medical delta
we add

Centre for Sustainability
Leiden-Delft-Erasmus Universities

Sustainable Hospitals

Assignment 1

Single-use versus multi-use surgical instruments: what are the costs and benefits?

Problem statement

During the last decades several instruments (disposables and reusables) have been developed to be used by gynaecologists in laparoscopic surgery. Disposable instruments create a lot of medical waste but require less maintenance. Reusable instruments are more expensive to purchase and need to be sterilized, but reduce the creation of waste.

This assignment focuses on instruments used by gynaecologists in the case of ectopic pregnancy in a patient. An ectopic pregnancy is a pregnancy that is implanted outside of the womb, usually in one of the fallopian tubes. These fallopian tubes connect the ovaries to the womb. An ectopic pregnancy cannot develop into a normal pregnancy. Besides expectant management and medication, one of the treatment options is surgery: where the fallopian tube containing the ectopic pregnancy will be removed (if the contralateral fallopian tube seems normal). In order to do so, it is possible to use disposable instruments (e.g. Harmonic scalpel, Ligasure) or (semi-)reusable instruments (e.g. Olympus sonosurg or 'simple' coagulation and cutting). From the perspective of environmental sustainability and cost-effectiveness: which one is better?

Research question(s)

1. What is the environmental impact of the use of disposable instruments compared to (semi)-reusable instruments to cut and coagulate tissue in case of an ectopic (tubal) pregnancy?
2. What are the costs and benefits of each choice in instrument?

Suggested academic backgrounds

This research assignment is open to any graduating Master students from Leiden University, TU Delft and Erasmus Rotterdam

- MSc Industrial Ecology students, for life cycle assessment
- MSc Global Business and Sustainability, for cost-benefit analyses
- MSc Healthcare Management, for multi-criteria analyses
- MSc Technical Medicine

Expected type of work

Literature review, life cycle assessment, interviews

Available data/reports or other relevant information sources for the assignment

Schulz et al. Environmental footprint of single-use surgical instruments in comparison with multi-use surgical instruments. Glocalized Solutions for sustainability in manufacturing, 623-628 (2011)
Leiden et al. Life cycle assessment of a disposable and a reusable surgery instrument set for spinal fusion surgeries. Recources, Conservation & Recycling (2020)
Ibbotson et al. Eco-efficiency of disposable and reusable surgical instruments – a scissors case. Int J Life Cycle Assess (2013) 18:1137–1148
Yung et al. Cost comparison of reusable and single-use ultrasonic shears for laparoscopic bariatric surgery. Obes Surg. 2010 Apr;20(4):512-8.

Assignment 2

Environmental impacts of large-scale computational modelling in medicine

Problem statement

In recent years, computational modelling is increasingly used in medicine. Creating a 'digital twin': a personalized computational model of the patient, could be used for the design of medical devices or for predicting the progression of a disease (e.g. https://www.vph-institute.org/). Where in musculoskeletal research, cadaveric or animal experiments were previously needed to determine loads in joints, currently many of these experiments are replaced by computational modelling studies. These *in silico* models allow us to explore the effect of variations in human anatomy or different treatments, including surgical approaches. This enables realistic simulations of personalized scenarios that cannot be performed in real life. Therefore there is a large potential for the use of modelling in research and clinical settings.

However, these models often require large computational power and data-storage facilities, of which the environmental burden is still unclear. It is unknown what the effect is of *in silico* modelling on the environment and the potential environmental benefit compared to traditional physical experiments.

Research question(s)

What is the environmental impacts of *in silico* modelling and how does this compare to traditional physical experiments (e.g. animal and cadaveric experiments)?

- Environmental burden in terms of e.g. CO2 output, waste, environmental resources (e.g. water, minerals)

Suggested academic background

This research assignment is open to any graduating Master students from Leiden University, TU Delft and Erasmus Rotterdam

- MSc Industrial Ecology
- MSc Biomedical Engineering
- MSc Industrial Design Engineering

Expected type of work

Analysis of experimental and computational sustainability, life cycle assessment. There should be a closer connection with normative environmental ethics- either within biomedical ethics or within technological ethics. This will in part orient the articles for review and the disciplinary focus.

