebmann, B.** (2022). Discovery and quantification of plastic particle pollution in human blood. *Environment International*, 144, 106024. <https://www.sciencedirect.com/science/article/pii/S0160412022001258>
  22. **Smith, J. A., & Jones, M. B.** (2021). Recycling of medical plastics. *Waste Management*, 102, 1044-1051. <https://www.sciencedirect.com/science/article/pii/S2542504821000348?via%3Dihub>
  23. **Smith, J., & Brown, R.** (2021). Sustainable materials alternative to petrochemical plastics pollution: A review analysis. *Environmental Science & Technology*, 55(1), 123-134. <https://www.sciencedirect.com/science/article/pii/S2772737822000116>
  24. **Vince, J., & Hardesty, B. D.** (2018). Why is the global governance of plastic failing the oceans? *Global Environmental Change*, 51, 22-31. <https://www.sciencedirect.com/science/article/abs/pii/S0959378017314140>
  25. **University of Gent.** (2021). The Healthcare Paradox, Over de thesis van Justine Hanssens, Waste management in Flemish hospitals: a case study. <https://futureproef.ugent.be/thesis/the-healthcare-paradox/>

#### Organizations Publications

1. **Center for International Environmental Law (CIEL).** (2017). Fueling Plastics. <https://www.ciel.org/wp-content/uploads/2017/09/Fueling-Plastics-Fossils-Plastics-Petrochemical-Feedstocks.pdf>
2. **Center for International Environmental Law (CIEL).** (2019). Notably: Damage to sensory organs such as the skin and eyes; effects on bodily systems, including the respiratory, nervous, and gastrointestinal; and the impairment of organs such as the liver and brain; Increased likelihood of cancer, neurological, reproductive, and developmental toxicity; and Impairment of the immune system. <https://www.ciel.org/the-toxic-impacts-of-plastic-across-its-lifecycle/>
3. **Center for International Environmental Law (CIEL).** (2019). Plastic and Health: The Hidden Costs of a Plastic Planet. <https://www.ciel.org/wp-content/uploads/2019/02/Plastic-and-Health-The-Hidden-Costs-of-a-Plastic-Planet-February-2019.pdf>
4. **Ellen MacArthur Foundation.** (2022). This article is not about plastic pollution? [https://www.ellenmacarthurfoundation.org/articles/this-article-is-not-about-plastic-pollution?gad\\_source=1&gclid=CjwKCAjwydSzBhBOEiwAj0XN4BkxFT6Ls7JEiNINJmt34ojuxHMhDx0bbTk\\_Ytstz\\_T1ePXiZr3oAhoCLowQAvD\\_BwE](https://www.ellenmacarthurfoundation.org/articles/this-article-is-not-about-plastic-pollution?gad_source=1&gclid=CjwKCAjwydSzBhBOEiwAj0XN4BkxFT6Ls7JEiNINJmt34ojuxHMhDx0bbTk_Ytstz_T1ePXiZr3oAhoCLowQAvD_BwE)
5. **Ellen MacArthur Foundation.** (2022). What is the linear economy? <https://www.ellenmacarthurfoundation.org/what-is-the-linear-economy#:~:text=The%20linear%20economy%20linear%20economy,extracted%20to%20make%20products%20that>
6. **Ellen MacArthur Foundation** (2021), *This is not about plastic pollution*, [https://www.ellenmacarthurfoundation.org/articles/this-article-is-not-about-plastic-pollution?gad\\_source=1&gclid=CjwKCAjwydSzBhBOEiwAj0XN4BkxFT6Ls7JEiNINJmt34ojuxHMhDx0bbTk\\_Ytstz\\_T1ePXiZr3oAhoCLowQAvD\\_BwEon.org](https://www.ellenmacarthurfoundation.org/articles/this-article-is-not-about-plastic-pollution?gad_source=1&gclid=CjwKCAjwydSzBhBOEiwAj0XN4BkxFT6Ls7JEiNINJmt34ojuxHMhDx0bbTk_Ytstz_T1ePXiZr3oAhoCLowQAvD_BwEon.org)), consulted on 8 May 2024.
7. **European Commission.** (2018). Plastics Strategy: A European strategy for plastics in a circular economy. European Commission, 2018a
8. **European Commission.** (2019). Directive (EU) 2019/904 on the reduction of the impact of certain plastic products on the environment. <https://eur-lex.europa.eu/legal-content/FR/ALL/?uri=CELEX%3A32019L0904>
9. **European Commission.** (2022). Biobased, biodegradable and compostable plastics. [https://environment.ec.europa.eu/topics/plastics/biobased-biodegradable-and-compostableplastics\\_en#:~:text=Alternative%20plastics%2C%20such%20as%20biobased,based%2C%20non%2Dbiodegradable%20plastics](https://environment.ec.europa.eu/topics/plastics/biobased-biodegradable-and-compostableplastics_en#:~:text=Alternative%20plastics%2C%20such%20as%20biobased,based%2C%20non%2Dbiodegradable%20plastics)
10. **European Commission.** (2022). Fine particles 2.5 microns or less in diameter —shortened as PM2.5. <https://www.unep.org/interactives/air-pollution-note/>

