

Transitioning to Reusable Medical Devices

Requirements for material logistics infrastructures

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Background



- Health care is a resource-intensive sector generating difficult-to-compose waste.
- Need for circular strategies for reusing, repairing, reprocessing, or recycling medical devices (MDs).
- In the past 30 years, high-income nations in healthcare relied on single-use (SU) MDs and downsized material logistics for reusable medical devices (RER MDs).
- Circular strategies must also focus on creating *infrastructures* for managing reusable devices.
- We present a taxonomy for reusable medical devices (RER MDs) and their requirements for material logistics infrastructure solutions in hospital settings.

- We derived data of medical devices and requirements for material logistics infrastructures from the HealthcareLCA database (Drew et al., 2022); an open-access repository for all healthcare-related Life Cycle Assessments (LCAs).
- As of December 2021, the *HealthcareLCA database* consists mostly of studies on MDs (40%), followed by pharmaceuticals (18%), procedures (11%), systems (11%), services (9%), medical interventions (5%), clinical investigations (3%), randomized controlled trails (1%), companies (1%), and industries (1%). Most studies follow a bottom-up approach, in which data is measured on the material input of a functional unit (72%); some used a top-down approach (13%).
- We reviewed additional literature and interviewed clinical and managerial staff in two leading Academic Hospitals in the Netherlands to derive cost estimates of using RER versus SU MDs.



Material logistics infrastructure components

- Transport (transportation steps of an MD through the hospital),
- ‘Tracking and tracing’ (type and tracking method of MD data to enable material logistics),
- ‘Storage space’ (space requirements to store MDs for reprocessing and repair),
- ‘Reprocessing’ and ‘Repair’ (required materials and equipment for reprocessing and repair),
- ‘Point of collection space’ (space requirements for waste recycling, incineration, landfill or external reprocessing or repair).

Criteria for evaluation

Type of reprocessing and repair

- Reprocessing:
 - Reuse and redistribution
 - Refurbishment and remanufacturing
- Reuse
 - Repair and maintenance



Types of reprocessing

- Light disinfection
- High-level disinfection
- Steam sterilization
- Hydrogen peroxide gas plasma sterilization
- Reprocessing endoscopes
- Reprocessing medical textiles
- Reprocessing SU MDs

Criteria for evaluation

Type of reprocessing and repair

- Reprocessing:
 - Reuse and redistribution
 - Refurbishment and remanufacturing
- Reuse
 - Repair and maintenance

Location of reprocessing

- Internal
- External

Types of reprocessing



Internal	External
Light disinfection (T1)	
High-level disinfection (T2)	High-level disinfection (T3)
Steam sterilization (T4)	Steam sterilization (T5)
Hydrogen peroxide gas plasma sterilization (T6)	Hydrogen peroxide gas plasma sterilization (T7)
Reprocessing endoscopes (T8)	Reprocessing endoscopes (T9)
Reprocessing medical textiles (T10)	
Reprocessing SU MDs (T11)	

Results

- Most RER MDs have lower environmental impact and/or costs compared to SU MDs
 - Hospitals should increase the use of RER MDs
 - Relying on RER MDs decreases dependency on suppliers and availability
- Transition to RER MDs requires significant changes to material logistics infrastructures
 - Infrastructure requirements are lowest for devices requiring light disinfection
 - Devices internally repaired or reprocessed have highest infrastructure requirements

Type of processing and material logistics infrastructures

Typology for all types of medical devices; all reprocessing types internal or external.