Available data/reports or other relevant information sources for the assignment

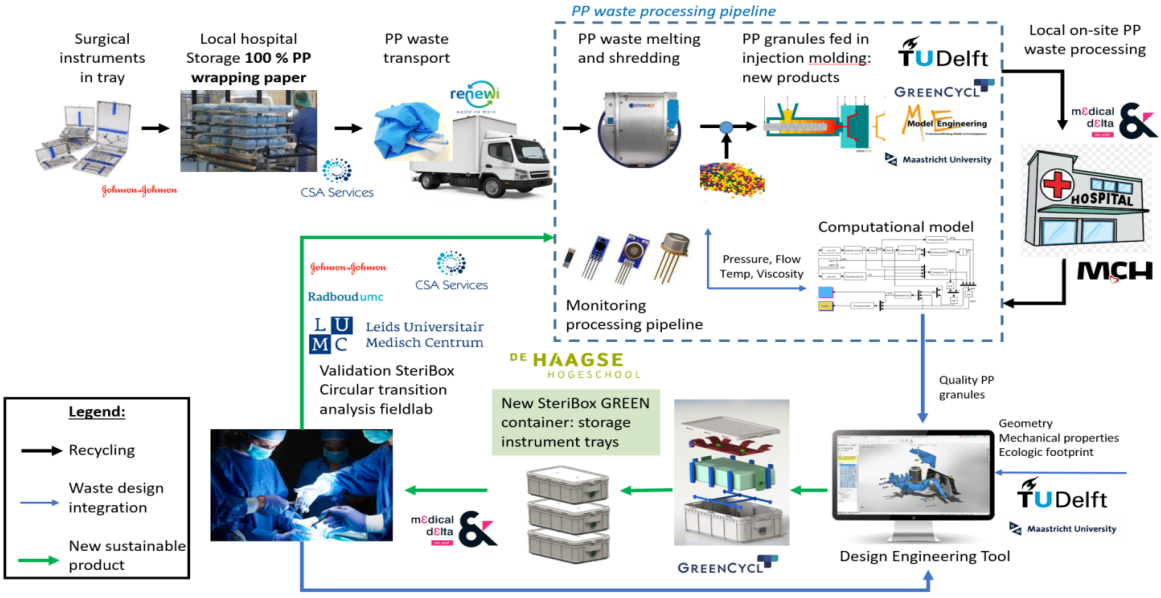
Viceconti, M., & Hunter, P. (2016). The virtual physiological human: ten years after. *Annual review of biomedical engineering*, *18*, 103-123.
Viceconti, M., Henney, A., & Morley-Fletcher, E. (2016). In silico clinical trials: how computer simulation will transform the biomedical industry. *International Journal of Clinical Trials*, *3*(2), 37-46.
Molero, A., Calabrò, M., Vignes, M., Gouget, B., & Gruson, D. (2021). Sustainability in healthcare: perspectives and reflections regarding laboratory medicine. *Annals of Laboratory Medicine*, *41*(2), 139-144.

Assignment 3

Transforming hospital waste to new medical equipment: how can injection moulding be safely utilised?

Problem statement

To reduce the CO2 emission related to processing of hospital waste and the manufacturing of new medical devices, an open collaboration between industry, hospitals and universities was created within the entity GreenCycl (www.greencycl.org). In line with the goals of the Green deal, new processes are being developed that allow for reprocessing or recycle of medical waste and disposed instruments. Some of these processes are proven to be sustainable from a technical point of view and hospitals are able to purchase products made from their own waste. However, uncertainties in infrastructure, MDR and national or local rules and regulations prevent fast upscaling towards other hospitals in the Netherlands and Europe. Recently, a recycling method was developed in our High Quality (HQ) field lab that allows (parts of) new surgical instruments to be injection moulded from reprocessed surgical drapes coming from the Operation room. Today, 5 different products are manufactured and used in the sterilisation department and new advanced laparoscopic instruments



Although the processes of GreenCycl are technically feasible, there are no general guidelines for all reprocessing steps that allow manufacturers to use instruments that are (partly) made from recycled materials.

