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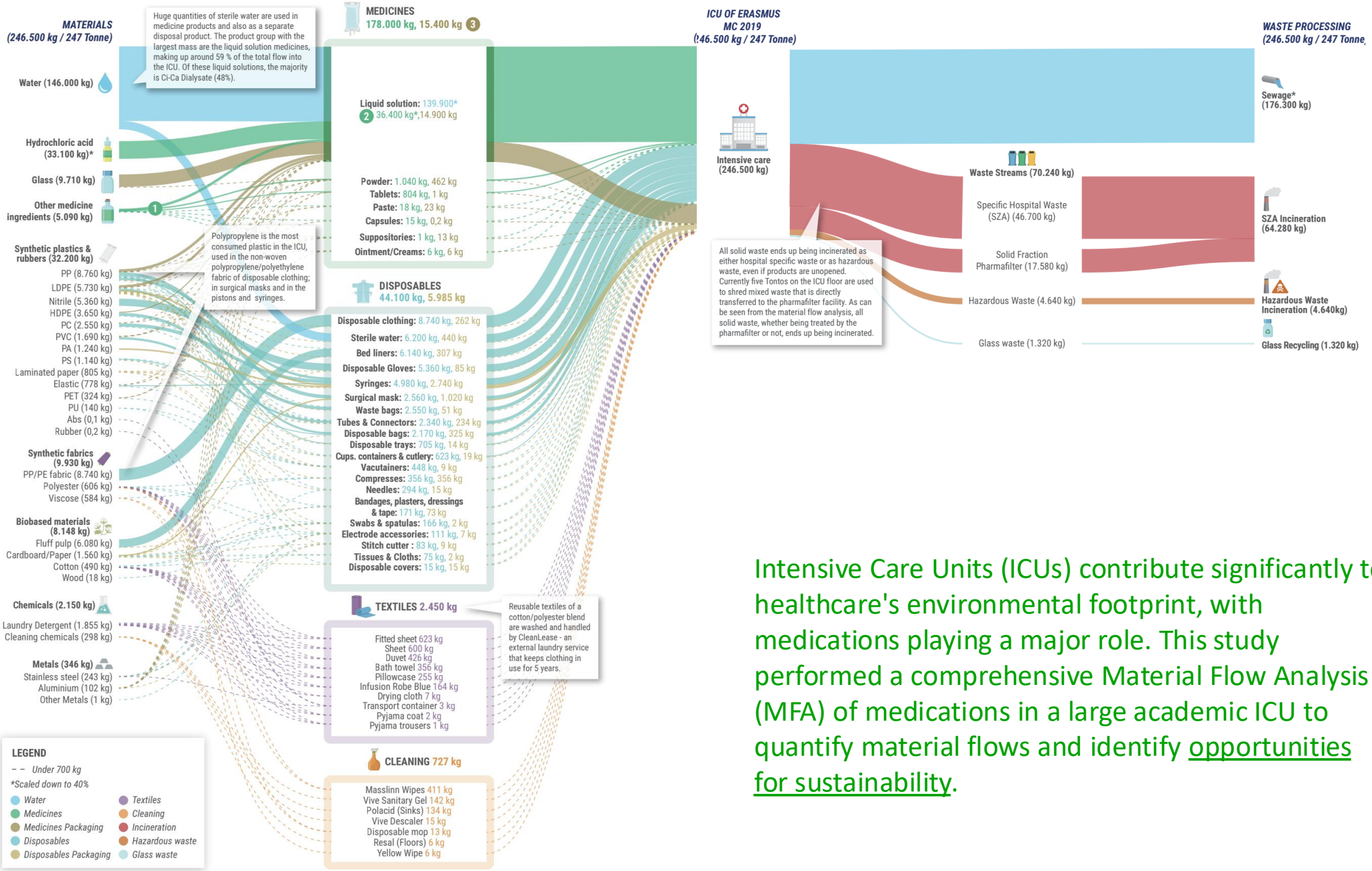
Circular Material Flow of Medication in the Intensive Care Unit

Jasper Klasen, MD, Silke Rijks, Diederik Gommers, MD, PhD, Jan Carel Diehl, PhD, Nicole Hunfeld, PhD



Intensive Care Units (ICUs) contribute significantly to healthcare's environmental footprint, with medications playing a major role. This study performed a comprehensive Material Flow Analysis (MFA) of medications in a large academic ICU to quantify material flows and identify opportunities for sustainability.

