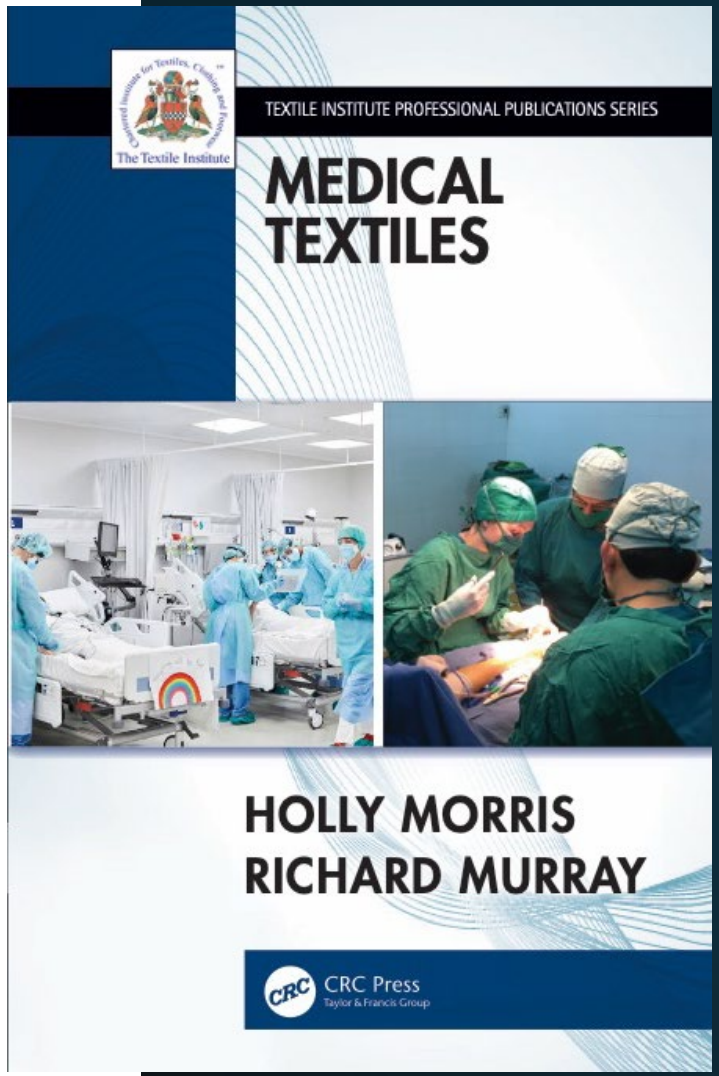
A Clinical Perspective on Improving Sustainability within Healthcare Textiles

Holly Morris CText FTI FRCSEd FHEA

Consultant Hand Surgeon

Disclosures

- Fellow of Textile Institute (Medical Textiles) and Member of Council
- Author of Textile Institute Professional Publication “Medical Textiles”
- Author of the Textile Progress entitled “Medical Textiles”
- Previous Member of Green Surgery Oversight Committee
- UKHACC Report – Medical Textile Guidance
- Medical Textile Working Party for Healthcare Without Harm
- Previously Chief Medical Officer for Revolution-ZERO. Have current financial interest.



Background

- Over (just!) 20 years in medical field
- Trained as Trauma and Orthopaedic surgeon
- Hand and microsurgical surgeon
- Interest in paediatric and congenital hands
- Undertake research related to fibres/fabrics in healthcare

- Developed interest in medical textiles based on love of textiles as a child

PULVERTAFT HAND CENTRE

The Pulvertaft Hand Centre within the Royal Derby Hospital

Te Whatu Ora
Health New Zealand

Definitions

Textile

“woven fabric, fibres, filaments and yarns, natural and manufactured, and most products for which these are a principal raw material”

Medical Textile

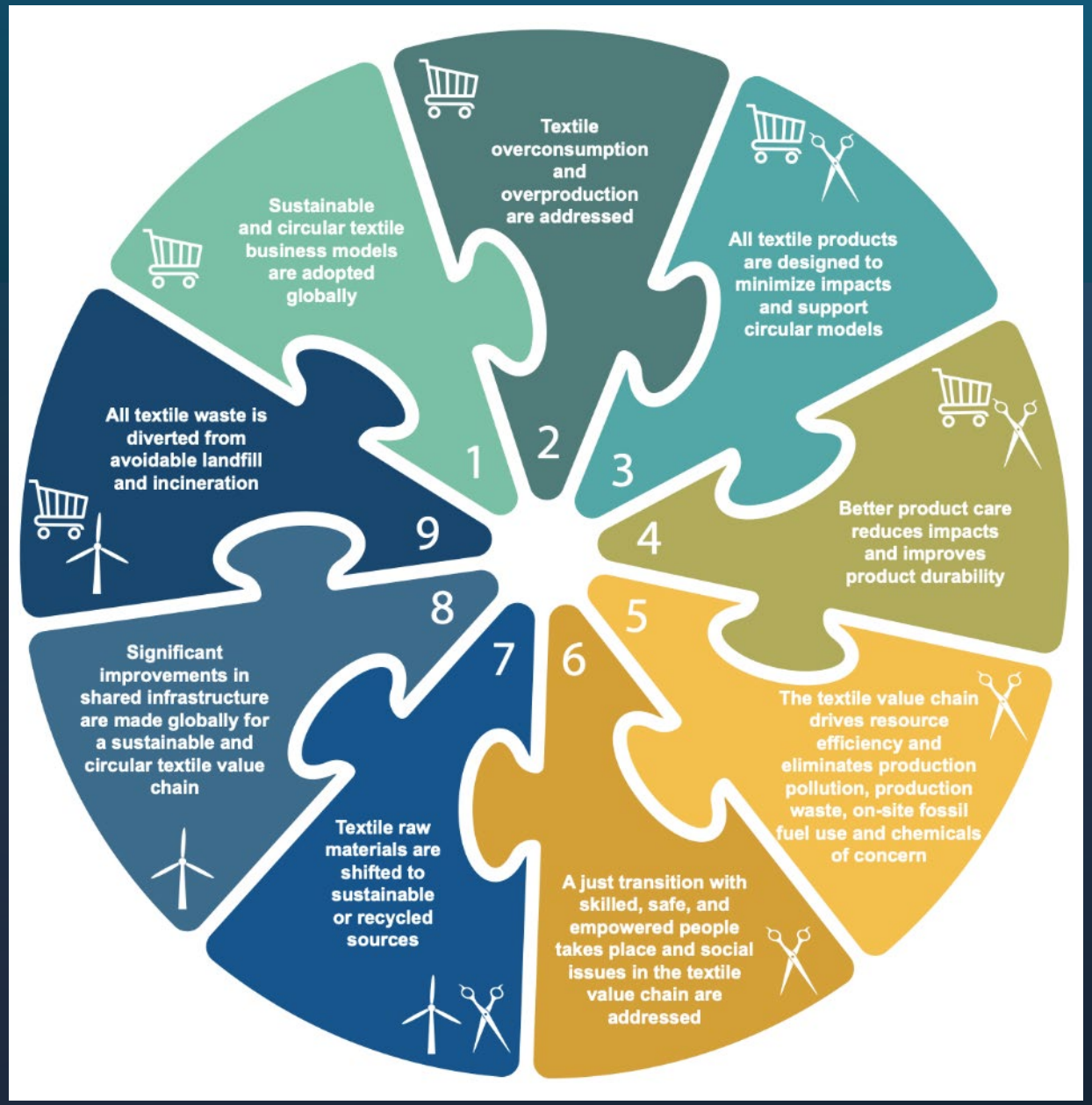
“a textile structure which has been designed and produced for use in any of a variety of medical applications, including implantable applications”

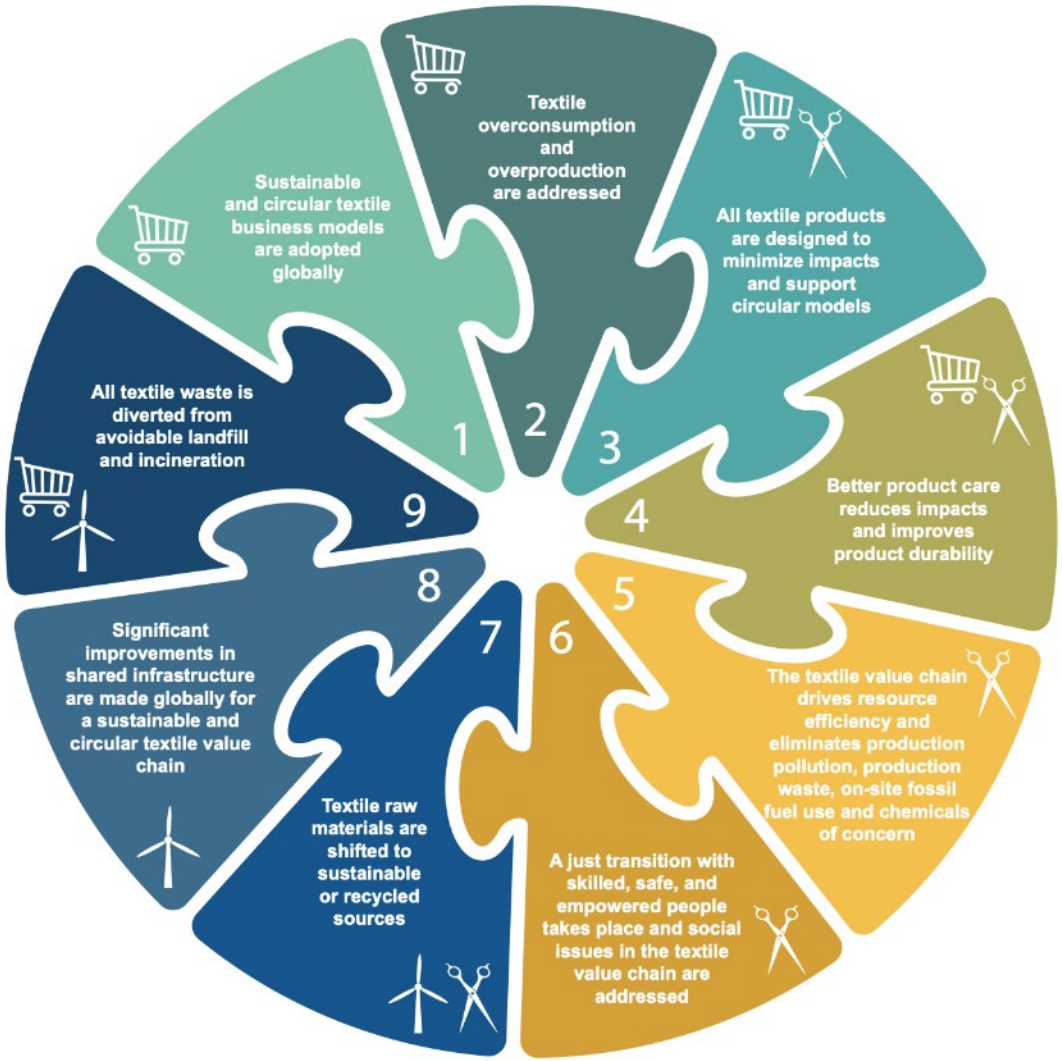
(The Textile Institute, 2024)