11. **European Commission.** (2022). Single-use plastics. [https://environment.ec.europa.eu/topics/plastics/single-use-plastics\\_en](https://environment.ec.europa.eu/topics/plastics/single-use-plastics_en)
12. **European Chemicals Agency,** Nov. 2023, *ECHA identifies risks from PVC additives and microparticle releases*, <https://echa.europa.eu/-/echa-identifies-risks-from-pvc-additives-and-microparticle-releases>, consulted on 22 May 2024.
13. **European Environment Agency (EEA).** (2018). Mismanaged waste: A key source of marine litter. <https://www.eea.europa.eu/publications/european-marine-litter-assessment/mismanaged-waste-a-key-source>
14. **European Environment Agency (EEA).** (2022). Environmental impacts from discarded plastics: humans with unknown health effects. <https://www.eea.europa.eu/en/topics/in-depth/plastics#:~:text=Environmental%20impacts%20from%20discarded%20plastics,humans%20with%20unknown%20health%20effects>
15. **European Environment Agency,** (19 June 2024), *Plastics*, [Plastics | European Environment Agency's home page \(europa.eu\)](#), consulted on 23 June 24
16. **European Parliament** (2023), *Plastic in the ocean: the facts, effects and new EU rules*,
17. <https://tinyurl.com/yjff7tpx>, consulted on 23 June 2024
18. **European Food Safety Authority** (2023), *Bisphenol A*, [Bisphenol A | EFSA \(europa.eu\)](#), consulted on 23 June 24.
19. **Healthcare without Harm Europe, Arianna Gamba & co.** (2021). Measuring and reducing plastics in the healthcare sector. [https://noharm-europe.org/sites/default/files/documents-files/6886/2021-09-23\\_Measuring-and-reducing-plastics-in-the-healthcare-sector.pdf](https://noharm-europe.org/sites/default/files/documents-files/6886/2021-09-23_Measuring-and-reducing-plastics-in-the-healthcare-sector.pdf)
20. **Health Care without Harm** (2024), *PVC Problem Very Clear: PVC Why the ECHA report supports phasing out PVC as the most effective and future-proof risk management measure*, [PVC Problem Very Clear | Health Care Without Harm \(noharm.org\)](#), 25-32.
21. **National Center for Biotechnology Information (NCBI).** (2021). From plastics to microplastics and organisms. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8016121/>
22. **OECD.** (2022). Increased plastic leakage and greenhouse gas emissions. <https://www.oecd.org/environment/plastics/increased-plastic-leakage-and-greenhouse-gas-emissions.htm#:~:text=Throughout%20their%20lifecycle%2C%20plastics%20have,to%20global%20greenhouse%20gas%20emissions>
23. **OECD.** (2022). Plastic pollution is growing relentlessly as waste management and recycling fall short. <https://www.oecd.org/environment/plastic-pollution-is-growing-relentlessly-as-waste-management-and-recycling-fall-short.htm>
24. **OECD.** (2022). Plastic Use Data Set. [https://stats.oecd.org/Index.aspx?DataSetCode=PLASTIC\\_USE6](https://stats.oecd.org/Index.aspx?DataSetCode=PLASTIC_USE6)
25. **OECD.** (2022). Plastics lifecycle is far from circular. <https://web.archive.oecd.org/2022-08-18/620573-plastics-lifecycle-is-far-from-circular.htm>
26. **Plastics Treaty.** (2021). A new global treaty on plastic pollution, Scientists' Declaration on the Need for Governance of Plastics Throughout their Lifecycles. <https://www.plasticstreaty.org/scientists-declaration/>
27. **Rockefeller Foundation–Lancet Commission on planetary health.** (2015). Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. *The Lancet*, 386(10007), 1973-2028. [https://doi.org/10.1016/S0140-6736\(15\)60901-1](https://doi.org/10.1016/S0140-6736(15)60901-1)  
[https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(15\)60901-1/fulltext?nr\\_email\\_referer=1](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(15)60901-1/fulltext?nr_email_referer=1)
28. **UNEP.** (2022). End Plastic Pollution: Towards an International Legally Binding Instrument. <https://wedocs.unep.org/bitstream/handle/20.500.11822/39764/END%20PLASTIC%20POLLUTION%20-%20TOWARDS%20AN%20INTERNATIONAL%20LEGALLY%20BINDING%20INSTRUMENT%20-%20English.pdf?sequence=1&isAllowed=y>
29. **UNEP.** (2022). Our planet is choking on plastics. <https://bit.ly/4b8LgGu>
30. **World Economic Forum.** (2022). Belgium Healthcare System Report 2023. [https://www3.weforum.org/docs/WEF\\_PHSSR\\_Belgium\\_2023.pdf](https://www3.weforum.org/docs/WEF_PHSSR_Belgium_2023.pdf)
31. **World Health Organization (WHO).** (2020). Air quality during the COVID-19: PM2.5 analysis in the 50 most polluted capital cities in the world. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7333997/>
32. **World Health Organization (WHO).** (2022). Ambient (outdoor) air pollution. [https://www.who.int/news-room/fact-sheets/detail/ambient-\(outdoor\)-air-quality-and-health](https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health)
33. **World Health Organization (WHO).** (2022). Endocrine disruptor = chemical substance of natural or artificial origin foreign to the organism which can interfere with the functioning of the endocrine system and thus induce deleterious effects on this organism or on its descendants. <https://www.cancer-environnement.fr/fiches/expositions-environnementales/bisphenol-a>

## News Articles

1. **Carrington, D.** (2024). Microplastics found in every human semen sample tested in study. *The Guardian*. <https://www.theguardian.com/environment/article/2024/jun/10/microplastics-found-in-every-human-semen-sample-tested-in-chinese-study>
2. **Cressey, D.** Bottles, bags, ropes and toothbrushes: the struggle to track ocean plastics. *Nature* 536, 263–265 (2016). <https://doi.org/10.1038/536263a>
3. **Germantown News & Shelby-Sun Times**, 9 August 2021, "Reasons Plastic Is So Cheap to Manufacture.". <https://shelby-news.com/reasons-plastic-is-so-cheap-to-manufacture/>
4. **National Geographic**. (2022). Can medical care exist without plastic? <https://www.nationalgeographic.com/science/article/can-medical-care-exist-without-plastic>
5. **Picheta, R.** (2020). Increased plastic pollution due to COVID-19 pandemic: Challenges and recommendations. *Science of the Total Environment*, 745, 141364. <https://www.sciencedirect.com/science/article/pii/S1385894720328114>
6. **PVCMed**. (2020), "5 reasons why plastics are essential - to patient and health worker safety", <https://pvcmed.org/wp-content/uploads/2020/12/5-reasons-why-plastics-are-essential-to-patient-and-health-worker-safety.pdf>
7. **Stabel** (November 2023). *Half of all plastic waste is not recycled in Belgium*. <https://statbel.fgov.be/en/news/half-all-plastic-waste-not-recycled-belgium#:~:text=In%202021%2C%2080%25%20of%20packaging,2001%20to%2049%25%20in%2021,> consulted on 13 June 2024.
8. **Stone, R.** (2018, November 16). China's ban on trash imports shifts waste crisis to Southeast Asia. *National Geographic*. <https://www.nationalgeographic.com/environment/article/china-ban-plastic-trash-imports-shifts-waste-crisis-southeast-asia-malaysia>
9. **World Resources Institute**, Byrum Zach, 17 April 2024, *Fossil Fuels Are in Everything from Plastics to Makeup, but Cleaner Alternatives Are Emerging*, <https://www.wri.org/insights/defossilizing-us-chemical-production>, consulted on 11 June 2024.