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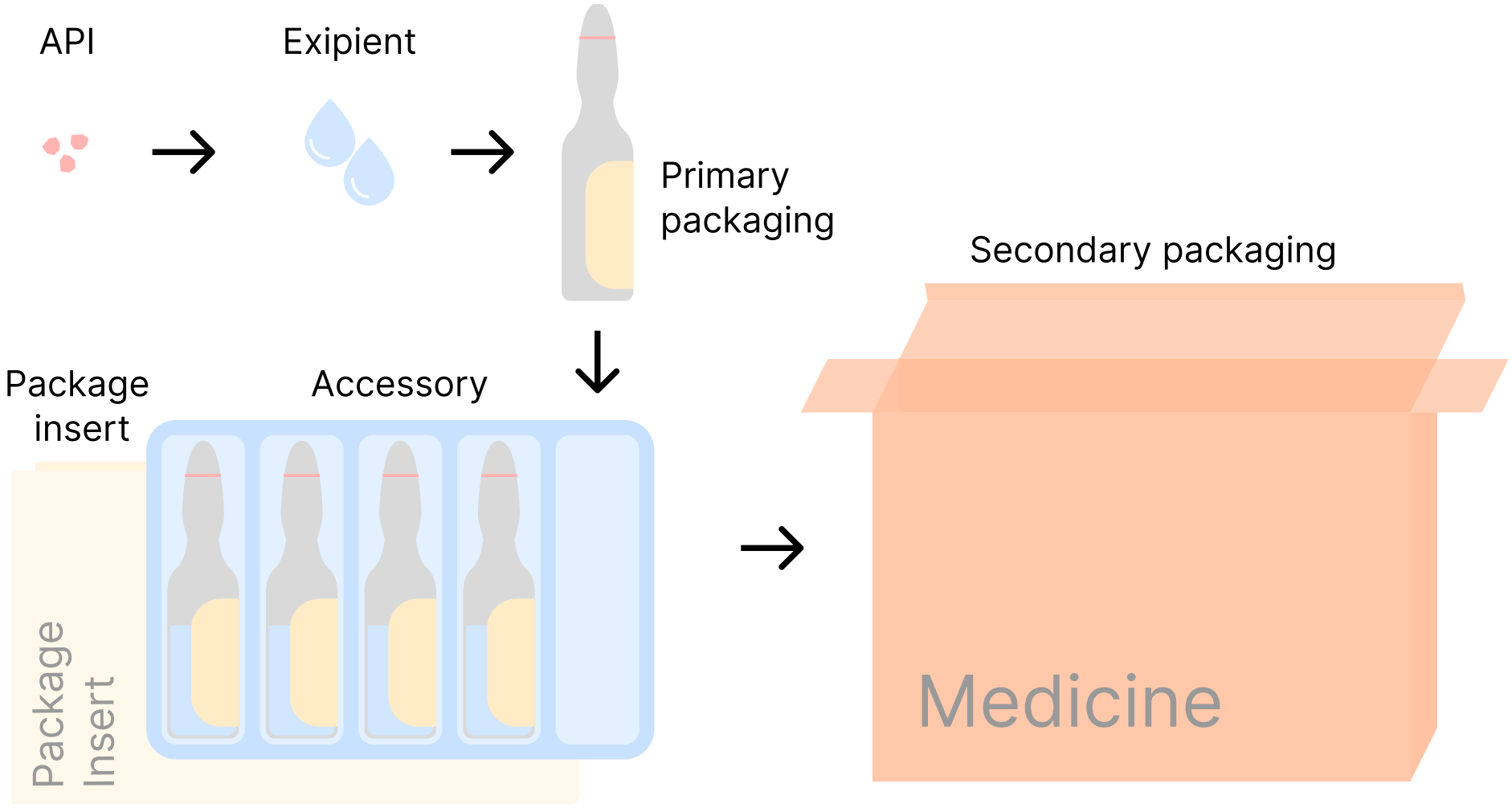
Performing an MFA

Medication and packaging typology



The data analysis comprised the following steps:

1. Determination of **API weight** for each medication.

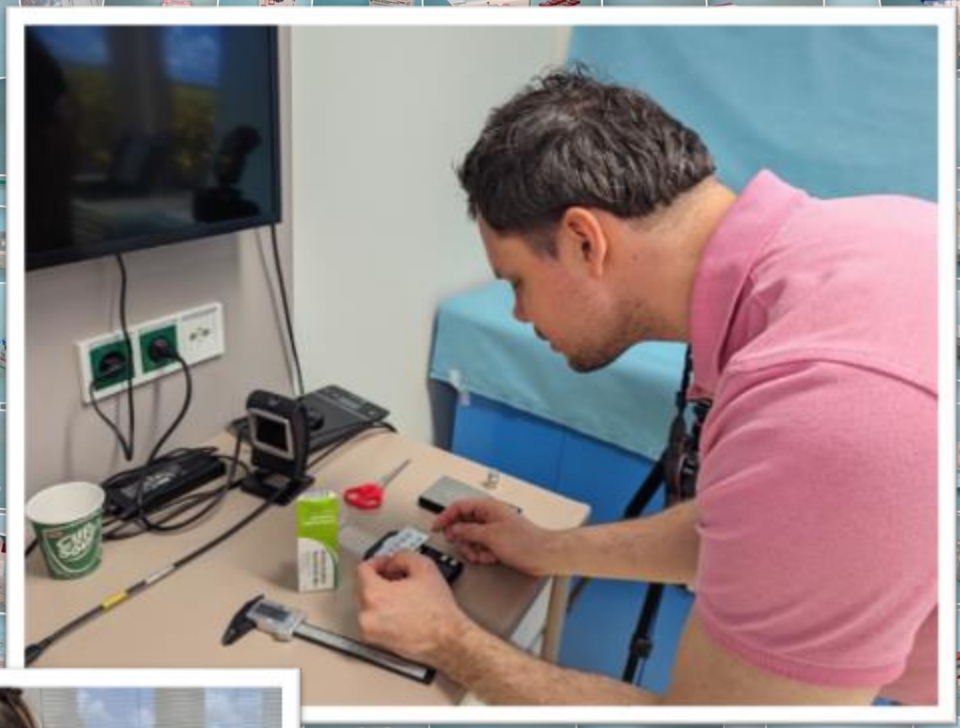
1. Calculation of **excipient weight** for each medication.

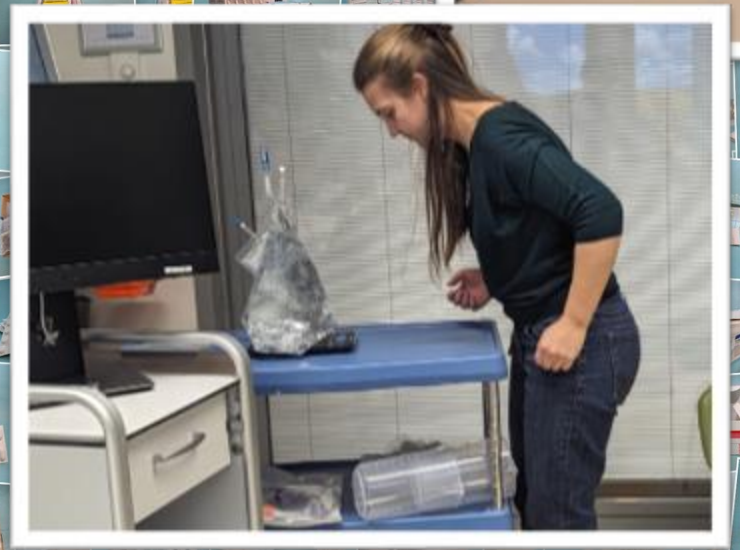
2. **Determination of weights for primary and secondary packaging, package inserts, and accessories.**

3. Calculation of mean weights for each component across weighed products. These mean weights were used to **extrapolate to non-weighed products.**

4. Calculation of **total waste** weight based on net empty packaging components.

5. Calculation of the weight and number of medications per patient per day (including CRRT).



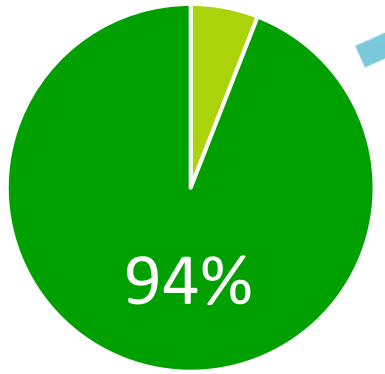


The ICU of the Erasmus MC

- 50-bed ICU
- All types of ICU care, including ECMO and CRRT

- 2569 admissions, mean length of stay 4.5 days
- 289 patients underwent CRRT (mean duration 8.1 days)