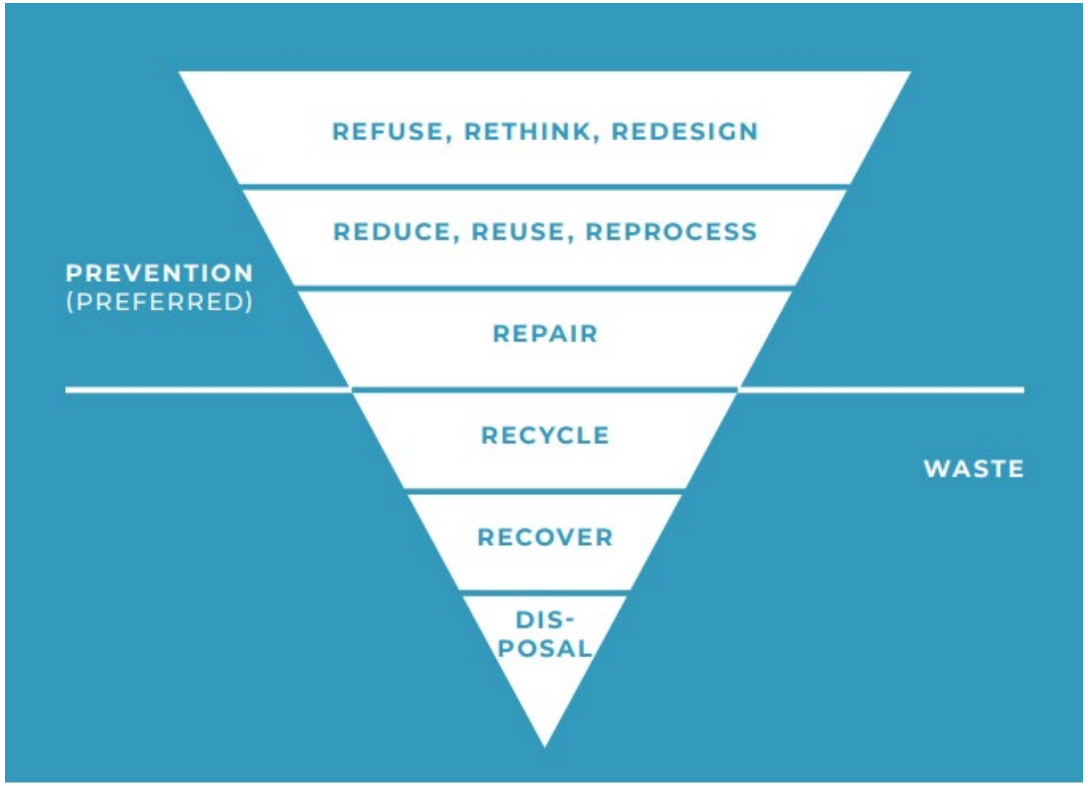
Medical Textiles

- Emerging subspecialist field
- First recognized as a field of the technical textile industry in 1995
- Fastest growing sector of technical textile industry
  - 2020 USD 13 billion
  - 2023 USD 33 billion
  - 2032 USD 48 billion
    - Global orthopaedic market 2019 USD 45 billion

(Morris & Murray, 2021)


1
Textile overconsumption and overproduction are addressed
2
All textile products are designed to minimize impacts and support circular models
3
Better product care reduces impacts and improves product durability
4
The textile value chain drives resource efficiency and eliminates production pollution, production waste, on-site fossil fuel use and chemicals of concern
5
A just transition with skilled, safe, and empowered people takes place and social issues in the textile value chain are addressed
6
Textile raw materials are shifted to sustainable or recycled sources
7
Significant improvements in shared infrastructure are made globally for a sustainable and circular textile value chain
8
All textile waste is diverted from avoidable landfill and incineration
9
Sustainable and circular textile business models are adopted globally





The waste hierarchy [Adapted from Zero Waste Europe's Zero waste hierarchy]

Why does it matter?

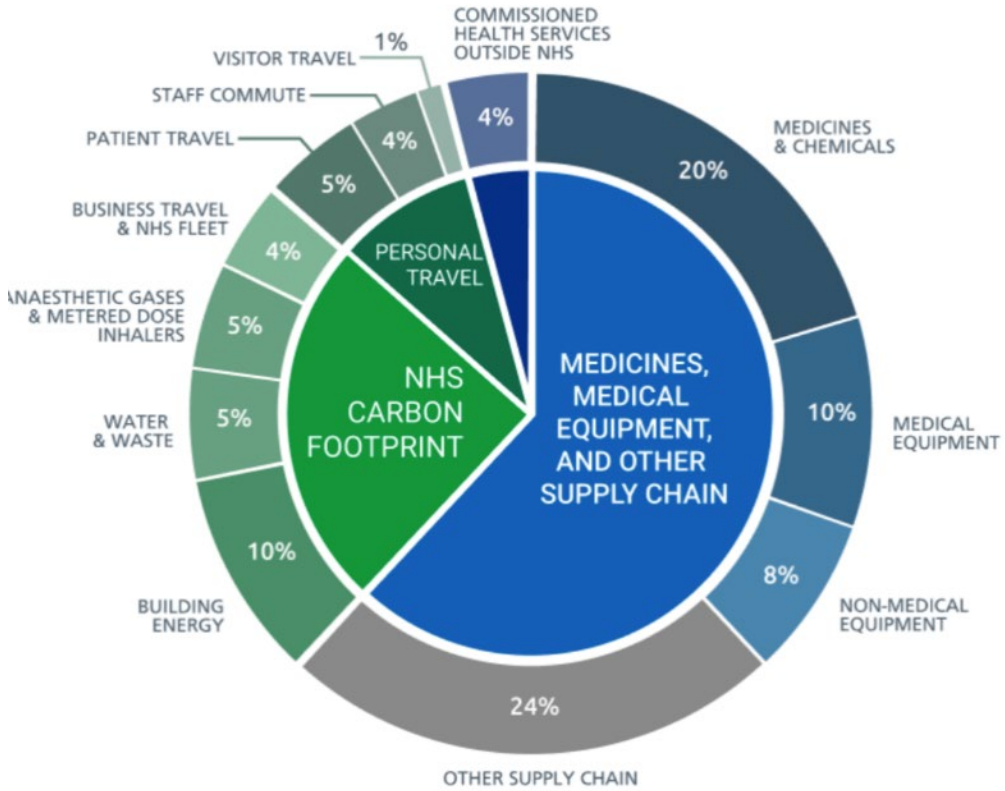
NHS Carbon Footprint

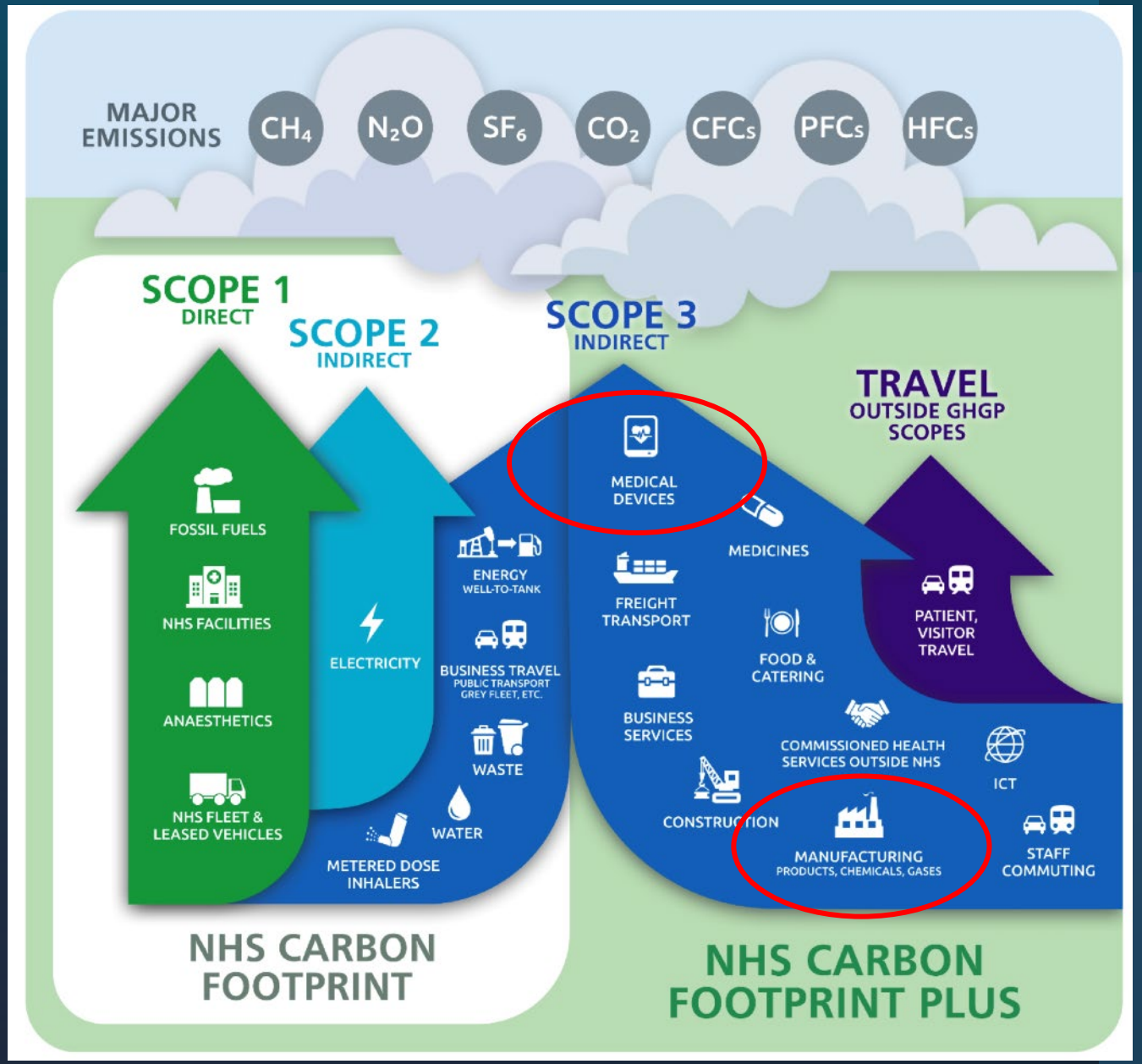
62% **Medicines, Equipment, Supply chain**