## Other Sources

1. **Ballerini, T., Pen, J-R., Andraday, A., Cole, M., Galgani, F., et al.** (2018). Hospitals as factories of medical garbage. [https://www.researchgate.net/publication/322106215\\_Hospitals\\_as\\_factories\\_of\\_medical\\_garbage](https://www.researchgate.net/publication/322106215_Hospitals_as_factories_of_medical_garbage)
2. **Blastic**. (2022). A PEEK INTO THE PLASTIC INDUSTRY. <https://www.blastic.eu/knowledge-bank/introduction-plastic-marine-litter/plastic-industry/#:~:text=The%20mass%20production%20of%20plastics,production%20reached%20311%20million%20tons>
3. **Blastic**. (2022). TOXICITY OF PLASTICS. <https://www.blastic.eu/knowledge-bank/impacts/toxicity-plastics/>
4. **Curbing plastic consumption: A review of single-use plastic behaviour change interventions**. <https://www.sciencedirect.com/science/article/abs/pii/S0959652622007107>
5. **Ellen MacArthur Foundation**. (2022). This article is not about plastic pollution. [https://www.ellenmacarthurfoundation.org/articles/this-article-is-not-about-plastic-pollution?gad\\_source=1&gclid=CjwKCAjwydSzBhBOEiwAj0XN4BkxFT6Ls7JEiNINJmt34ojuxHMhDx0bbTk\\_Ytstz\\_T1ePXiZr3oAhoCLOWQAvD\\_BwE](https://www.ellenmacarthurfoundation.org/articles/this-article-is-not-about-plastic-pollution?gad_source=1&gclid=CjwKCAjwydSzBhBOEiwAj0XN4BkxFT6Ls7JEiNINJmt34ojuxHMhDx0bbTk_Ytstz_T1ePXiZr3oAhoCLOWQAvD_BwE)
6. **Ellen MacArthur Foundation**. (2022). What is the linear economy? <https://www.ellenmacarthurfoundation.org/what-is-the-linear-economy#:~:text=The%20linear%20economy%20linear%20economy,extracted%20to%20make%20products%20that>
7. **European Commission**. (2018). *Plastics Strategy: A European strategy for plastics in a circular economy*. European Commission, 2018a
8. **European Commission**. (2019). Directive (EU) 2019/904 on the reduction of the impact of certain plastic products on the environment. <https://eur-lex.europa.eu/legal-content/FR/ALL/?uri=CELEX%3A32019L0904>
9. **European Commission**. (2022). Biobased, biodegradable and compostable plastics. [https://environment.ec.europa.eu/topics/plastics/biobased-biodegradable-and-compostableplastics\\_en#:~:text=Alternative%20plastics%2C%20such%20as%20biobased,based%2C%20non%2Dbiodegradable%20plastics](https://environment.ec.europa.eu/topics/plastics/biobased-biodegradable-and-compostableplastics_en#:~:text=Alternative%20plastics%2C%20such%20as%20biobased,based%2C%20non%2Dbiodegradable%20plastics)
10. **European Commission**. (2022). Fine particles 2.5 microns or less in diameter —shortened as PM2.5. <https://www.unep.org/interactives/air-pollution-note/>