- 1800 different medications delivered, totalling 1.098.736 deliveries



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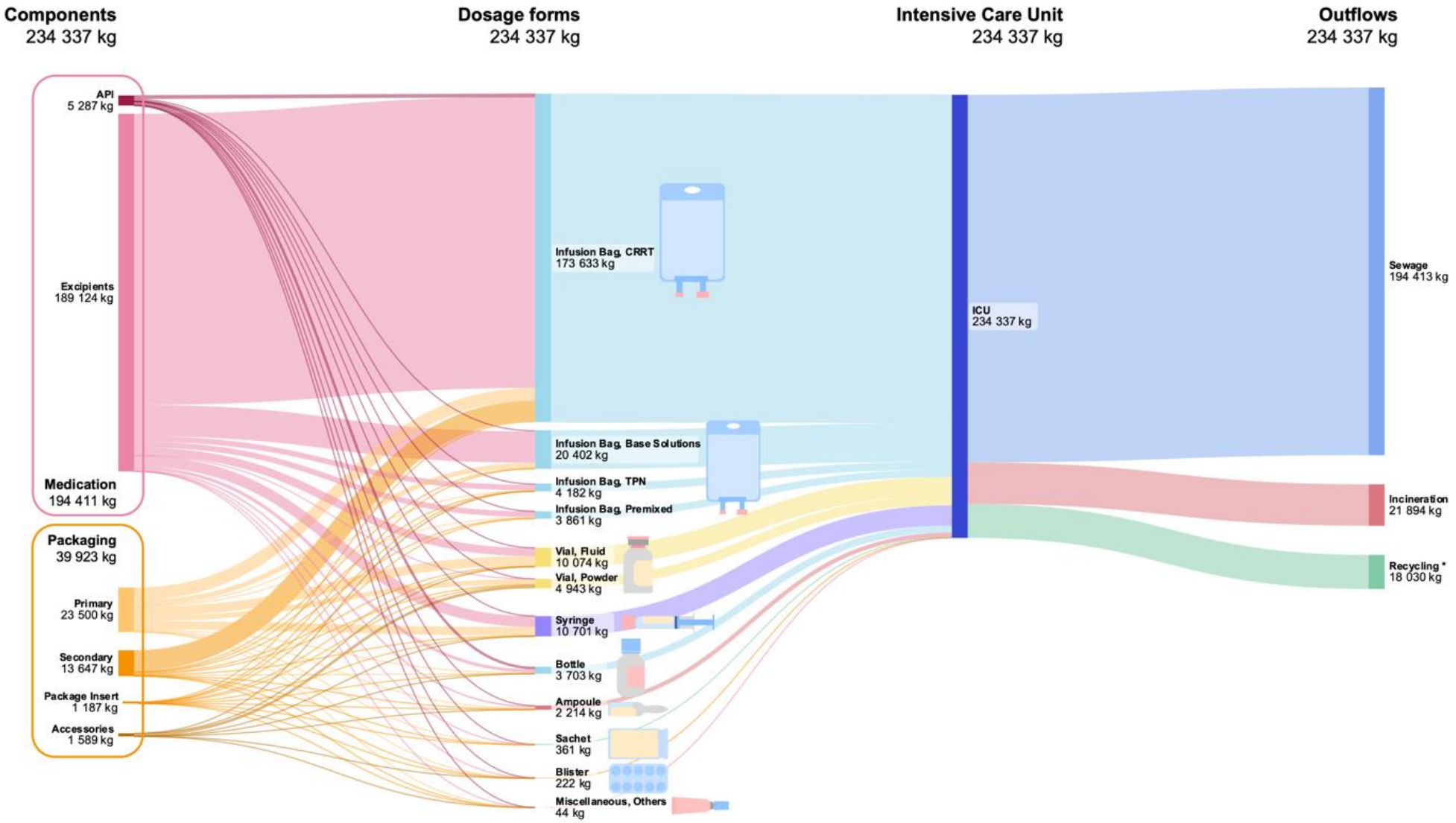
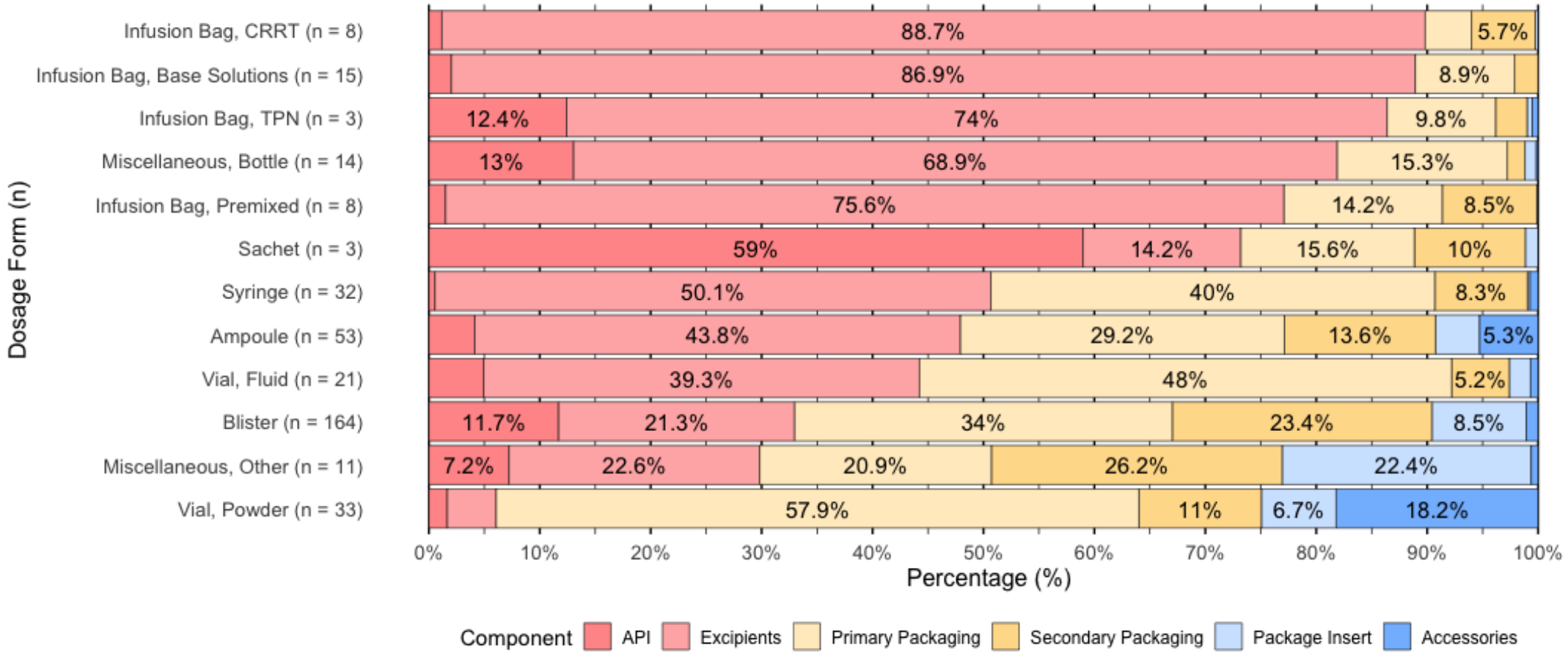
Results