5% **Anaesthetic gases**

15% **Energy, water and waste**

14% **Travel (staff & patients)**




MAJOR EMISSIONS
CH_4
N_2O
SF_6
CO_2
CFCs
PFCs
HFCs
SCOPE 1
DIRECT
SCOPE 2
INDIRECT
SCOPE 3
INDIRECT
TRAVEL
OUTSIDE GHGP SCOPES
FOSSIL FUELS
NHS FACILITIES
ANAESTHETICS
NHS FLEET & LEASED VEHICLES
ELECTRICITY
ENERGY WELL-TO-TANK
BUSINESS TRAVEL PUBLIC TRANSPORT GREY FLEET, ETC.
WASTE
WATER
METERED DOSE INHALERS
MEDICAL DEVICES
MEDICINES
FREIGHT TRANSPORT
FOOD & CATERING
BUSINESS SERVICES
COMMISSIONED HEALTH SERVICES OUTSIDE NHS
ICT
CONSTRUCTION
MANUFACTURING PRODUCTS, CHEMICALS, GASES
STAFF COMMUTING
PATIENT, VISITOR TRAVEL
NHS CARBON FOOTPRINT
NHS CARBON FOOTPRINT PLUS

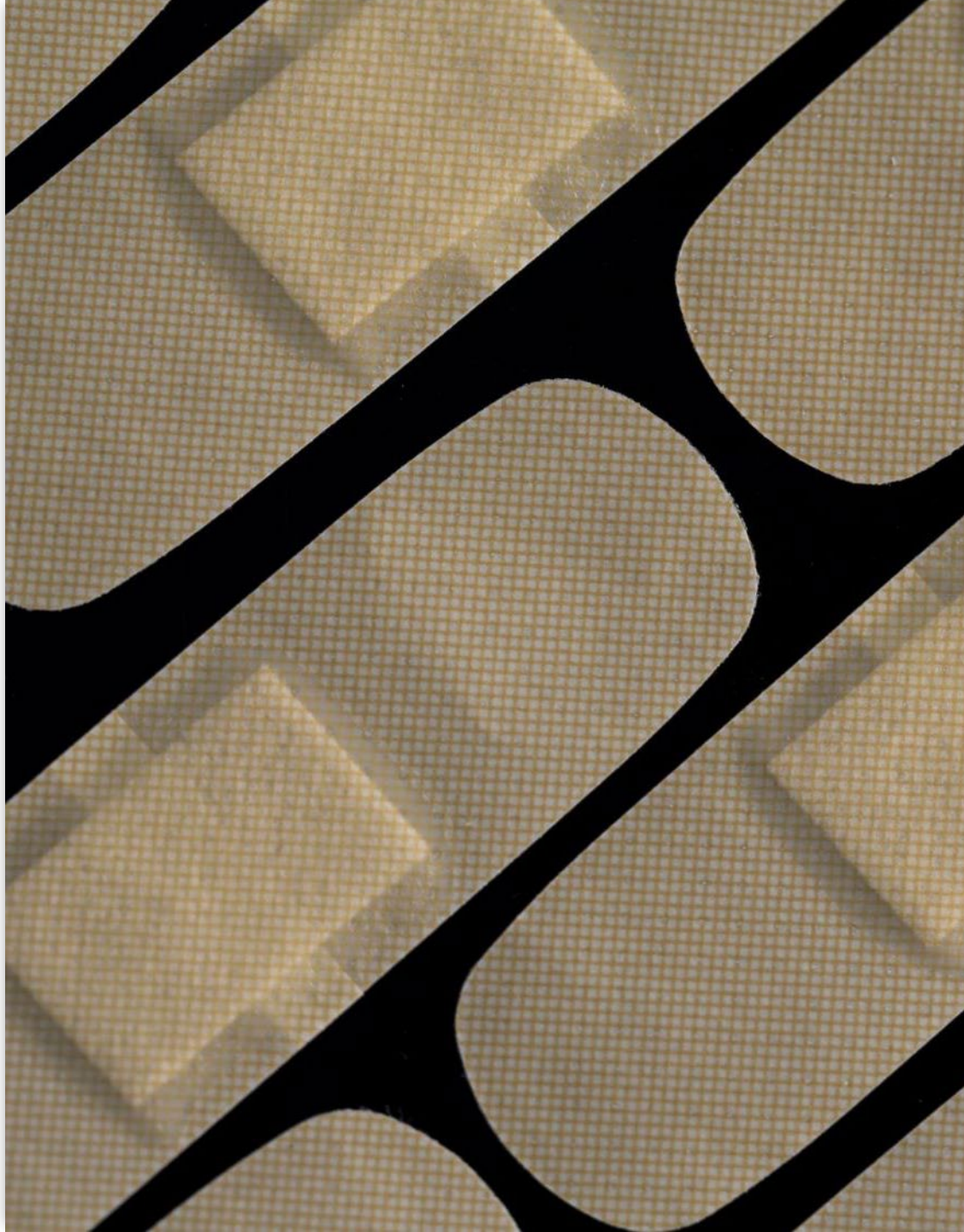
The main components of healthcare waste…

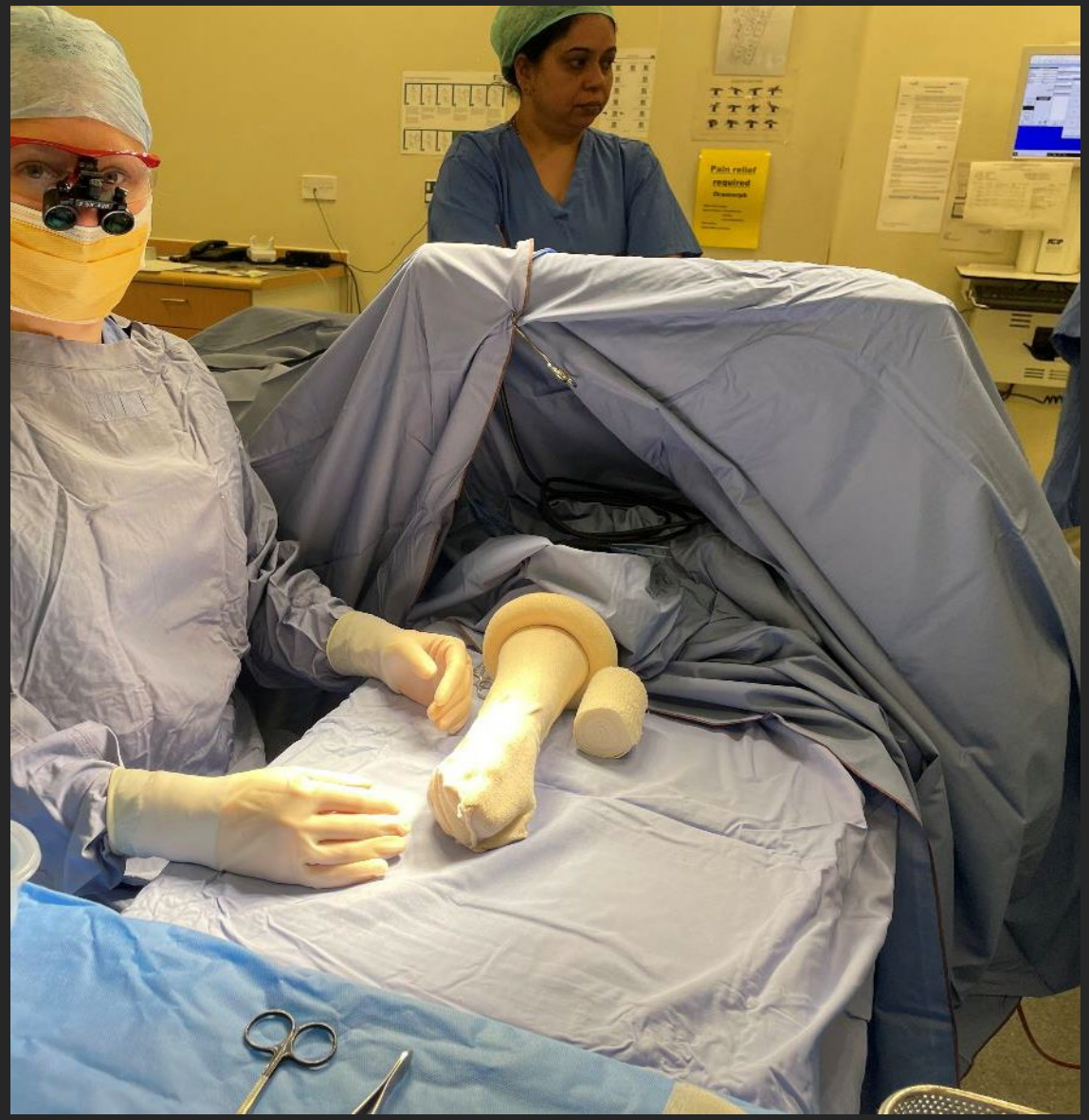
- Plastic (39.3-50%)
- Textiles (14-31%)
- Paper (11.2-25%)
- Glass (0.3-22.7%)
- Wood (3.2-20%)
- Rubber (3.4-6.6%)
- Metal (0.3-5%)
- Other waste (1.4-18.6%)

Medical Textile Subfields

(Morris and Murray 2021)

- Implantable
- Non-Implantable
- Healthcare and hygiene
- Extracorporeal
- Smart Textiles
- Furnishing fabrics and textiles in healthcare settings
- Components of devices for environmental control

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What solutions do we have?