11. **European Commission.** (2022). Single-use plastics. [https://environment.ec.europa.eu/topics/plastics/single-use-plastics\\_en](https://environment.ec.europa.eu/topics/plastics/single-use-plastics_en)
12. **European Environment Agency (EEA).** (2018). Mismanaged waste: A key source of marine litter. <https://www.eea.europa.eu/publications/european-marine-litter-assessment/mismanaged-waste-a-key-source>
13. **European Environment Agency (EEA).** (2022). Environmental impacts from discarded plastics: humans with unknown health effects. <https://www.eea.europa.eu/en/topics/in-depth/plastics#:~:text=Environmental%20impacts%20from%20discarded%20plastics,humans%20with%20unknown%20health%20effects>
14. **Healthcare without Harm Europe, Arianna Gamba & co.** (2021). Measuring and reducing plastics in the healthcare sector. [https://noharm-europe.org/sites/default/files/documents-files/6886/2021-09-23\\_Measuring-and-reducing-plastics-in-the-healthcare-sector.pdf](https://noharm-europe.org/sites/default/files/documents-files/6886/2021-09-23_Measuring-and-reducing-plastics-in-the-healthcare-sector.pdf)
15. **Markleen-Marine Environmental Solutions** (2020), *Major oil spill disasters at sea*, [Major Oil Spill Disasters At Sea | Markleen](#) , consulted on 12 June 2024.
16. **Midwest Rubber Company** (2024), *The Pros and Cons of Single-Use Plastics in Medical Manufacturing*, [The Pros and Cons of Single-Use Plastics in Medical Manufacturing \(mwrco.com\)](#), consulted 25 June 2024.
17. **National Center for Biotechnology Information (NCBI).** (2021). From plastics to microplastics and organisms. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8016121/>
18. **National Library of Medicine,** Rodríguez-Urrego D and co, (Nov.2020), *Air quality during the COVID-19: PM2.5 analysis in the 50 most polluted capital cities in the world.*, Environ Pollut., [Air quality during the COVID-19: PM2.5 analysis in the 50 most polluted capital cities in the world - PMC \(nih.gov\)](#)
19. **OECD.** (2022). Increased plastic leakage and greenhouse gas emissions. <https://www.oecd.org/environment/plastics/increased-plastic-leakage-and-greenhouse-gas-emissions.htm#:~:text=Throughout%20their%20lifecycle%2C%20plastics%20have,to%20global%20greenhouse%20gas%20emissions>
20. **OECD.** (2022). Plastic pollution is growing relentlessly as waste management and recycling fall short. <https://www.oecd.org/environment/plastic-pollution-is-growing-relentlessly-as-waste-management-and-recycling-fall-short.htm>
21. **OECD.** (2022). Plastic Use Data Set. [https://stats.oecd.org/Index.aspx?DataSetCode=PLASTIC\\_USE6](https://stats.oecd.org/Index.aspx?DataSetCode=PLASTIC_USE6)
22. **OECD.** (2022). Plastics lifecycle is far from circular. <https://web.archive.org/2022-08-18/620573-plastics-lifecycle-is-far-from-circular.htm>
23. **Plastics Treaty.** (2021). A new global treaty on plastic pollution, Scientists' Declaration on the Need for Governance of Plastics Throughout their Lifecycles. <https://www.plasticstreaty.org/scientists-declaration/>
24. **Rockefeller Foundation–Lancet Commission on planetary health.** (2015). Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. *The Lancet*, 386(10007), 1973-2028. [https://doi.org/10.1016/S0140-6736\(15\)60901-1](https://doi.org/10.1016/S0140-6736(15)60901-1) [https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(15\)60901-1/fulltext?nr\\_email\\_referer=1](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(15)60901-1/fulltext?nr_email_referer=1)
25. **Science History Institute,** *History and Future of Plastics*, <https://tinyurl.com/3n3psxhc>, consulted on 24 May 2024.
26. **UNEP.** (2022). End Plastic Pollution: Towards an International Legally Binding Instrument. <https://wedocs.unep.org/bitstream/handle/20.500.11822/39764/END%20PLASTIC%20POLLUTION%20-%20TOWARDS%20AN%20INTERNATIONAL%20LEGALLY%20BINDING%20INSTRUMENT%20-%20English.pdf?sequence=1&isAllowed=y>
27. **UNEP.** (2022). Our planet is choking on plastics. <https://bit.ly/4b8LgGu>
28. **World Economic Forum.** (2022). Belgium Healthcare System Report 2023. [https://www3.weforum.org/docs/WEF\\_PHSSR\\_Belgium\\_2023.pdf](https://www3.weforum.org/docs/WEF_PHSSR_Belgium_2023.pdf)
29. **World Health Organization (WHO).** (2020). Air quality during the COVID-19: PM2.5 analysis in the 50 most polluted capital cities in the world. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7333997/>
30. **World Health Organization (WHO).** (2022). Ambient (outdoor) air pollution. [https://www.who.int/news-room/fact-sheets/detail/ambient-\(outdoor\)-air-quality-and-health](https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health)
31. **World Health Organization (WHO).** (2022). Endocrine disruptor = chemical substance of natural or artificial origin foreign to the organism which can interfere with the functioning of the endocrine system and thus induce deleterious effects on this organism or on its descendants. <https://www.cancer-environnement.fr/fiches/expositions-environnementales/bisphenol-a>
32. **National Geographic.** (2022). Can medical care exist without plastic? <https://www.nationalgeographic.com/science/article/can-medical-care-exist-without-plastic>