Research question(s)

- What is needed for hospitals to safely use products made (partly) from injection moulded recycled (potentially contaminated) medical waste from a Quality Assurance/Risk perspective.
- How does regulation differ over European and non-European countries.

Expected type of work

stakeholder analysis and legislation analysis resulting in a practical guideline Including, testing, storage, wrapping, cleaning and decontamination of the materials during the different transitional stages from waste till Injection molding. This work can be executed in close collaboration with Industry experts from GreenCycl and Van straten medical.

Available data/reports or other relevant information sources for the assignment

Surgical waste reprocessing; injection moulding with recycled blue wrapping paper from the operating room, Cleaner production B. van Straten, D.R. van der Heiden, D. Robertson, C. Riekwel, F.W. Jansen, M. van der Elst, T. Horeman, Cleaner production (2021), in press

van Straten, B., & Horeman, T. (2020). NEN-spec Medische Hulpmiddelen voor eenmalig gebruik: Richtlijn voor hergebruik tijdens COVID-19.

Joseph, B., James, J., Kalarikkal, N., & Thomas, S. (2021). Recycling of medical plastics. *Advanced Industrial and Engineering Polymer Research*.

Azouz, S., Boyll, P., Swanson, M., Castel, N., Maffi, T., & Rebecca, A. M. (2019). Managing barriers to recycling in the operating room. *The American Journal of Surgery*, *217*(4), 634-638.

Assignment 4

The environmental footprint of Interventional Radiology: Towards a sustainable Interventional Radiology department

Problem statement

Interventional radiology (IR) is a significant contributor of hospital waste. It uses many items that are single-use or which contain extensive packaging. The reduction of energy and material waste is often not high priority for interventional radiologists. In the context of transitioning towards sustainable hospitals, it is becoming increasingly important that we all contribute to the reduction of hospital waste. The first step is understanding where the environmental footprint of the department originates. Therefore, this research assignment is an exploration of where the material-energy nexus in the IR department.

Research question(s)

What are the drivers, barriers, challenges, and opportunities in improving the environmental sustainability of the IR department?

- What is the energy consumption of the IR department, and how can it be reduced?
- What are the material flows within the IR department, and how can waste be reduced?

Expected type of work

Interviews with IR employees; Life cycle assessment of products; Material flow analysis, cost-benefit analysis

Suggested academic background

This research assignment is open to any graduating Master students from Leiden University, TU Delft and Erasmus Rotterdam

- MSc Healthcare Management, for multi-criteria analyses
- MSc Global Business and Sustainability, for cost-benefit analyses
- MSc Industrial Ecology students, for life cycle assessment / material flow analyses
- MSc Population Health Management
- MSc Health Sciences
- MSc Industrial Design Engineering

Available data/reports or other relevant information sourcees for the assignment

Chua ALB, Amin R, Zhang J, Thiel CL, Gross JS. The Environmental Impact of Interventional Radiology: An Evaluation of Greenhouse Gas Emissions from an Academic Interventional Radiology Practice. J Vasc Interv Radiol. 2021 Jun;32(6):907-915.e3. doi: 10.1016/j.jvir.2021.03.531. Epub 2021 Mar 29. PMID: 33794372.

Brassil MP, Torreggiani WC. Recycling in IR, What IR Specialists Can Do to Help. Cardiovasc Intervent Radiol. 2019 Jun;42(6):789-790. doi: 10.1007/s00270-019-02206-9. Epub 2019 Mar 18. PMID: 30887103.