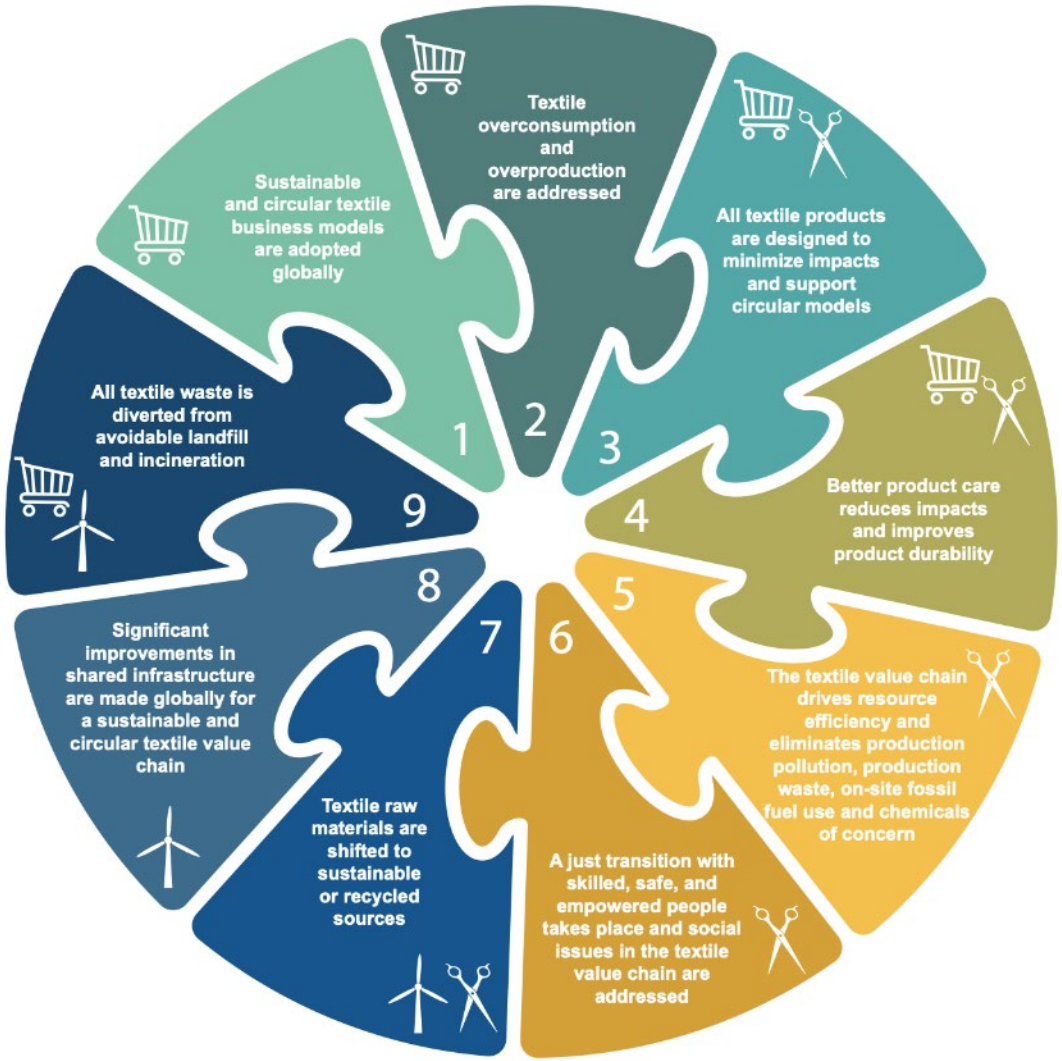
Green Surgery

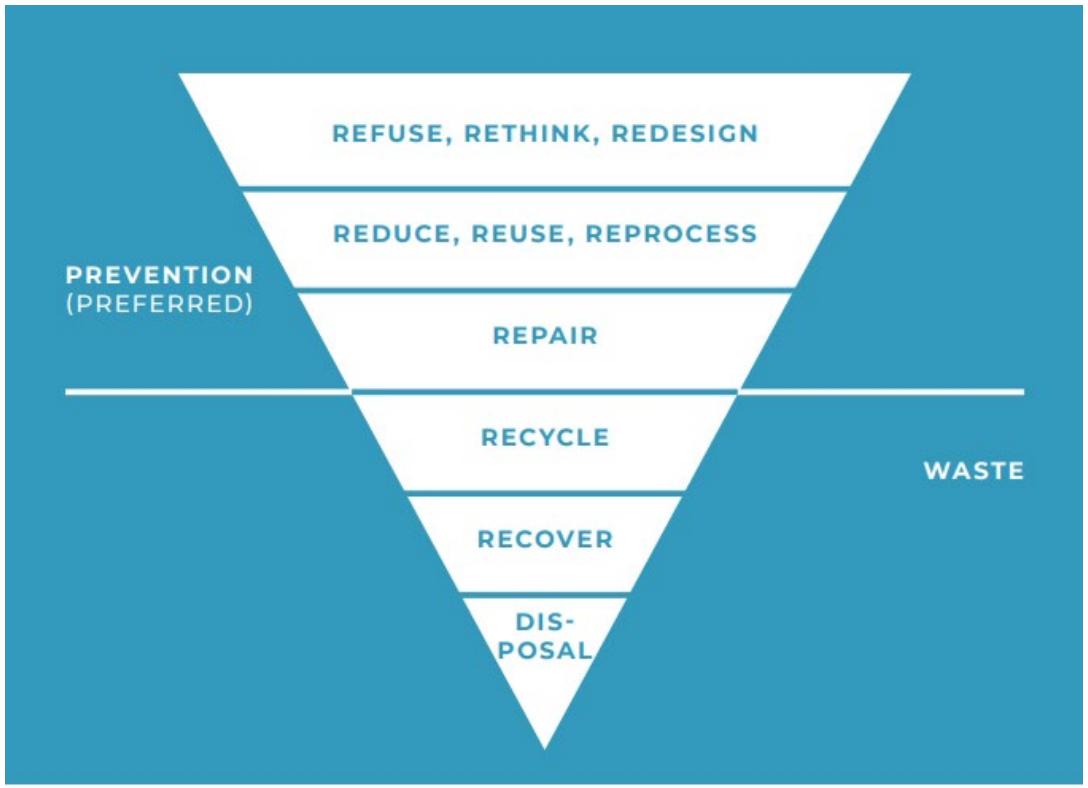
Reducing the environmental impact of surgical care

brighton and sussex medical school

CENTRE for SUSTAINABLE HEALTHCARE

UK Health Alliance on Climate Change





The waste hierarchy [Adapted from Zero Waste Europe's Zero waste hierarchy]

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Royal College of Surgeons of England
ADVANCING SURGICAL CARE

ROYAL COLLEGE OF PHYSICIANS AND SURGEONS OF GLASGOW

RCSI

Intercollegiate Green Theatre Checklist

Below are a list of recommendations to reduce the environmental impact of operating theatres. All the relevant guidance and published evidence has been included in the Compendium of evidence, accessed via the QR code:

Anaesthesia

1	Consider local/regional anaesthesia where appropriate (with targeted O_2 delivery only if necessary)	☐
2	Use TIVA whenever possible with high fresh gas flows (5-6 L) and, if appropriate, a low O_2 concentration	☐
3	Limit Nitrous Oxide (N_2O) to specific cases only and if using: ▸ check N_2O pipes for leaks or consider decommissioning the manifold and switching to cylinders at point of use; ▸ introduce N_2O crackers for patient-controlled delivery.	☐
4	If using inhalational anaesthesia: ▸ use lowest global warming potential (sevoflurane better than isoflurane better than desflurane); ▸ consider removing desflurane from formulary; ▸ use low-flow target controlled anaesthetic machines; ▸ consider Volatile Capture Technology.	☐
5	Switch to reusable equipment (e.g. laryngoscopes, underbody heaters, slide sheets, trays)	☐
6	Minimise drug waste ("*Don't open it unless you need it*", pre-empt propofol use)	☐

Preparing for Surgery

7	Switch to reusable textiles, including theatre hats, sterile gowns, patient drapes, and trolley covers	☐
8	Reduce water and energy consumption: ▸ rub don't scrub: after first water scrub of day, you can use alcohol rub for subsequent cases; ▸ install automatic or pedal-controlled water taps.	☐
9	Avoid clinically unnecessary interventions (e.g. antibiotics, catheterisation, histological examinations)	☐

Intraoperative Equipment

10	REVIEW & RATIONALISE: ▸ surgeon preference lists for each operation - separate essential vs. optional items to have ready on side; ▸ single-use surgical packs - what can be reusable and added to instrument sets? what is surplus? (request suppliers remove these); ▸ instrument sets - open only what and when needed, integrate supplementary items into sets, and consolidate sets only if it allows smaller/fewer sets (please see guidance).	☐
11	REDUCE: avoid all unnecessary equipment (eg swabs, single-use gloves), "*Don't open it unless you need it*"	☐
12	REUSE: opt for reusables, hybrid, or remanufactured equipment instead of single-use (e.g. diathermy, gallipots, kidney-dishes, light handles, quivers, staplers, energy devices)	☐
13	REPLACE: switch to low carbon alternatives (e.g. skin sutures vs. clips, loose prep in gallipots)	☐

After the Operation

14	RECYCLE or use lowest carbon appropriate waste streams as appropriate: ▸ use domestic or recycling waste streams for all packaging; ▸ use non-infectious offensive waste (yellow/black tiger), unless clear risk of infection; ▸ ensure only appropriate contents in sharps bins (sharps/drugs); ▸ arrange metals/battery collection where possible.	☐
15	REPAIR: ensure damaged reusable equipment is repaired, encourage active maintenance	☐
16	POWER OFF: lights, computers, ventilation, AGSS, temperature control when theatre empty	☐

DISCLAIMER: These suggestions are based upon current evidence and broadly generisable, however, specific environmental impacts will depend upon local infrastructure and individual Trusts' implementation strategies.