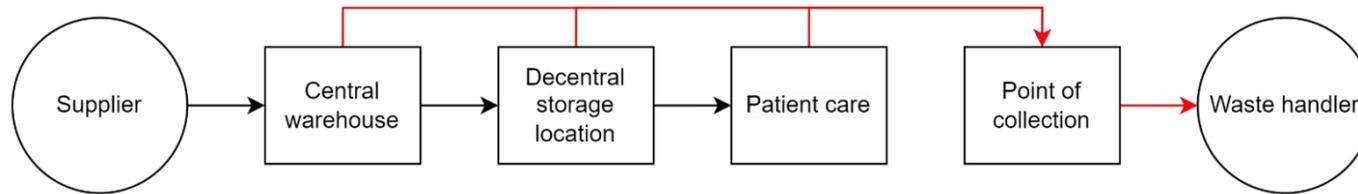
Types of MDs		Material logistics infrastructure elements and their requirements						
Reprocessing type	Internal/external	Transport	Tracking and tracing	Reprocessing	Repair	Storage space	Point of collection space	
T0	Single use medical devices (no reprocessing)	-	Figure 4	Inventory levels, current location of unique MDs, waste generated for separate	-	-	Central warehouse, decentral storage locations	Waste department for separate streams
T1	Light disinfection	Internal	Figure 5	-	Disinfection wipes, (enzyme bath), employees	-	Prolonged use (↓↓), reprocessing equipment (↑)	Prolonged use (↓↓), reprocessing equipment (↑)
T2	High-level disinfection	Internal	Figure 6	RER subparts) history: locations, #cycles	machine, PPE, packaging, employees	-	(↑↑), reprocessing packaging (↑), other reprocessing equipment (↑)	More use cycles (↓↓), reprocessing equipment (↑)
T3		External	Figure 7	Unique MD (and RER subparts) history: locations	-	-	Reprocessing time (↑↑↑)	More separate streams

Types of MDs		Material logistics infrastructure elements and their requirements					
Reprocessing type	Internal/external	Transport	Tracking and tracing	Reprocessing	Repair	Storage space	Point of collection space
T4	Internal	Figure 8	Unique MD (and RER subparts) history: locations, #cycles, #repairs	CSSD, washing machine, autoclave, sterile packaging, PPE, employees	Repair equipment, employees	Reprocessing time (↑↑), sterile packaging: blue wrap (↑) or sterile packaging: rigid sterilization containers (↑↑), other reprocessing equipment (↑)	More use cycles (↓↓), sterile packaging: rigid sterilization containers (↓)
T5	External	Figure 9	RER subparts) history: locations	-	-	Reprocessing time (↑↑↑)	More separate streams
T6	Internal	Figure 8	Unique MD (and RER subparts) history: locations, #cycles, #repairs	CSSD, washing machine, hydrogen peroxide gas plasma sterilizer, sterile packaging, PPE, employees	Repair equipment, employees	Reprocessing time (↑↑), sterile packaging (↑), other reprocessing equipment (↑)	More use cycles (↓↓)
T7	External	Figure 9	Unique MD history: locations	-	-	Reprocessing time (↑↑↑)	More separate streams

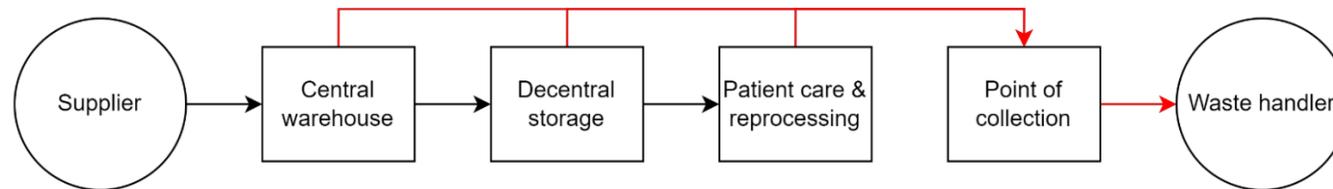
Types of MDs		Material logistics infrastructure elements and their requirements						
Reprocessing type	Internal/external	Transport	Tracking and tracing	Reprocessing	Repair	Storage space	Point of collection space	
T8	Reprocessing endoscopes	Internal	Figure 8	Unique MD (and RER subparts) history: locations, #cycles, #repairs	(CSSD), endoscope reprocessing machine, endoscope drying machine, (hydrogen peroxide gas plasma sterilizer), (sterile) packaging, PPE, employees	Repair equipment, employees	Reprocessing time (↑↑), (sterile) packaging (↑), other reprocessing equipment (↑)	More use cycles (↓↓)
T9		External	Figure 9	Unique MD history: locations	-	-	Reprocessing time (↑↑↑)	More separate streams
T10	Reprocessing medical textiles	External	Figure 7	Unique MD history: locations	-	-	Reprocessing time (↑↑↑), thicker material (↑), prolonged use (↓↓)	More separate streams
T11	Reprocessing single use medical devices	External	Figure 7	Unique MD history: locations	-	-	Reprocessing time (↑↑↑)	Lot more separate streams