Assignment 5

In-house developed tests versus commercial tests: what are the implications of medical device regulation (MDR) for sustainability?

Problem statement

The newly introduced European rules for medical devices (MDR) and In Vitro Diagnostic Regulation (IVDR) affect manufacturers, importers and distributors of medical devices. For example, a product may now fall into a different risk class and therefore must meet stricter safety and quality requirements. These rules have consequences for healthcare institutions, healthcare providers and (indirectly) for patients.

This research assignment investigates the implications for clinical laboratories. In clinical laboratories, blood samples are analyzed to determine the concentration of certain medicines, such as antibiotics and anti-cancer drugs. These measurements are essential because some drugs may be harmful to the patient if dosed too high or will not have the desired effect if dosed too low. In the past, most labs developed their own test methods, manufacturing their own reagents, diluents, standard solutions. These are so-called 'in-house developed tests' (LDTs). With the introduction of the new IVDR, laboratories will be required to switch to commercially available test methods. This raises the question: what will the environmental, social and economic implications of the transition be?

Research question(s)

What are the environmental, social and economic costs and benefits of commercial tests vs. In-house developed tests? **Case study: IVD-R proof LC-MS assay kit**

Expected type of work

Literature review, interviews in the lab and/or with commercial suppliers, cost-benefit analysis, life cycle assessment

Suggested academic backgrounds

This research assignment is open to any graduating Master students from Leiden University, TU Delft and Erasmus Rotterdam

- MSc Health Economics, Policy & Law
- MSc Governance of Sustainability
- MSc Healthcare Management
- MSc Health Sciences
- MSc Industrial Ecology

Available data/reports or other relevant information sources for the assignment

McAlister S, Barratt AL, Bell KJ, McGain F. The carbon footprint of pathology testing. Med J Aust. 2020 May;212(8):377-382. doi: 10.5694/mja2.50583. Epub 2020 Apr 18. PMID: 32304240.
The carbon footprint of treating patients with septic shock in the intensive care unit.
McGain F, Burnham JP, Lau R, Aye L, Kollef MH, McAlister S.Crit Care Resusc. 2018 Dec;20(4):304-312.
The carbon footprint of an Australian satellite haemodialysis unit. Lim AE, Perkins A, Agar JW.

Assignment 6

The environmental, social and economic implications of blood-sampling at home

Problem statement

Kidney transplant receivers use immunosuppressants to prevent organ rejection. However, these immunosuppressants need to be dosed very precisely. If the dose is too low; the kidney will be rejected. If dosed too high; toxicity and organ failure may occur. Several measurements are needed to make a single dose adjustment. Therefore, these patients need to give blood samples frequently, and consequently spend a lot of time in the blood sampling facility of the hospital.

Dried blood spot sampling (DBS) is a new means of blood sampling which the patients can do at home. This research assignment is an investigation of the environmental, social and economic implications of DBS in comparison to traditional blood sampling at the hospital. Some of the implications to consider may be: reduction of patient travel-time, different use of equipment, cost-savings.

Research question(s)

What are the environmental, economic and social impacts of DBS sampling, and how do they compare to traditional methods for blood samples?

Expected type of work

Literature review, interviews in the lab and/or with commercial supplier

Suggested academic backgrounds

This research assignment is open to any graduating Master students from Leiden University, TU Delft and Erasmus Rotterdam

- MSc Healthcare Management
- MSc Innovation Management
- MSc Governance of Sustainability
- MSc Health Sciences

Available data/reports or other relevant information sources for the assignment

McAlister S, Barratt AL, Bell KJ, McGain F. The carbon footprint of pathology testing. Med J Aust. 2020 May;212(8):377-382. doi: 10.5694/mja2.50583. Epub 2020 Apr 18. PMID: 32304240.