Intercollegiate Green Theatre Scorecard. November 2022.


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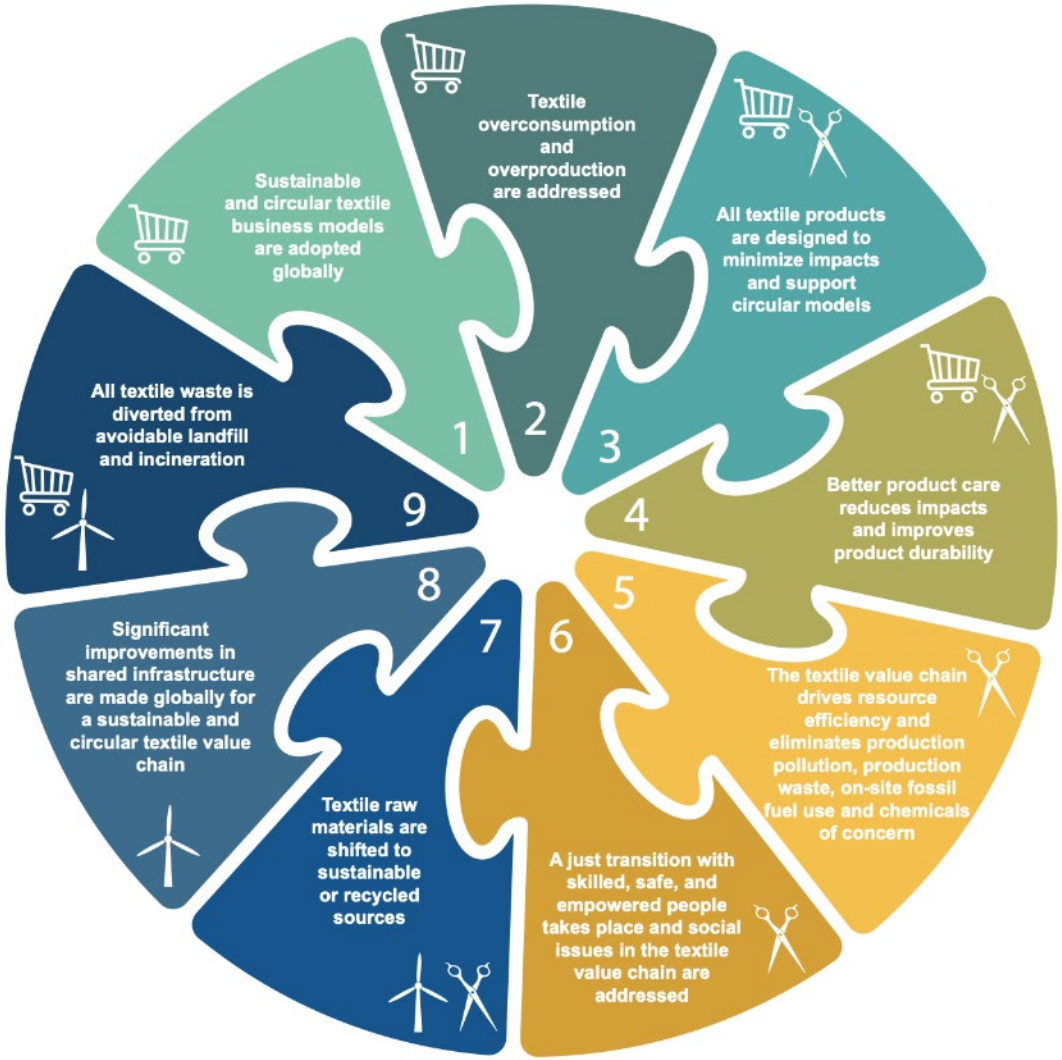
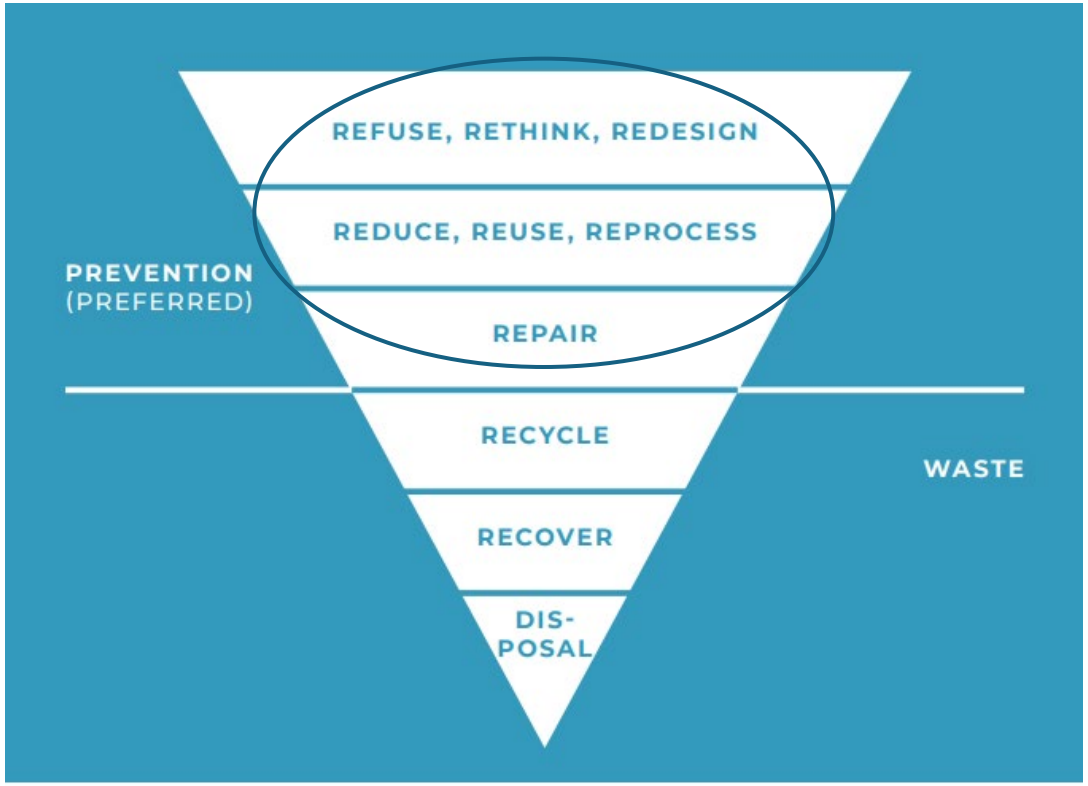
Prevention is BETTER than cure





The waste hierarchy [Adapted from Zero Waste Europe's Zero waste hierarchy]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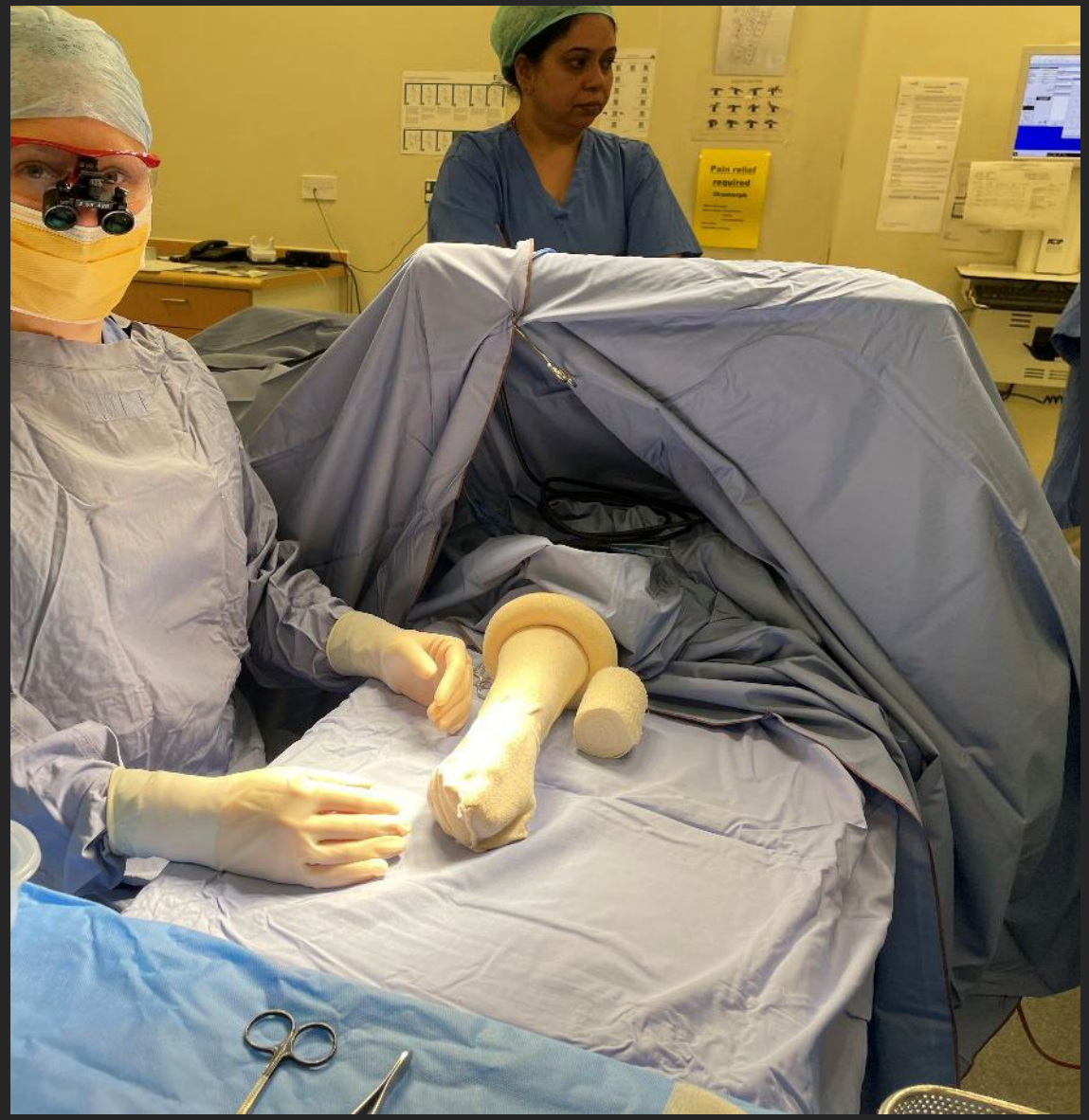
Reduce, Reuse, Reprocess