Material infrastructure changes

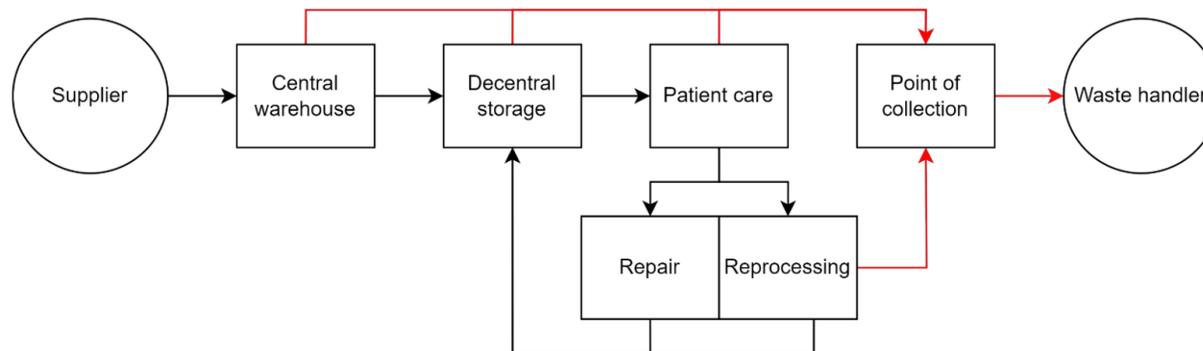
Simplified flow diagram SU MDs (and their packaging).



Simplified flow diagram of RER MDs (and their packaging) reprocessed by light disinfection.



Simplified flow diagram of RER MDs (and their packaging) internally reprocessed or repaired.



Key Insights from Previous Research:

- Developed value retention strategies for specific medical devices (MDs).
- Created circular business models tailored to the value of MDs.

Existing Gaps in previous research:

- Incomplete inclusion of all medical device types.
- Overlooked material logistics infrastructure needs.

Novel taxonomy of RER MDs and requirements for material logistics infrastructures

- Comprehensive overview and analytical lens for exploring the requirements of transitioning towards reusable medical devices (RER MDs)
- Establish consistency in terminology to advance comparisons and consistency across future healthcare sustainability studies on RER MDs
- Detail the infrastructure requirements that should be carefully considered, when transitioning towards different RER MDs.

Question

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Additional slides

Single use medical devices T0

Simplified flow diagram SU MDs (and their packaging).

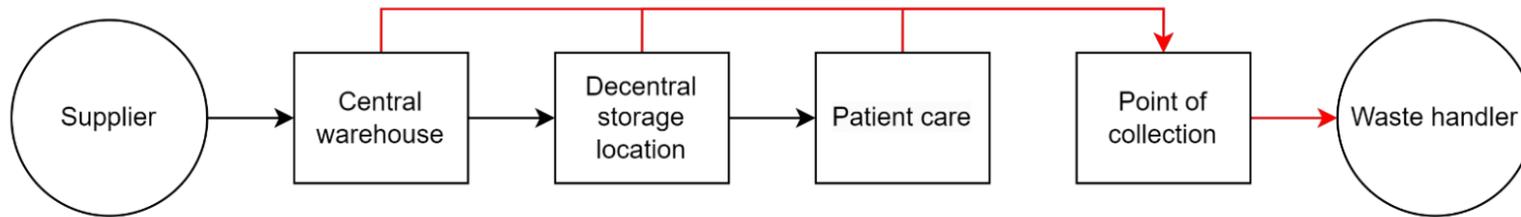


Table 2

Typology for single use medical devices (T0).