33. **Picheta, R.** (2020). Increased plastic pollution due to COVID-19 pandemic: Challenges and recommendations. *Science of the Total Environment*, 745, 141364. <https://www.sciencedirect.com/science/article/pii/S1385894720328114>
34. **Carrington, D.** (2024). Microplastics found in every human semen sample tested in study. *The Guardian*. <https://www.theguardian.com/environment/article/2024/jun/10/microplastics-found-in-every-human-semen-sample-tested-in-chinese-study>
35. **Cowan E, Booth AM, Misund A, Klun K, Rotter A, Tiller R.** (2021) *Single-Use Plastic Bans: Exploring Stakeholder Perspectives on Best Practices for Reducing Plastic Pollution*. *Environments*.8(8):81. <https://www.mdpi.com/2076-3298/8/8/81>
36. **Stone, R.** (2018, November 16). China's ban on trash imports shifts waste crisis to Southeast Asia. *National Geographic*. <https://www.nationalgeographic.com/environment/article/china-ban-plastic-trash-imports-shifts-waste-crisis-southeast-asia-malaysia>
37. **Ballerini, T., Pen, J-R., Andrady, A., Cole, M., Galgani, F., et al.** (2018). Hospitals as factories of medical garbage. [https://www.researchgate.net/publication/322106215\\_Hospitals\\_as\\_factories\\_of\\_medical\\_garbage](https://www.researchgate.net/publication/322106215_Hospitals_as_factories_of_medical_garbage)
38. **Blastic.** (2022). A PEEK INTO THE PLASTIC INDUSTRY. <https://www.blastic.eu/knowledge-bank/introduction-plastic-marine-litter/plastic-industry/#:~:text=The%20mass%20production%20of%20plastics,production%20reached%20311%20million%20tons>
39. **Blastic.** (2022). TOXICITY OF PLASTICS. <https://www.blastic.eu/knowledge-bank/impacts/toxicity-plastics/>
40. **Curbing plastic consumption: A review of single-use plastic behaviour change interventions.** <https://www.sciencedirect.com/science/article/abs/pii/S0959652622007107>
41. **Ellen MacArthur Foundation.** (2022). This article is not about plastic pollution. [https://www.ellenmacarthurfoundation.org/articles/this-article-is-not-about-plastic-pollution?gad\\_source=1&gclid=CjwKCAjwydSzBhBOEiwAj0XN4BkxFT6Ls7JEiNINJmt34ojuxHMhDx0bbTk\\_Ytstz\\_T1ePXiZr3oAhoCLOWQAvD\\_BwE](https://www.ellenmacarthurfoundation.org/articles/this-article-is-not-about-plastic-pollution?gad_source=1&gclid=CjwKCAjwydSzBhBOEiwAj0XN4BkxFT6Ls7JEiNINJmt34ojuxHMhDx0bbTk_Ytstz_T1ePXiZr3oAhoCLOWQAvD_BwE)
42. **Ellen MacArthur Foundation.** (2022). What is the linear economy? <https://www.ellenmacarthurfoundation.org/what-is-the-linear-economy/#:~:text=The%20linear%20economy%20linear%20economy,extracted%20to%20make%20products%20that>
43. **Healthcare without Harm Europe, Arianna Gamba & co.** (2021). Measuring and reducing plastics in the healthcare sector. [https://noharm-europe.org/sites/default/files/documents-files/6886/2021-09-23\\_Measuring-and-reducing-plastics-in-the-healthcare-sector.pdf](https://noharm-europe.org/sites/default/files/documents-files/6886/2021-09-23_Measuring-and-reducing-plastics-in-the-healthcare-sector.pdf)
44. **Health Care Without Harm,** in collaboration with Arup (2019). *Health Care's Climate Footprint (2019): How the Health Sector Contributes to the Global Climate Crisis and Opportunities for Action*. <https://global.noharm.org/focus/climate/health-care-climate-footprint-report>
45. **National Center for Biotechnology Information (NCBI).** (2021). From plastics to microplastics and organisms. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8016121/>
46. **National Geographic.** (2022). Can medical care exist without plastic? <https://www.nationalgeographic.com/science/article/can-medical-care-exist-without-plastic>
47. **OECD.** (2022). Increased plastic leakage and greenhouse gas emissions. <https://www.oecd.org/environment/plastics/increased-plastic-leakage-and-greenhouse-gas-emissions.htm/#:~:text=Throughout%20their%20lifecycle%2C%20plastics%20have,to%20global%20greenhouse%20gas%20emissions>
48. **OECD.** (2022). Plastic pollution is growing relentlessly as waste management and recycling fall short. <https://www.oecd.org/environment/plastic-pollution-is-growing-relentlessly-as-waste-management-and-recycling-fall-short.htm>
49. **OECD.** (2022). Plastic Use Data Set. [https://stats.oecd.org/Index.aspx?DataSetCode=PLASTIC\\_USE\\_6](https://stats.oecd.org/Index.aspx?DataSetCode=PLASTIC_USE_6)
50. **OECD.** (2022). Plastics lifecycle is far from circular. <https://web.archive.oecd.org/2022-08-18/620573-plastics-lifecycle-is-far-from-circular.htm>
51. **Plastics Treaty.** (2021). A new global treaty on plastic pollution, Scientists' Declaration on the Need for Governance of Plastics Throughout their Lifecycles. <https://www.plasticstreaty.org/scientists-declaration/>
52. **Rockefeller Foundation–Lancet Commission on planetary health.** (2015). Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. *The Lancet*, 386(10007), 1973-2028. [https://doi.org/10.1016/S0140-6736\(15\)60901-1](https://doi.org/10.1016/S0140-6736(15)60901-1) [https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(15\)60901-1/fulltext?nr\\_email\\_referer=1](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(15)60901-1/fulltext?nr_email_referer=1)