The carbon footprint of treating patients with septic shock in the intensive care unit. McGain F, Burnham JP, Lau R, Aye L, Kollef MH, McAlister S.Crit Care Resusc. 2018 Dec;20(4):304-312.

https://www.lumc.nl/org/transplantatie-centrum/patienten/praktische-informatie/2007342/

Assignment 7

Towards sustainability in the clinical microbiology laboratory

Problem statement

Only recently, hospitals started to take sustainability into account by signing a Green Deal to improve environmental sustainability in healthcare (Green Deal Duurzame Zorg, 2019). Although healthcare is necessary, it is carbon-intensive and has a negative impact on climate change. Besides patient-care, care-supporting departments, like a microbiology laboratory should also take responsibility for these developments.

In a microbiology lab, infectious samples are handled, which should not be contaminated and should not be transmitted to health care workers. It is important to keep patients and healthcare workers safe, which has led to strict regulations for handling products and materials. Due to regulations that focus on safety and stability of clinical specimens, complex procedures take place with many disposable products to decrease the risk of infection. Despite all the positive characteristics of disposable consumables, the amount of waste has grown exponentially, and the harmful environmental consequences concern all parts of the product cycle: production, transport, use and disposal. This raises the question of how did this non-sustainable behavior build up over the past few years and how can we improve this?

Research question(s)

- How did unsustainable behaviour build up over the past years and which regulations played a role?
- What is the environmental impact of the clinical microbiology laboratory?
- Are there alternatives for the products and materials used that have a high environmental impact?
- Can these alternatives be designed?

Suggested academic backgrounds

This research assignment is open to any graduating Master students from Leiden University, TU Delft and Erasmus Rotterdam

- MSc Health Economics, Policy & Law
- MSc Governance of Sustainability
- MSc Healthcare Management
- MSc Health Sciences
- MSc Industrial Ecology
- MSc Technical Medicine
- MSc Medicine
- MSc Industrial design Engineering
- MSc Biomedical Engineering

Expected type of work

Ecological footprint analysis, life cycle assessment of disposable plastics; possibly design of alternative materials, engagement of companies and distributors.

Available data/reports or other relevant information sources for the assignment

Life Cycle Greenhouse Gas Emissions of Gastrointestinal Biopsies in a Surgical Pathology Laboratory, Ilyssa O Gordon, Jodi D Sherman, Michael Leapman, Michael Overcash, Cassandra L Thiel.
American Journal of Clinical Pathology, 2021
https://doi.org/10.1093/ajcp/aqab021

Carbon Footprint Modeling of a Clinical Lab
Kai Ni, Yihua Hu, Xianming Ye, Hamzah S AlZubi, Phil Goddard and Mohammed Alkahtani.
Energies 2018, 11(11), 3105
https://doi.org/10.3390/en11113105

The carbon footprint of pathology testing.
McAlister, S., Barratt, A.L., Bell, K.J. and McGain, F. (2020),
Med. J. Aust., 212: 377-382.

Assignment 8

Centralization of hospital data: what are the opportunities for sustainable patient care?

Problem statement

Healthcare professionals and hospitals devote significant attention to the registration of clinical outcome measurements, for instance pain scores or bed stay after surgery. In addition to the difficulty in obtaining reliable and meaningful scores on such measures, it is currently challenging to get insight into how such scores are influenced by procedure or organization-specific parameters. For example, thelength of the procedure, the surplus of interventions that may have been taken by the anesthesiologist during the procedure to stabilize the patient, or even the availability of nurses in perioperative processes are likely to affect scores.

Emerging technologies such as artificial intelligence may help in obtaining such insights. However, all the required data is stored in different locations for different purposes. Aggregating and standardizing data points will be a challenge. Furthermore, it is likely to face technical, regulatory, organizational obstacles, and its value to patient care is still unknown. This research assignment is an exploratory study on the challenges and opportunities in centralizing hospital data, and a holistic (i.e. people, planet, profit) examination of what its consequences may be for patient care.