- Significant carbon footprint reductions can be seen by switching from single-use to reusable products

- The majority of carbon footprint for a reusable item is from the reprocessing phase
  - Sterilisation of reusable products has been shown to be responsible for 20% of the carbon footprint of all products in the five most common operations in England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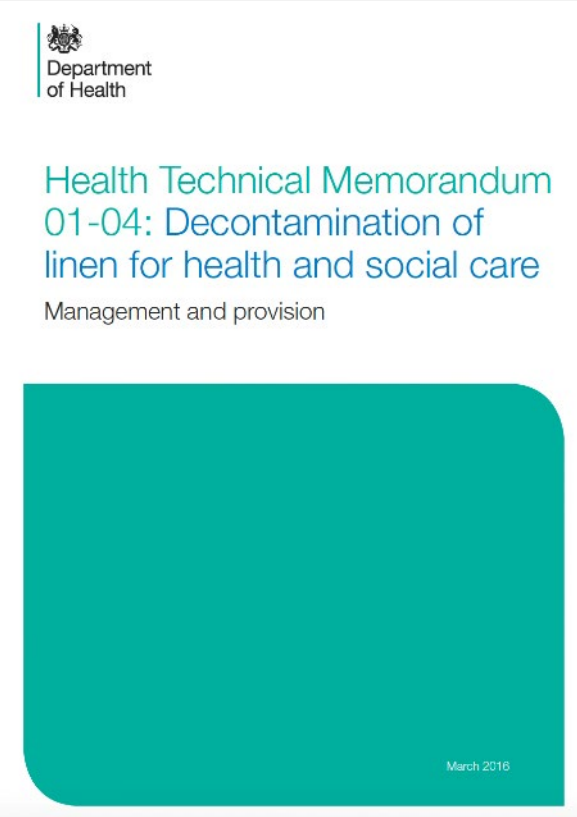
Reduce, Reuse, Reprocess

- Lack of attention has been paid to the environmental impact of healthcare linen laundering

  - Renewable energy sources
  - Optimising machine loading
  - Using environmentally preferable detergents
  - Capturing microfibres

Decontamination of linen



For thermal disinfection methods, the washing process should have a cycle in which the temperature of the load is either maintained

at 71°C for not less than three minutes

or at 65°C for not less than ten minutes

or (but alternative time/temperature relationships may be used provided the efficacy of the process is equal to the 65°C or 71°C processes).

Mixing time should be added to ensure heat penetration and assure disinfection across the wash load.

Renewable Energy Sources

Optimizing Machine Loading

- Correct weight of textiles
- Factor in how dirty
- Correct ratio of textiles
- Time
- Temperature
- Careful mixing

- Drying

? Polymer bead laundering

? Polymer bead laundering

	Baseline		Xeros	
Fixed Costs				
Fixed Costs	Purchase Price	$13,000.00	Yearly Lease	$11,700.00
	Yearly Machine Amortized Cost (3% for 12 years)	$1,291.35	Deposit	$2,500.00
			Borrowing Costs on Deposit (3%)	$75.00
Total Yearly Fixed Costs		**$1,291.35**		**$11,775.00**
Variable Costs				
Electical	Electricity / 1000 lb. (kWh)	9.8	Electricity / 1000 lb. (kWh)	20.1
	Electricity Cost ($ / kWh)	$0.12	Electricity Cost ($ / kWh)	$0.12
	Electricity Cost / 1000 lbs.	**$1.17**	**Electrical Cost / 1000 lbs.**	**$2.42**
Water + Sewage	Water Cost / 1000 gal	$2.55	Water Cost / 1000 gal	$2.55
	Water Used / lb Laundry (gal)	1.55	Water Used / lb Laundry (gal)	0.64
	Water Cost / 1000 lbs.	**$3.96**	**Water Cost / 1000 lbs.**	**$1.64**
Gas	Gas Cost ($ / Therm)	$1.00	Gas Cost ($ / Therm)	$1.00
	Hot Water (gal / 1000 lbs)	1233	N/A	
	Gas Use / 1000 lbs. (therm)	12.8		
	Gas Cost / 1000 lbs.	**$12.80**		
Chemical	**Chemical Cost / 1000 lbs.**	**$14.88**	**Included In Yearly Lease**	
Maintenance	Yealy Maintenance Cost	$350.00	**Included In Yearly Lease**	
	/ 1000 lbs	**$1.90**		
Total Variable Costs / 1000 lbs.		**$34.71**		**$4.06**

? Polymer bead laundering

- 60lb laundry
- 45 minutes

- 1/3 of water
- 88% less energy (as no hot water used)
- Removes 15% more water so less drying
- 4% CO_2 emissions
- Unchanged wash quality

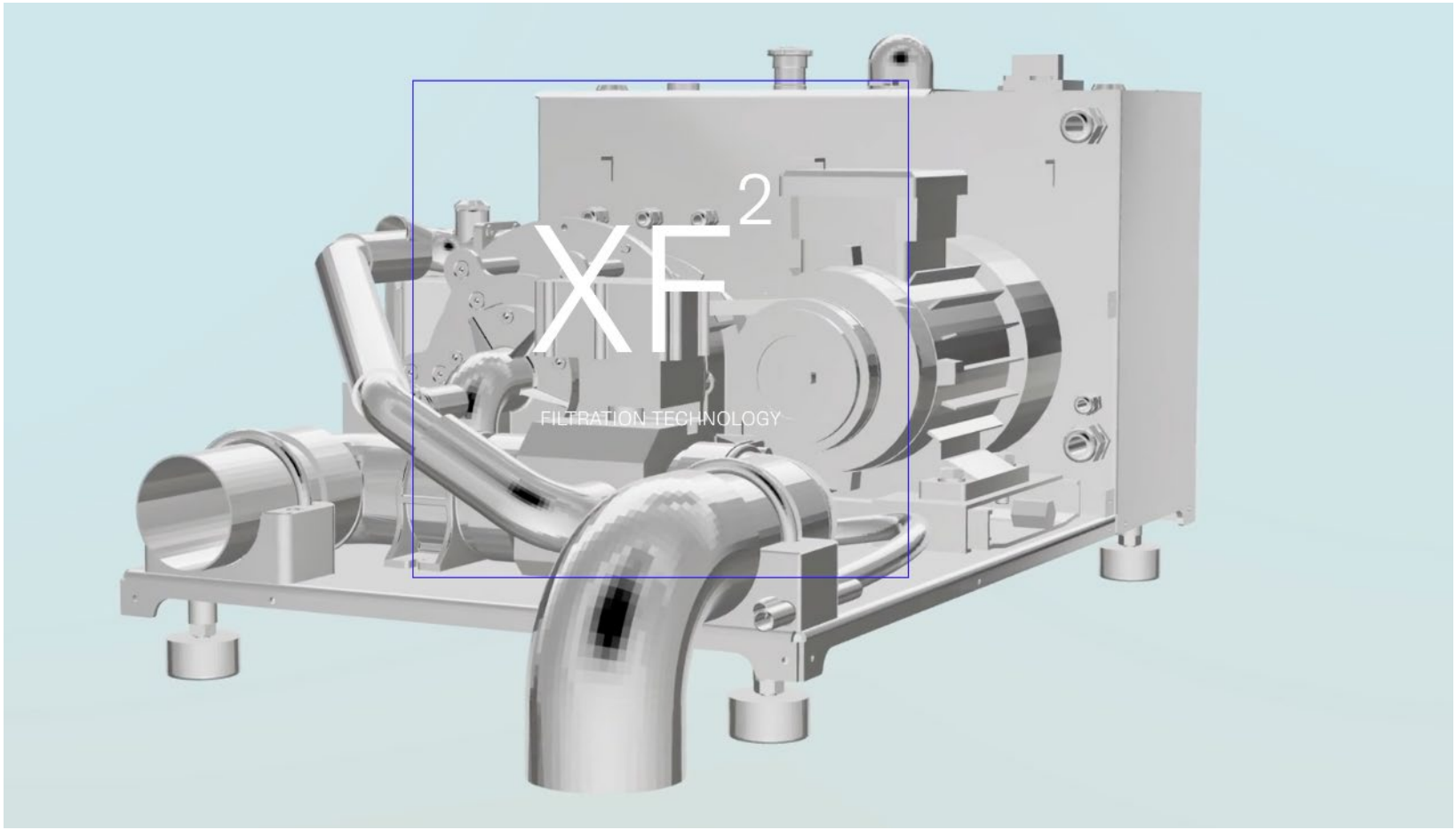
Detergents

- Synthetic surfactants
- Phosphates
- Methylene blue active substances

- Packaging

- Solutions – include coagulation, filtration, biological reactors, adsorption or advanced oxidation

Capturing Microfibres



Other alternatives....