Types of MDs		Material logistics infrastructure elements and their requirements					
Reprocessing type	Internal/external	Transport	Tracking and tracing	Reprocessing	Repair	Storage space	Point of collection space
T0 Single use medical devices (no reprocessing)	-	Figure 4	Inventory levels, current location of unique MDs, waste generated for separate streams	-	-	Central warehouse, decentral storage locations	Waste department for separate streams

Light disinfection T1

Figure 5

Simplified flow diagram of RER MDs (and their packaging) reprocessed by light disinfection.

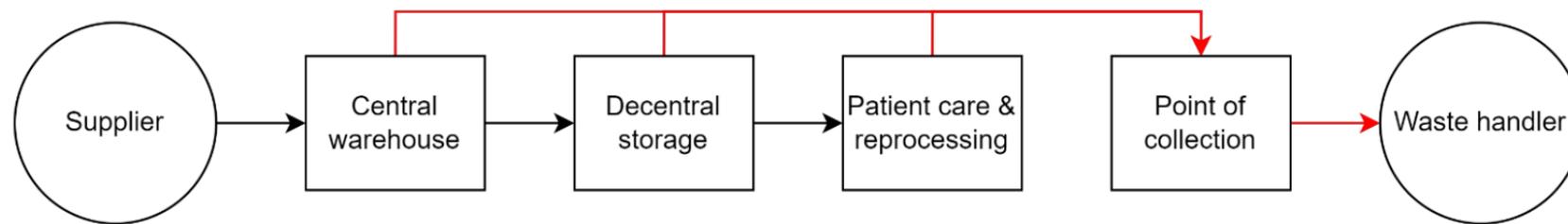


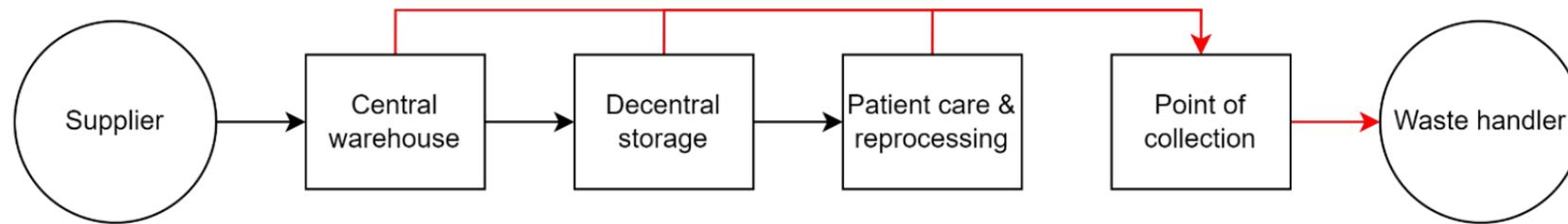
Table 3

Typology for light disinfection (T1).

Types of MDs		Material logistics infrastructure elements and their requirements						
Reprocessing type	Internal/external	Transport	Tracking and tracing	Reprocessing	Repair	Storage space	Point of collection space	
T1	Light disinfection	Internal	Figure 5	-	Disinfection wipes, (enzyme bath), employees	-	Prolonged use (↓↓), reprocessing equipment (↑)	Prolonged use (↓↓), reprocessing equipment (↑)

Light disinfection T1

Simplified flow diagram of RER MDs (and their packaging) reprocessed by light disinfection.