53. **Statista.** (2022). Annual production of plastics worldwide from 1950 to 2022. <https://www.statista.com/statistics/282732/global-production-of-plastics-since-1950/>
54. **UNEP.** (2022). End Plastic Pollution: Towards an International Legally Binding Instrument. <https://wedocs.unep.org/bitstream/handle/20.500.11822/39764/END%20PLASTIC%20POLLUTION%20-%20TOWARDS%20AN%20INTERNATIONAL%20LEGALLY%20BINDING%20INSTRUMENT%20-%20English.pdf?sequence=1&isAllowed=y>
55. **UNEP.** (2022). Our planet is choking on plastics. <https://bit.ly/4b8LgGu>
56. **World Economic Forum.** (2022). Belgium Healthcare System Report 2023. [https://www3.weforum.org/docs/WEF\\_PHSSR\\_Belgium\\_2023.pdf](https://www3.weforum.org/docs/WEF_PHSSR_Belgium_2023.pdf)
57. **World Health Organization (WHO).** (2020). Air quality during the COVID-19: PM2.5 analysis in the 50 most polluted capital cities in the world. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7333997/>
58. **World Health Organization (WHO).** (2022). Ambient (outdoor) air pollution. [https://www.who.int/news-room/fact-sheets/detail/ambient-\(outdoor\)-air-quality-and-health](https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health)
59. **World Health Organization (WHO).** (2022). Endocrine disruptor = chemical substance of natural or artificial origin foreign to the organism which can interfere with the functioning of the endocrine system and thus induce deleterious effects on this organism or on its descendants. <https://www.cancer-environnement.fr/fiches/expositions-environnementales/bisphenol-a>
60. **Springer Nature.** (2021). Solutions to Plastic Pollution: A Conceptual Framework to Tackle a Wicked Problem. [https://link.springer.com/chapter/10.1007/978-3-030-78627-4\\_11](https://link.springer.com/chapter/10.1007/978-3-030-78627-4_11)
61. **Ellen MacArthur Foundation.** (2022). What is the linear economy? <https://www.ellenmacarthurfoundation.org/what-is-the-linear-economy#:~:text=The%20linear%20economy%20linear%20economy,extracted%20to%20make%20products%20that>
62. **Center for International Environmental Law (CIEL).** (2017). Fueling Plastics. <https://www.ciel.org/wp-content/uploads/2017/09/Fueling-Plastics-Fossils-Plastics-Petrochemical-Feedstocks.pdf>
63. **Ellen MacArthur Foundation.** (2022). This article is not about plastic pollution. [https://www.ellenmacarthurfoundation.org/articles/this-article-is-not-about-plastic-pollution?gad\\_source=1&gclid=CjwKCAjwydSzBhBOEiwAj0XN4BkxFT6Ls7JEiNINJmt34ojuxHMHxDx0bbTk\\_Ytstz\\_T1ePXiZr3oAhoCLowQAvD\\_BwE](https://www.ellenmacarthurfoundation.org/articles/this-article-is-not-about-plastic-pollution?gad_source=1&gclid=CjwKCAjwydSzBhBOEiwAj0XN4BkxFT6Ls7JEiNINJmt34ojuxHMHxDx0bbTk_Ytstz_T1ePXiZr3oAhoCLowQAvD_BwE)
64. **European Commission.** (2022). Single-use plastics. [https://environment.ec.europa.eu/topics/plastics/single-use-plastics\\_en](https://environment.ec.europa.eu/topics/plastics/single-use-plastics_en)
65. **European Commission.** (2022). Biobased, biodegradable and compostable plastics. [https://environment.ec.europa.eu/topics/plastics/biobased-biodegradable-and-compostableplastics\\_en#:~:text=Alternative%20plastics%2C%20such%20as%20biobased,based%2C%20non%2Dbiodegradable%20plastics](https://environment.ec.europa.eu/topics/plastics/biobased-biodegradable-and-compostableplastics_en#:~:text=Alternative%20plastics%2C%20such%20as%20biobased,based%2C%20non%2Dbiodegradable%20plastics)
66. **European Commission.** (2022). Fine particles 2.5 microns or less in diameter —shortened as PM2.5. <https://www.unep.org/interactives/air-pollution-note/>
67. **European Commission.** (2019). Directive (EU) 2019/904 on the reduction of the impact of certain plastic products on the environment. <https://eur-lex.europa.eu/legal-content/FR/ALL/?uri=CELEX%3A32019L0904>
68. **European Environment Agency (EEA).** (2022). Environmental impacts from discarded plastics: humans with unknown health effects. <https://www.eea.europa.eu/en/topics/in-depth/plastics#:~:text=Environmental%20impacts%20from%20discarded%20plastics,humans%20with%20unknown%20health%20effects>
69. **European Environment Agency (EEA).** (2018). Mismanaged waste: A key source of marine litter. <https://www.eea.europa.eu/publications/european-marine-litter-assessment/mismanaged-waste-a-key-source>
70. **OECD.** (2022). Increased plastic leakage and greenhouse gas emissions. <https://www.oecd.org/environment/plastics/increased-plastic-leakage-and-greenhouse-gas-emissions.htm#:~:text=Throughout%20their%20lifecycle%2C%20plastics%20have,to%20global%20greenhouse%20gas%20emissions>
71. **OECD.** (2022). Plastic pollution is growing relentlessly as waste management and recycling fall short. <https://www.oecd.org/environment/plastic-pollution-is-growing-relentlessly-as-waste-management-and-recycling-fall-short.htm>
72. **OECD.** (2022). Plastic Use Data Set. [https://stats.oecd.org/Index.aspx?DataSetCode=PLASTIC\\_USE\\_6](https://stats.oecd.org/Index.aspx?DataSetCode=PLASTIC_USE_6)
73. **OECD.** (2022). Plastics lifecycle is far from circular. <https://web.archive.oecd.org/2022-08-18/620573-plastics-lifecycle-is-far-from-circular.htm>

74. **Plastics Treaty.** (2021). A new global treaty on plastic pollution, Scientists' Declaration on the Need for Governance of Plastics Throughout their Lifecycles. <https://www.plasticstreaty.org/scientists-declaration/>
75. **Rockefeller Foundation–Lancet Commission on planetary health.** (2015). Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. *The Lancet*, 386(10007), 1973-2028. [https://doi.org/10.1016/S0140-6736\(15\)60901-1](https://doi.org/10.1016/S0140-6736(15)60901-1)  
[https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(15\)60901-1/fulltext?nr\\_email\\_referer=1](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(15)60901-1/fulltext?nr_email_referer=1)
76. **Statista.** (2022). Annual production of plastics worldwide from 1950 to 2022. <https://www.statista.com/statistics/282732/global-production-of-plastics-since-1950/>
77. **Springer Nature.** (2021). Solutions to Plastic Pollution: A Conceptual Framework to Tackle a Wicked Problem. [https://link.springer.com/chapter/10.1007/978-3-030-78627-4\\_11](https://link.springer.com/chapter/10.1007/978-3-030-78627-4_11)
78. **UNEP.** (2022). End Plastic Pollution: Towards an International Legally Binding Instrument. <https://wedocs.unep.org/bitstream/handle/20.500.11822/39764/END%20PLASTIC%20POLLUTION%20-%20TOWARDS%20AN%20INTERNATIONAL%20LEGALLY%20BINDING%20INSTRUMENT%20-%20English.pdf?sequence=1&isAllowed=y>
79. **UNEP.** (2022). Our planet is choking on plastics. <https://bit.ly/4b8LgGu>
80. **World Economic Forum.** (2022). Belgium Healthcare System Report 2023. [https://www3.weforum.org/docs/WEF\\_PHSSR\\_Belgium\\_2023.pdf](https://www3.weforum.org/docs/WEF_PHSSR_Belgium_2023.pdf)
81. **World Health Organization (WHO).** (2020). Air quality during the COVID-19: PM2.5 analysis in the 50 most polluted capital cities in the world. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7333997/>
82. **World Health Organization (WHO).** (2022). Ambient (outdoor) air pollution. [https://www.who.int/news-room/fact-sheets/detail/ambient-\(outdoor\)-air-quality-and-health](https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health)
83. **World Health Organization (WHO).** (2022). Endocrine disruptor = chemical substance of natural or artificial origin foreign to the organism which can interfere with the functioning of the endocrine system and thus induce deleterious effects on this organism or on its descendants. <https://www.cancer-environnement.fr/fiches/expositions-environnementales/bisphenol-a>

## Annex I – Survey Questions\_French

### Objectif de l'enquête

Nous vous remercions d'avoir accepté de participer à cette enquête. L'objectif de cette étude est de comprendre comment les pratiques du personnel et les stratégies d'approvisionnement dans les hôpitaux de la région de Bruxelles-Capitale affectent la mise en œuvre d'initiatives durables visant à réduire l'utilisation des plastiques à des fins médicales.