Research question(s)

To what extent could centralization of hospital data facilitate sustainable patient care?

- What are the current limitations (technical, regulatory, organizational) in creating hospital data warehouses?
- What are the drivers and barriers for explorative data science studies into the relationship between clinical outcome measures and interoperative and organizational performance measures for improvement of patient care?

Suggested academic backgrounds

This research assignment is open to any graduating Master students from Leiden University, TU Delft and Erasmus Rotterdam

- MSc Innovation Management
- MSc Health Sciences
- MSc Technical Medicine
- MSc Healthcare Management

Expected type of work

State of the art research in hospital data management (literature, products on the market), interviews to get concrete information on discipline specific clinical outcome measures, how these are registered and how these are used. Needed background/ expertise: As this is a multidisciplinary topic one needs at least a basic understanding of clinical parameters, informatics and computer science.

Deliverables: a concrete proposal for bringing together relevant data sources in a durable manner to facilitate data science on the quality of care.

Assignment 9

Future perspectives for sustainability in the Central Sterile Services Department

Problem statement

Any procedure in the operating room (OR) requires the use of reusable surgical instruments. These instruments are supplied in so-called *instrument nets* that are specifically put together for an operation. As an indication, the Leiden University Medical Center (LUMC) has more than 2500 nets in stock with 2000 different compositions and uses more than 15,000 different types of instruments.

All surgical instruments are cleaned, disinfected, manually checked and sterilized after each use by 'Central Sterile Services Departments (CSSD)'. This 'RDS process' is a labour-intensive process in which a lot of water, chemicals and energy is consumed. The CSSD thus contributes to more than 10% of the CO_2 footprint in the OR center (converted ~0.5kiloton CO_2-eq per year). With this impact, the CSSD contributes to CO_2 footprint and thereby has a negative impact on environmental sustainability. However, out of literature it is not clear what the exact environmental impact is and how it can be improved. The question arises to what extent sustainability plays a role in the CSSD? Is there awareness and are departments trying to improve, or is this a subject that is still on the background because little is known?

Research question(s)

1. What is the state-of-the art of environmental sustainability in CSSD's?
2. What is the environmental impact of a CSSD?

Suggested academic backgrounds

This research assignment is open to any graduating Master students from Leiden University, TU Delft and Erasmus Rotterdam

- MSc Industrial Ecology students
- MSc Global Business and Sustainability
- MSc Healthcare Management
- MSc Global Business and Sustainability
- MSc Health sciences
- MSc Governance of Sustainability
- MSc Medicine
- MSc Technical Medicine

Expected type of work

Qualitative study, interviews, life cycle assessment

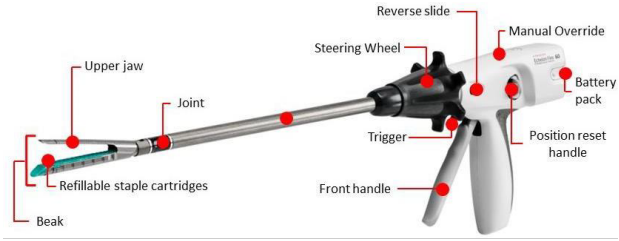
Available data/reports or other relevant information sources for the assignment

McGain et al. Hospital steam sterilizer usage: could we switch off to save electricity and water? J Health Serv Res Policy. 2016 Jul;21(3):166-71.
McGain et al. Steam sterilisation's energy and water footprint. Aust Health Rev. 2017 Mar;41(1):26-32.