The Engineer UK
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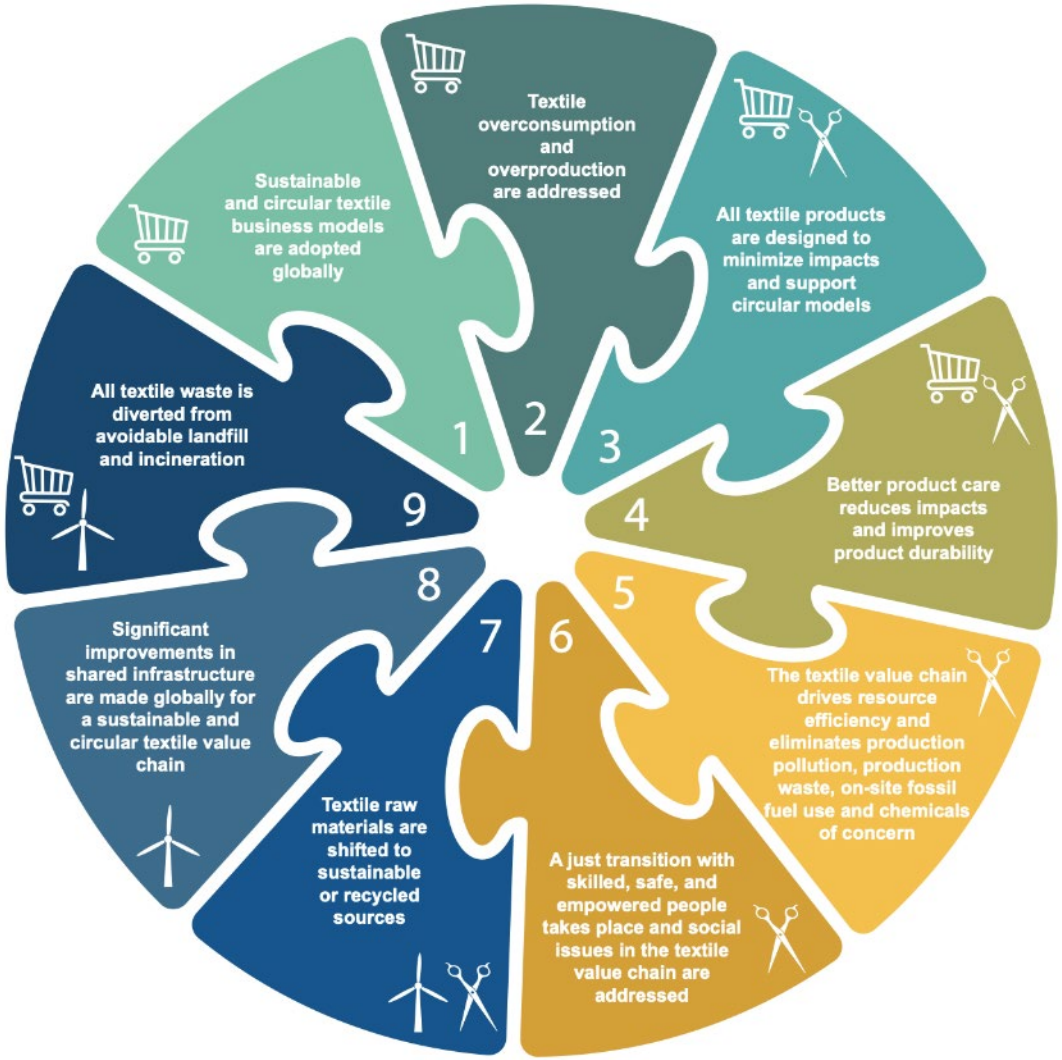
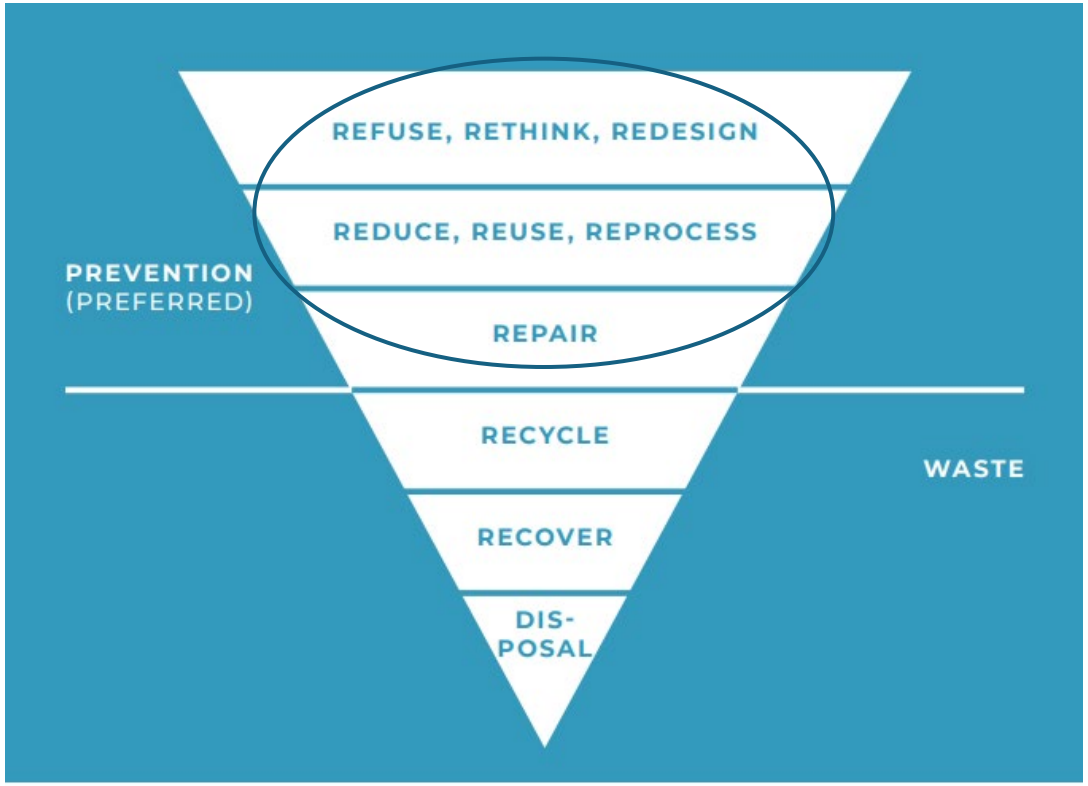
Efforts to eliminate medical textile waste are advancing in Cornwall where a new modular laundry system from Revolution-ZERO is making it easier to for hospitals to use reusable PPE.

The Engineer - Modular laundry system could help reduce medical textile waste

theengineer.co.uk • 3 min read

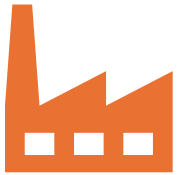




The waste hierarchy [Adapted from Zero Waste Europe's Zero waste hierarchy]

80% of the carbon footprint is determined at the design stage

Refuse, Rethink, Redesign



Medical supply chains are a major source of greenhouse gas emissions

Models for sustainable design

Reducing complexity to allow for easier reuse and recycling

Using renewable and sustainable raw materials

Reducing the amount of resource consumed

Using sustainable manufacturing processes and minimising waste

Reports of labour rights abuses in the manufacture of products used in healthcare

Refuse

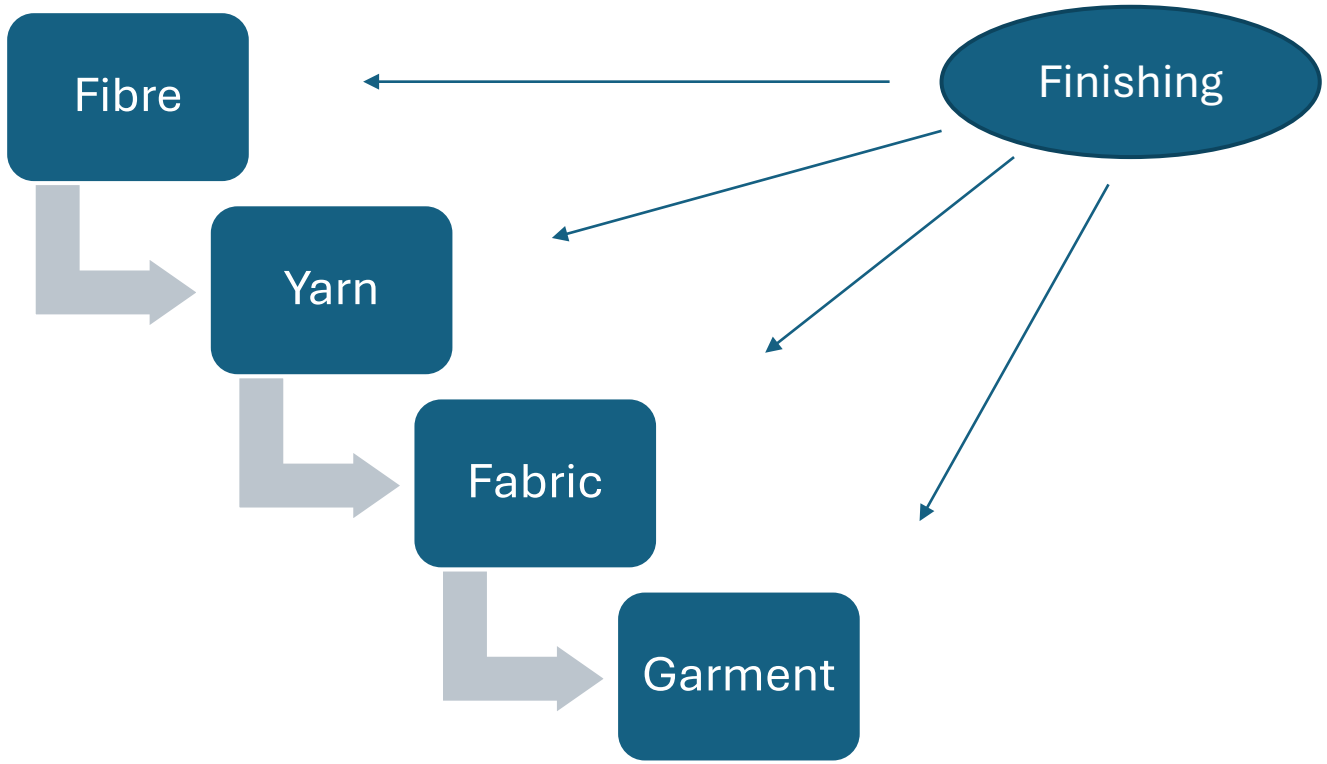
Reports of labour rights abuses in the manufacture of products used in healthcare