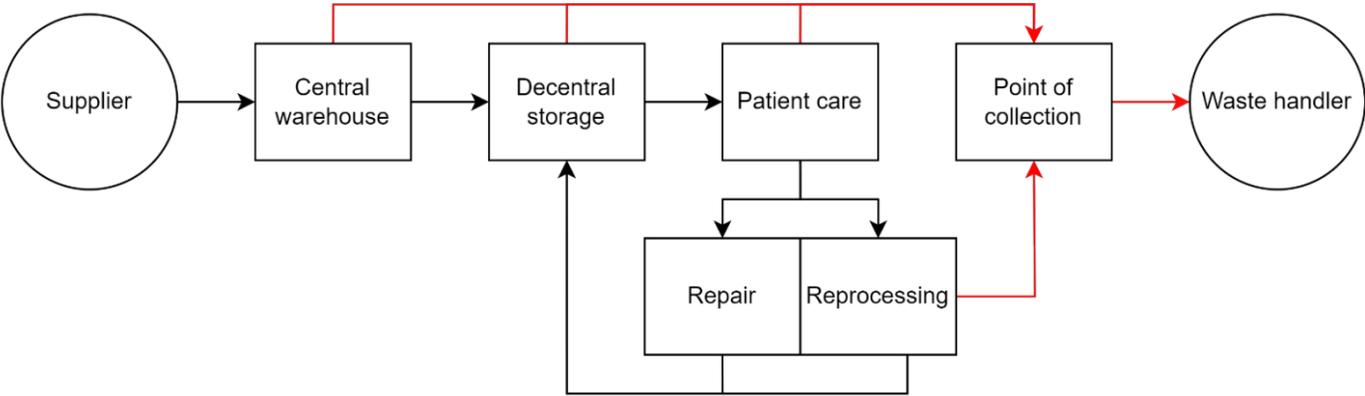
High-level disinfection (T2 & T3)

Typology for high-level disinfection internal (T2) and external (T3).

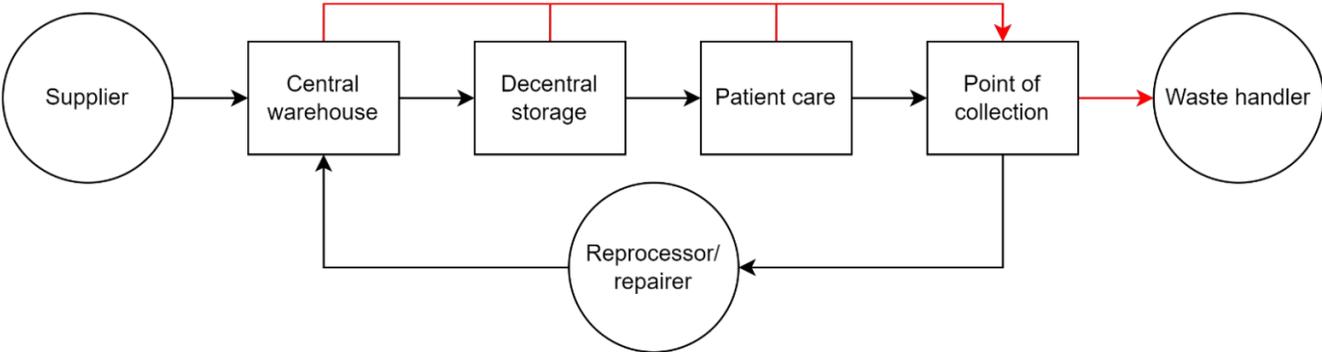
Types of MDs		Material logistics infrastructure elements and their requirements					
Reprocessing type	Internal/external	Transport	Tracking and tracing	Reprocessing	Repair	Storage space	Point of collection space
T2	Internal	Figure 6	Unique MD (and RER subparts) history: locations, #cycles	CSSD, washing machine, PPE, packaging, employees	-	Reprocessing time (↑↑), reprocessing packaging (↑), other reprocessing equipment (↑)	More use cycles (↓↓), reprocessing equipment (↑)
T3	External	Figure 7	Unique MD (and RER subparts) history: locations	-	-	Reprocessing time (↑↑↑)	More separate streams

Steam sterilization (T4 & T5)

Simplified flow diagram of RER MDs (and their packaging) internally reprocessed or repaired.