Assignment 10

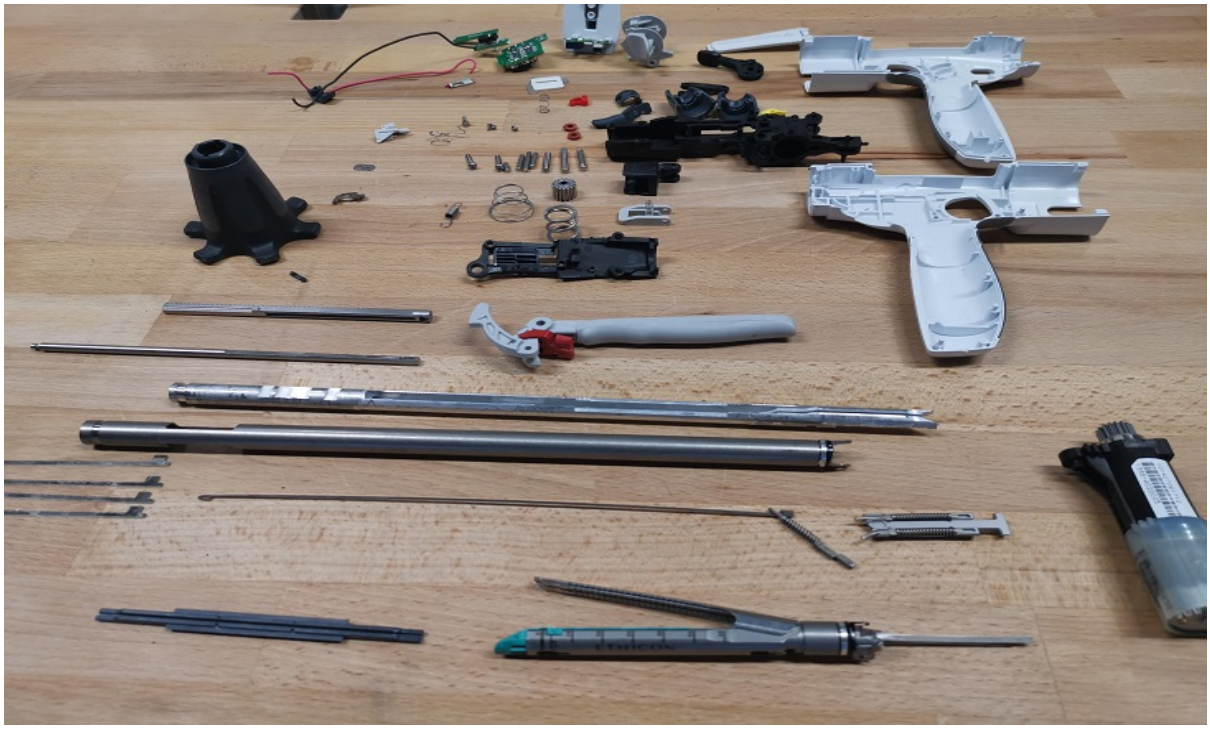
Reusing components of disposable equipment: what are the design, regulatory and supply chain implications?

Case study: Safe reuse of mechanical and electrical components of the disposable laparoscopic multistapler



Problem statement

To reduce the CO2 emission related to processing of hospital waste and the manufacturing of new medical devices, an open collaboration between industry, hospitals and universities was created within the entity GreenCycl (www.greencycl.org). In line with the goals of the Green deal, new processes are being developed that allow or foster reuse, reprocess or recycle of components from complex disposed instruments. Some of these processes are proven to be sustainable from a technical point of view. However, uncertainties in infrastructure, MDR and national or local rules and regulations prevent fast upscaling in Europe or allow the larger health industry to reuse valuable instrument parts after being harvested at our HQ living lab in the Meern.



Although the processes of GreenCycl are technically feasible, there are no general guidelines for all reprocessing steps that allow manufacturers to use refurbished components in their new devices.

Research question(s)

- What type of components from (potentially contaminated) disposable laparoscopic instruments are suitable for reuse from a Quality Assurance/Risk perspective.
- What is needed to use undamaged parts from (potentially contaminated) used surgical devices in new disposable devices of the same type.
- How can/should the integrity of parts be guaranteed.
- How does the use of reprocessed components influence a company's manufacturing line and value chain.