- More than 60 million workers are employed in the garment and footwear sector

- UNICEF estimates that more than 100 million children are affected in the garment and footwear supply chain globally
  - Child Labour – long hours, poor conditions, abuse, poor pay, no access to schooling, poor health and safety
  - Children of working parents - weak maternity protection, absence of childcare and breastfeeding support
  - Community members – access to education and schooling, poor living conditions, water, sanitation and hygiene, air pollution

- Direct reports of child abuse in manufacturing of medical textiles

Rethink



Redesign

Lead Applicant

Full Name	Professor Parikshit Goswami	**Institution**	University of Huddersfield
ORCID iD	0000-0003-1488-409X	**Position**	Associate Dean Research, Innovation, and Knowledge Exchange

Joint Lead Applicant

Full Name	Ms Holly Morris	**Institution**	University Hospitals of Derby and Burton NHS Foundation Trust
ORCID iD	0000-0001-9909-1181	**Position**	Consultant Hand Surgeon

Co-Applicant	Organisation	Specify role in resear
Dr Anna Selby	University Hospitals of Derby and Burton NHS Foundation Trust	Responsible for PPI. Lead WP2. Co-lead WP4. Part of project management team providing assistance with administration tasks within UHDB and dissemination of research findings.
Mr Nick Johnson	University Hospitals of Derby and Burton NHS Foundation Trust	Consultant hand and wrist surgeon who has experience in managing and leading NIHR grants. He will act as research and clinical adviser.

nt	Organisation	Specify role in research
	PPI representative	PPI representative - lived experience of wearing a s according to INVOLVE guidance.
Miss Kelly Halsall	BEAGLE ORTHOPAEDIC LIMITED	Commercial partner with knowledge of the splint ma experienced in delivery of new products in the NHS. WP5, WP7 and WP8.
Dr Athanasios Angelis-Dimakis	University of Huddersfield	Leading section of WP3 on LCA

Redesign

THE JOURNAL OF THE TEXTILE INSTITUTE
https://doi.org/10.1080/00405000.2024.2321633

REVIEW ARTICLE

Improving medical textiles to create a greener operating theatre

Holly Morris[a] and Richard Murray[b]

[a]Pulvertaft Hand Centre, Royal Derby Hospital, Derby, UK; [b]Manchester Metropolitan University, Wilmslow, UK

ABSTRACT

By generating almost 5% of the world's carbon emissions, healthcare, if it were a country, would be the world's fifth biggest polluter and for the UK in 2017, the health sector alone was responsible for 4.4% of its net global greenhouse gas emissions and 6.3% of that country's carbon footprint. In 2020, the UK National Health Service became the first health service to announce its intention to achieve Net Zero emissions. Between 20% and 33% of health care waste is thought to originate from a hospital's operating rooms and up to 90% of this is sent for unnecessary hazardous-waste disposal. Current practice allows the use of disposable or re-usable textile items but textile products can still account for up to 30% of the waste generated within an operating theatre. This paper explains the steps that those working in textile product development and those working in healthcare can take to reduce the textile-related carbon footprint and, in particular, to how medical textile items, such as gowns and drapes can be selected to produce a lower carbon footprint. Attention is also paid to how reusable textiles can be microbiologically decontaminated and laundered in the most economical and ecologically-acceptable fashion. The paper draws attention to the need for willingness to implement already-existing solutions for environmentally-acceptable personal protective equipment (PPE) and low carbon-footprint laundry processes for the cleaning and microbiological decontamination of all types of re-usable textiles employed within the operating theatre. Where redesign of PPE is required, the need is stressed for sensitive adjustment of standards to support the implementation of reusable forms, whilst maintaining the original high performance requirements expected in actual use.

ARTICLE HISTORY
Received 26 August 2023
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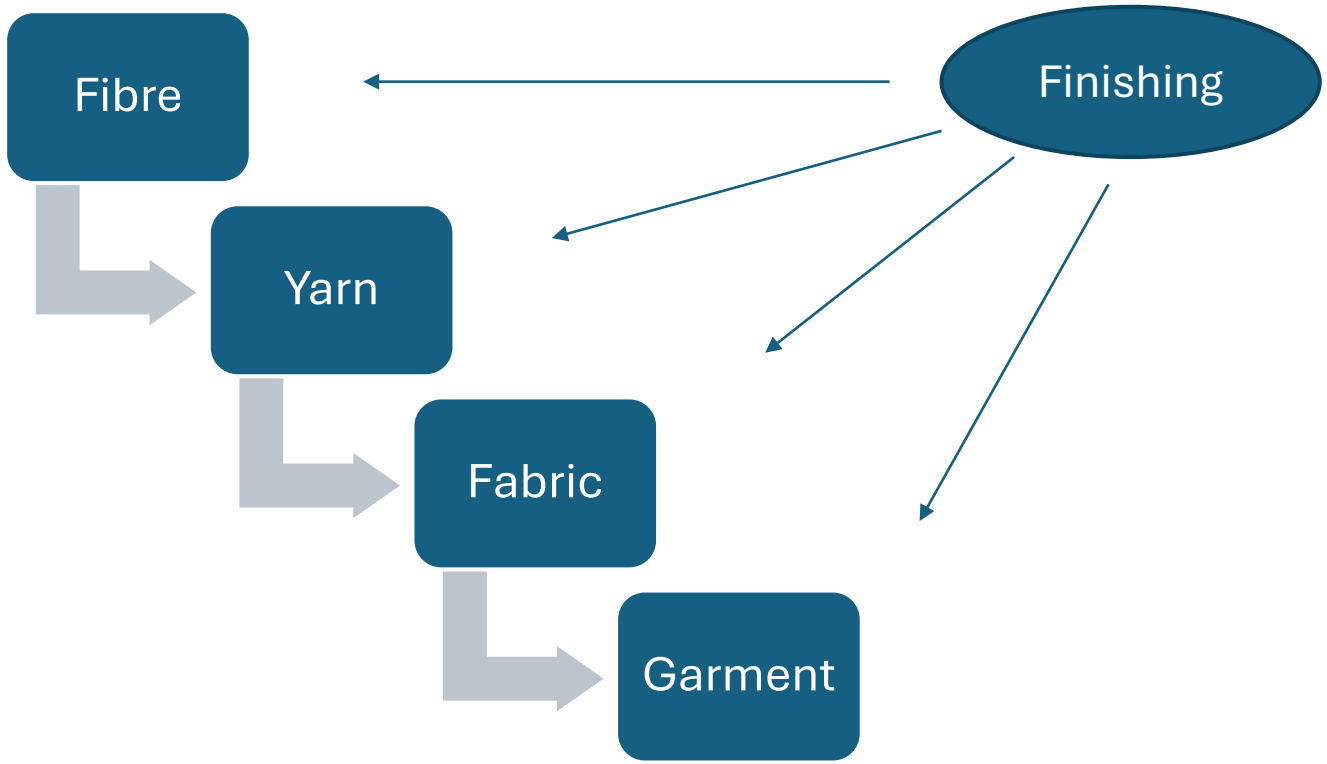
KEYWORDS
Medical textiles; sustainability; laundering; decontamination; circular economy; PPE

Rethink



Fibres/Yarn

- Eco fibres
- Waste products – fibre, water, chemicals

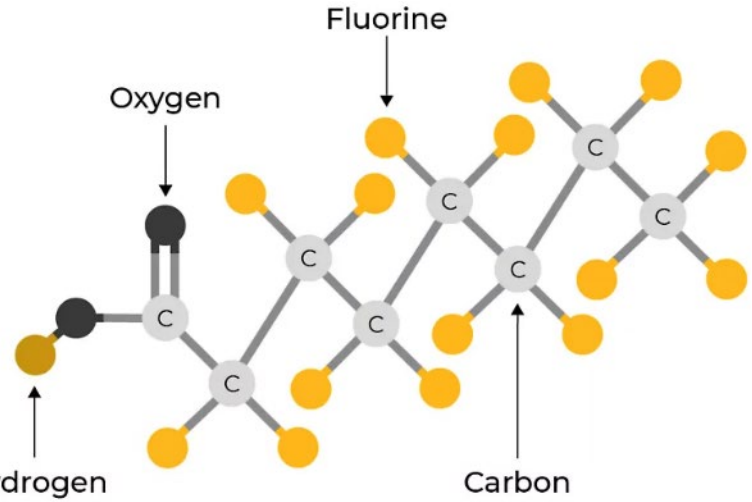
- Life cycle assessments

Fabric/Garment and Finishing

- Nanotechnology
- Waterless dyes

- Avoiding toxic chemicals eg PFAS

- Energy sources
- Waste water

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The Pulvertaft Hand Centre within the Royal Derby Hospital

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EMERGING TECHNOLOGIES CONFERENCE at Advanced Textiles EXPO

Thank you

Any questions?