Simplified flow diagram of RER MDs (and their packaging) externally reprocessed or repaired.



Steam sterilization (T4 & T5)

Typology for steam sterilization internal (T4) and external (T5).

Types of MDs		Material logistics infrastructure elements and their requirements					
Reprocessing type	Internal/external	Transport	Tracking and tracing	Reprocessing	Repair	Storage space	Point of collection space
T4 Steam sterilization	Internal	Figure 8	Unique MD (and RER subparts) history: locations, #cycles, #repairs	CSSD, washing machine, autoclave, sterile packaging, PPE, employees	Repair equipment, employees	Reprocessing time (↑↑), sterile packaging: blue wrap (↑) or sterile packaging: rigid sterilization containers (↑↑), other reprocessing equipment (↑)	More use cycles (↓↓), sterile packaging: rigid sterilization containers (↓)
	External	Figure 9	Unique MD (and RER subparts) history: locations	-	-	Reprocessing time (↑↑↑)	More separate streams

Hydrogen peroxide gas plasma sterilization (T6 & T7)

Typology for hydrogen peroxide gas plasma sterilization internal (T4) and external (T5).

Types of MDs		Material logistics infrastructure elements and their requirements						
Reprocessing type	Internal/external	Transport	Tracking and tracing	Reprocessing	Repair	Storage space	Point of collection space	
T6	Hydrogen peroxide sterilization	Internal	Figure 8	Unique MD (and RER subparts) history: locations, #cycles, #repairs	CSSD, washing machine, hydrogen peroxide gas plasma sterilizer, sterile packaging, PPE, employees	Repair equipment, employees	Reprocessing time (↑↑), sterile packaging (↑), other reprocessing equipment (↑)	More use cycles (↓↓)
		External	Figure 9	Unique MD history: locations	-	-	Reprocessing time (↑↑↑)	More separate streams

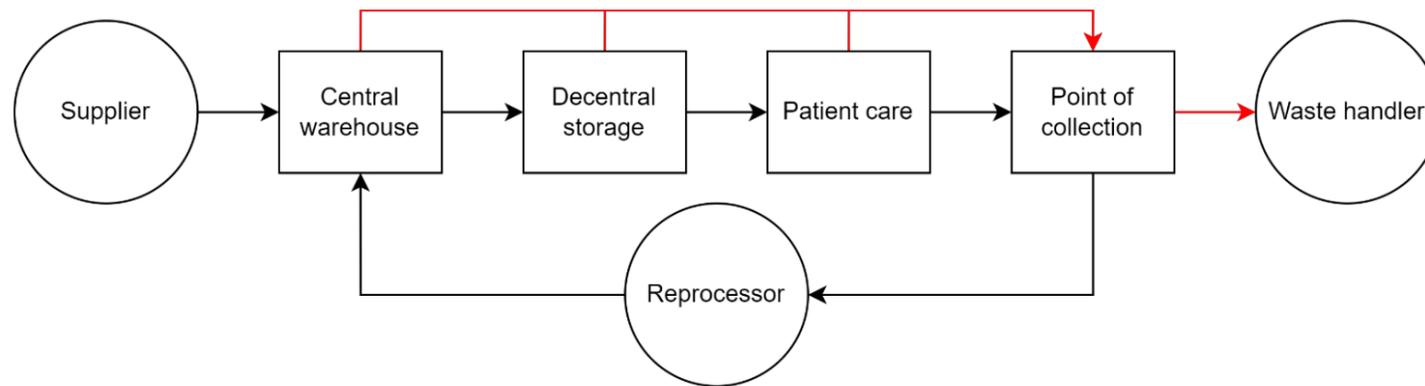
Reprocessing endoscopes (T8 & T9)

Typology for reprocessing endoscopes internal (T8) and external (T9).