Expected type of work

Parts flow analysis, stakeholder analysis and legislation analysis resulting in practical guideline Including, testing, storage, wrapping, cleaning and decontamination of the parts and finally part (re)numbering before parts are brought back in circulation.

This work can be executed in close collaboration with Industry experts from GreenCycl and Van straten medical.

Available data/reports or other relevant information sources for the assignment

van Straten, B., Ligtelijn, S., Droog, L., Putman, E., Dankelman, J., Weiland, N. S., & Horeman, T. (2021). A Life Cycle Assessment of reprocessing face masks during the Covid-19 pandemic.

van Straten, B., Dankelman, J., van der Eijk, A., & Horeman, T. (2021). A Circular Healthcare Economy; a feasibility study to reduce surgical stainless steel waste. *Sustainable Production and Consumption*, *27*, 169-175.

van Straten, B., Robertson, D., Oussoren, H., Espindola, S. E. P., Ghanbari, E., Dankelman, J., ... & Horeman, T. (2021). Sterilization of disposable face masks with respect to COVID-19 shortages; a nationwide field study including 19 sterilisation departments. *medRxiv*.

van Straten, B., & Horeman, T. (2020). NEN-spec Medische Hulpmiddelen voor eenmalig gebruik: Richtlijn voor hergebruik tijdens COVID-19.

Assignment 11

The Green Baby Project: Development of a Sustainability Model to Assess the Environmental Footprint of Medical Care and Technology for Child Birth and Early Human Life

Problem statement

Modern medicine requires innovative strategies to achieve high value and sustainable outcomes for both patients and the environment, against increasing health care costs, use of materials and other sources of waste. This has become ever more evident during the COVID-19 pandemic, when strategies were rapidly developed to reduce considerable waste and environmental impact on the planet while protecting population health.

To help inform decisions on health policy, guide the development of new technology, better monitor treatments and listen to the needs of patients born into a world of rapidly evolving climate change, we need to develop reliable models for estimating the CO2 footprint of the care we wish to provide, the technology we use, the short-term and long-term effects of treatment on the environment. This will then allow us to identify critical points in the process that are best suited for redesign to reduce the visible impact (material use, waste production), hidden impact (e.g. production processes prior to material use, life cycle assessment) and improve the sustainable nature of care itself (e.g. prevention of complications, need for interventions, healthy childhood development). In the Green Baby project, we aim to develop these models for a number of use cases involving medical care and technology around the time we are born. This project is a collaboration between the Institute for Fetal and Neonatal Care and the Centre for Sustainability, as part of the Medical Delta, and will benefit from the access to real-world data from the Dutch Perinatal Registry, as well as highly detailed data from the Erasmus MC maternity and neonatal Intensive care units.

Research question(s)

What Is the CO2 footprint and environmental impact of medical care and technology around the time of birth? Development and validation of sustainability models for child birth and neonatal care.

Expected type of work

Critical appraisal of literature. Development and validation of a Greenbaby tool to assess the environmental Impact using real-world data on an Individual and national level (Big data). Working out 1-3 use cases for testing the modelling tool.

Available data/reports or other relevant information sources for the assignment

1. Dutch Government, 2021. https://www.rijksoverheid.nl/onderwerpen/duurzame-zorg/meer-duurzaamheid-in-de-zorg
2. Van Straten B et al. A life cycle assessment of reprocessing face masks during the COVID-19 pandemic. Sci Rep. 2021 Sep 3;11(1):17680. https://doi.org/10.1038/s41598-021-97188-5
3. Been JV et al. Impact of COVID-19 mitigation measures on the Incidence of preterm birth: a national quasi-experimental study. Lancet Public Health. 2020 Nov;5(11):e604-e611.
4. https://www.lunduniversity.lu.se/article/four-lifestyle-choices-most-reduce-your-carbon-footprint
5. B. Porcelijn & CE Delft. 2017. The Hidden Impact. https://thinkbigactnow.org/en/