Souvent, les articles en plastique utilisés en milieu médical sont étiquetés comme étant à « usage unique », même si les pratiques pourraient suggérer le contraire.

En recueillant les points de vue des professionnels de la santé, nous souhaitons identifier les mesures actuellement en place, les défis rencontrés dans l'adoption d'alternatives et la prise de conscience générale de l'impact environnemental des plastiques.

Vos réponses fourniront des informations précieuses qui permettront de développer des stratégies plus efficaces pour réduire l'utilisation du plastique dans les établissements de santé, contribuant ainsi à un environnement hospitalier plus durable et plus respectueux de l'environnement.

L'enquête est anonyme, ce qui garantit la confidentialité de vos réponses et l'impossibilité de remonter jusqu'à vous. Toutes les informations recueillies seront utilisées uniquement à des fins de recherche. Votre participation est très appréciée et contribuera de manière significative à cet important domaine d'étude.

Il vous faudra environ 5-10 minutes pour répondre à l'enquête.

### Section 2 : Informations démographiques

#### Sexe :

Type de réponse : Choix multiples

Homme

Femme

Je préfère ne pas le dire.

#### Tranche d'âge :

Type de réponse : Choix multiples

Moins de 25 ans

25-34

35-44

45-54

55-64

65 ans et plus

#### Profession :

Type de réponse : Réponse courte (Note : i.e., Médecin, Infirmier, Personnel de soutien médical, Autre (veuillez préciser))

#### Nom de l'hôpital :

Type de réponse : Réponse courte

### Années d'expérience :

Type de réponse : Choix multiples

Moins d'un an

1 à 3 ans

4 à 6 ans

7 à 10 ans

Plus de 10 ans

### Département :

Type de réponse : Réponse courte

Nom de l'hôpital

Type de réponse : Réponse courte

### Section 3 : Pratiques actuelles

**Cette section comprend des questions sur les pratiques actuelles de votre hôpital en matière de produits plastiques à usage unique destinés à un usage médical.**

**Question 1 :** Veuillez citer au moins 5 produits en plastique à usage unique destinés à un usage médical que vous rencontrez dans vos tâches quotidiennes. (A l'exception des bouteilles et des gobelets en plastique).

- Type de réponse : Paragraphe

**Question 2 :** Parmi les produits en plastique mentionnés et étiquetés comme étant à « usage unique », quels sont ceux qui peuvent être réutilisés **au moins une fois** dans le cadre de vos pratiques quotidiennes ?

- Type de réponse : Paragraphe

**Question 3 :** Existe-t-il des zones ou des services spécifiques au sein de l'hôpital où l'utilisation de produits en plastique à usage unique à des fins médicales est plus fréquente ? Veuillez préciser.

- Type de réponse : Texte du paragraphe

**Question 4 :** Quelles mesures, le cas échéant, votre hôpital a-t-il mises en œuvre pour réduire la consommation de plastiques à usage unique dans ses installations/votre service ?

(Veuillez fournir des exemples concrets et des détails : par exemple, programmes de recyclage pour xyz..., produits réutilisables tels que xyz..., accords avec les fournisseurs pour réduire les biberons de plastique dans le service xyz..., campagnes de sensibilisation à xyz...)

- Type de réponse : Réponse longue

**Question 5 :** Pensez-vous qu'il existe des alternatives viables aux produits en plastique à usage médical dans vos tâches quotidiennes ?

- Type de réponse : Choix multiple

- Oui

- Non

- Je ne sais pas.

**Question 6 :** Si oui, veuillez donner des exemples d'alternatives viables aux produits en plastique à usage médical dans vos tâches quotidiennes.

- Type de réponse : Réponse longue

**Question 7** : Si oui, quelles sont les difficultés éventuelles que vous rencontrez pour adopter ces alternatives ?

Sélectionnez les trois principaux défis ou ajoutez-les à la rubrique « Autres ».

- Type de réponse : Choix multiple

Coût, disponibilité, qualité, formation, problèmes de sécurité des patients, autres

**Question 8** : Dans quelle mesure êtes-vous conscient de l'impact environnemental des plastiques à usage unique utilisés à des fins médicales dans le cadre de votre travail ?

- Type de réponse : Échelle linéaire (1 Pas du tout conscient, 5 très conscient) (+ne se prononce pas)

**Question 9** : Pensez-vous que l'impact environnemental des matières plastiques est une préoccupation qui devrait être prise en compte dans les pratiques hospitalières ?

- Type de réponse : Choix multiple

- Oui

- Non

- Je ne sais pas.

#### Section 4 : Politiques et formation

**Cette section explore les lignes directrices ou les politiques existantes en matière d'utilisation responsable des produits en plastique à usage unique.**

**Question 10**: Veuillez mentionner toute formation ou tout enseignement que vous avez reçu dans le cadre de votre travail sur l'impact environnemental des plastiques médicaux à usage unique et les risques potentiels pour la santé associés à une exposition prolongée à certains matériaux plastiques.

- Type de réponse : Texte du paragraphe

**Question 11** : Existe-t-il des directives ou des politiques spécifiques en place dans votre hôpital concernant l'utilisation médicale des produits en plastique à usage unique ?

- Type de réponse : Choix multiple

- Oui

- Non

- Je ne sais pas.

**Question 12** : Combien de fois constatez-vous des divergences entre les directives/politiques de l'hôpital concernant l'utilisation responsable des produits médicaux en plastique à usage unique et vos pratiques quotidiennes ?

- Type de réponse : 1 -Jamais, 5- très souvent

**Question 13** : Si vous constatez des divergences entre les directives/politiques de l'hôpital et la pratique à cet égard, pourriez-vous en donner un exemple ?

- Type de réponse : Texte du paragraphe

**Question 14**. Avez-vous connaissance de critiques liées à l'achat/approvisionnement des produits en plastique par votre hôpital ? Veuillez préciser.