Types of MDs		Material logistics infrastructure elements and their requirements						
Reprocessing type	Internal/external	Transport	Tracking and tracing	Reprocessing	Repair	Storage space	Point of collection space	
T8	Reprocessing endoscopes	Internal	Figure 8	Unique MD (and RER subparts) history: locations, #cycles, #repairs	(CSSD), endoscope reprocessing machine, endoscope drying machine, (hydrogen peroxide gas plasma sterilizer), (sterile) packaging, PPE, employees	Repair equipment, employees	Reprocessing time (↑↑), (sterile) packaging (↑), other reprocessing equipment (↑)	More use cycles (↓↓)
		External	Figure 9	Unique MD history: locations	-	-	Reprocessing time (↑↑↑)	More separate streams

Reprocessing medical textiles (T10)

Simplified flow diagram of RER MDs (and their packaging) externally reprocessed.

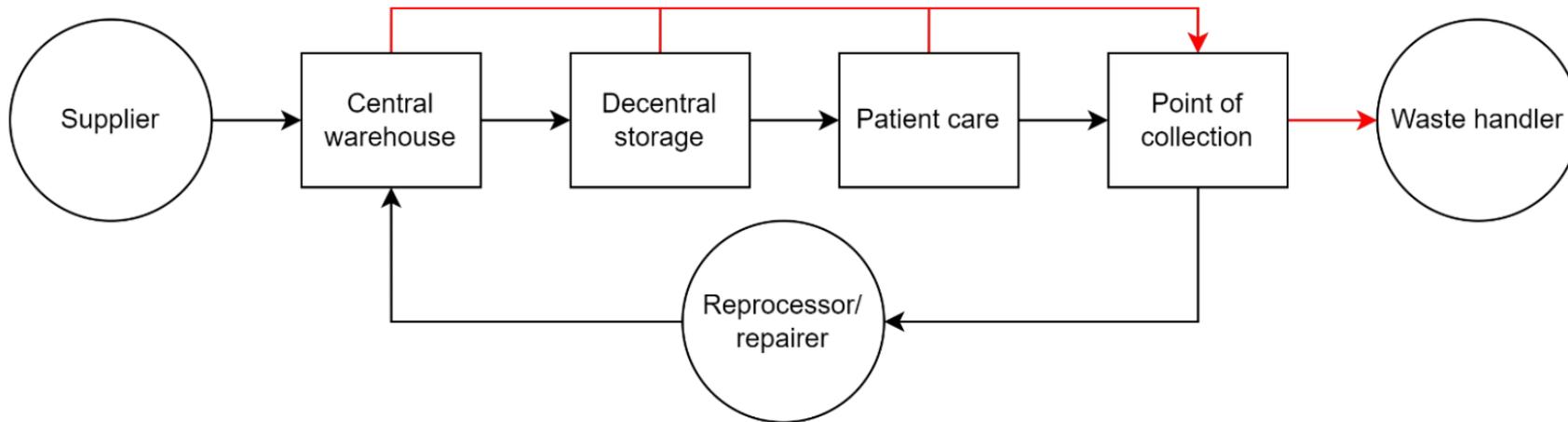


Typology for reprocessing medical textiles (T10).

Types of MDs		Material logistics infrastructure elements and their requirements						
Reprocessing type	Internal/external	Transport	Tracking and tracing	Reprocessing	Repair	Storage space	Point of collection space	
T10	Reprocessing medical textiles	External	Figure 7	Unique MD history: locations	-	-	Reprocessing time (↑↑↑), thicker material (↑), (prolongued use (↓↓))	More separate streams, (prolongued use (↓↓))

Reprocessing single use medical devices (T11)

Simplified flow diagram of RER MDs (and their packaging) externally reprocessed or repaired.



Typology for reprocessing single use medical devices.

Types of MDs		Material logistics infrastructure elements and their requirements					
Reprocessing type	Internal/external	Transport	Tracking and tracing	Reprocessing	Repair	Storage space	Point of collection space
T11 Reprocessing single use medical devices	External	Figure 9	Unique MD history: locations	-	-	Reprocessing time (↑↑↑)	Lot more separate streams