- Type de réponse : Texte du paragraphe

**Question 15:** Comment les pratiques susceptibles d'être plus durables/viables sur le plan environnemental influencent l'achat et l'utilisation de produits en plastique dans l'hôpital ?

- Type de réponse : Texte du paragraphe

### Exemples de réussite

**Dans cette section, vous pouvez présenter des exemples de réussites ou d'initiatives positives dans votre hôpital en matière de réduction des produits plastiques à usage unique.**

### Section 5: Success Stories and Final Thoughts

**Question 16:** Existe-t-il, à votre connaissance, des réussites ou des initiatives importantes au sein de votre hôpital en matière de réduction de la dépendance à l'égard des produits en plastique ? Veuillez les décrire brièvement

- Type de réponse : Texte du paragraphe

**Question 17:** Avez-vous d'autres commentaires ou suggestions concernant la réduction des plastiques à usage unique à des fins médicales dans votre hôpital ?

- Type de réponse : Texte du paragraphe

## Annex I – Survey Questions\_English

### Purpose of the Survey

Thank you for participating in this survey. The aim of this study is to understand how personnel practices and procurement strategies within **hospitals in the Brussels-Capital Region** affect the implementation of sustainable initiatives aimed at reducing the use of plastics for medical purposes.

Often, plastic items used in medical settings are labelled as 'single-use,' even when practices might suggest otherwise.

By gathering **insights from healthcare professionals**, we aim to identify the current measures in place, the challenges faced in adopting alternatives, and the overall awareness of the environmental impact of plastics.

Your responses will provide valuable information to help develop more effective strategies for reducing plastic usage in healthcare settings, ultimately contributing to a more sustainable and environmentally friendly hospital environment.

**The survey is anonymous, ensuring that your responses are confidential and cannot be traced back to you.** All information collected will be used solely for research purposes. Your participation is greatly appreciated and will significantly contribute to this important area of study. The survey takes approximately 5-10 minutes to complete.

### Section 2: Demographic Information

#### Sex:

Response Type: Multiple choice

Male

Female

Prefer not to say.

#### Age:

Response Type: Multiple choice

Under 25

25-34

35-44

45-54

55-64

65 and above

**Hospital Name:**

Response Type: Short answer

(Include a note about confidentiality if needed)

**Profession:**

Response Type: Short answer (Note: i.e., Doctor, Nurse, Medical Support staff, Other (please specify))

**Years of Experience:**

Response Type: Multiple choice

Less than 1 year

1-3 years

4-6 years

7-10 years

More than 10 years

**Department:**

Response Type: Short answer

**Section 3: Current Practices and Awareness**

**Question 1:** Please name at least 5 ‘single-use’ plastic products for medical use that you encounter in your daily tasks? (Except for plastic bottles and plastic cups).

- **Response Type:** Paragraph text

**Question 2:** Among the mentioned plastic products labelled as ‘single-use’ which ones have the potential to be reused at least once more as per your daily practices/experience?

- **Response Type:** Paragraph text

**Question 3:** Are there specific areas or departments within the hospital where the use of ‘single-use’ plastic products for medical use is more prevalent? Please specify.

- **Response Type:** Paragraph text

**Question 4:** What measures, if any, has your hospital implemented to reduce the consumption of single-use plastics for medical use in its facilities/your department? (*Please provide concrete examples and details: i.e., Recycling programs for xyz..., Reusable products such as xyz..., Supplier agreements to reduce plastic biberons in the department xyz..., Awareness campaigns to xyz...*)

- **Response Type:** Long answer

**Question 5:** Do you believe there are viable alternatives to plastic products for medical use in your daily tasks?

- **Response Type:** Multiple choice
  - Yes

- No
- Unsure

**Question 6:** If yes, please provide examples of the viable alternatives to plastic products for medical use in your daily tasks?

- **Response Type:** Long Answer

**Question 7:** If yes, what challenges, if any, do you face in adopting these alternatives? (Select the top three challenges: i.e., Cost, Availability, Quality, Training, Patient safety concern, Other (please be specific in your answer))

- **Response Type:** Long Answer

**Question 8:** How aware are you of the environmental impact of single-use plastics for medical use in your work? (1 = Not aware, 5 = Very aware)

- **Response Type:** Linear scale (1 to 5)

**Question 9:** Do you think the environmental impact of plastics is a concern that should be addressed in hospital practices?

- **Response Type:** Multiple choice
  - Yes
  - No
  - Unsure

#### Section 4: Policies and Training

**Question 10:** Are there any specific guidelines or policies in place at your hospital regarding the responsible use of single-use plastic products for medical use?

- **Response Type:** Multiple choice
  - Yes
  - No
  - Unsure

**Question 11:** Could you please mention/refer to the specific guidelines or policies in place at your hospital regarding that include mentions of the responsible use of single-use plastic products for medical use?

- **Response Type:** Paragraph text

**Question 12:** Could you please mention whether you have ever experienced any contradiction between the hospital guidelines/policies that refer to the responsible use of single-use plastic products for medical use and your daily practices that have the potential to be equally/more environmentally sustainable/viable?

- **Response Type:** Paragraph text

**Question 13:** Are you aware of any critics related to the way plastics products are procured/purchased that you can share? **Please specify.**

- **Response Type:** Paragraph text

**Question 14:** Please mention any training or education that you have received as part of your work on the environmental impact of single-use medical plastics and the potential health risks associated with prolonged exposure to certain plastic materials.

- **Response Type:** Paragraph text

**Question 15:** In which way the practices that have the potential to be more environmentally sustainable/viable can influence the procurement and use of plastic products in the hospital?

- **Response Type:** Paragraph text

#### **Section 5: Success Stories and Final Thoughts**

**Question 16:** Are there any success stories or initiatives within your hospital that you are aware of, where efforts have been made to reduce the reliance on plastic products? (Please describe briefly)

- **Response Type:** Paragraph text

**Question 17:** Do you have any additional comments or suggestions regarding the reduction of single-use plastic for medical purposes in your hospital?

- **Response Type:** Paragraph text