Material Flow of the ICU; Role of CRRT



Low API content in medication

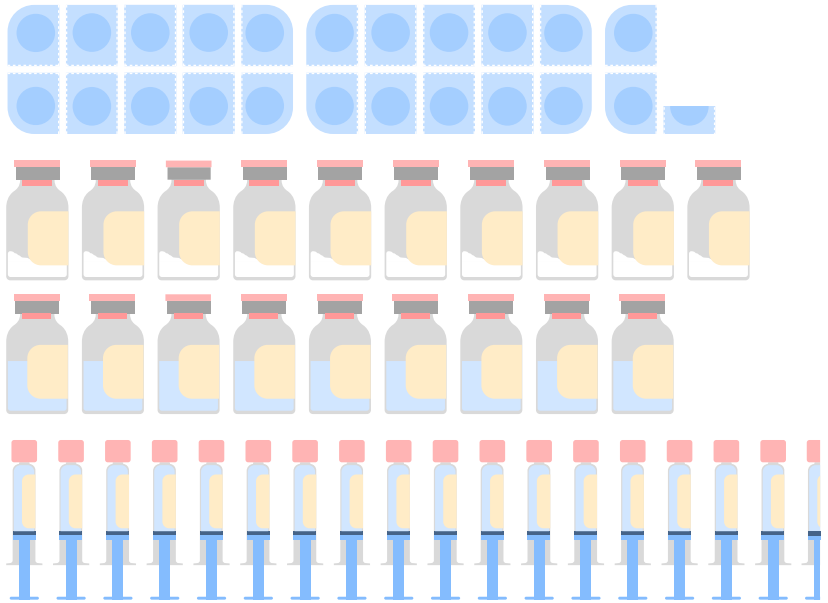


Daily medication per patient

22.5
Blisters

19
Vials

17.5
Syringes

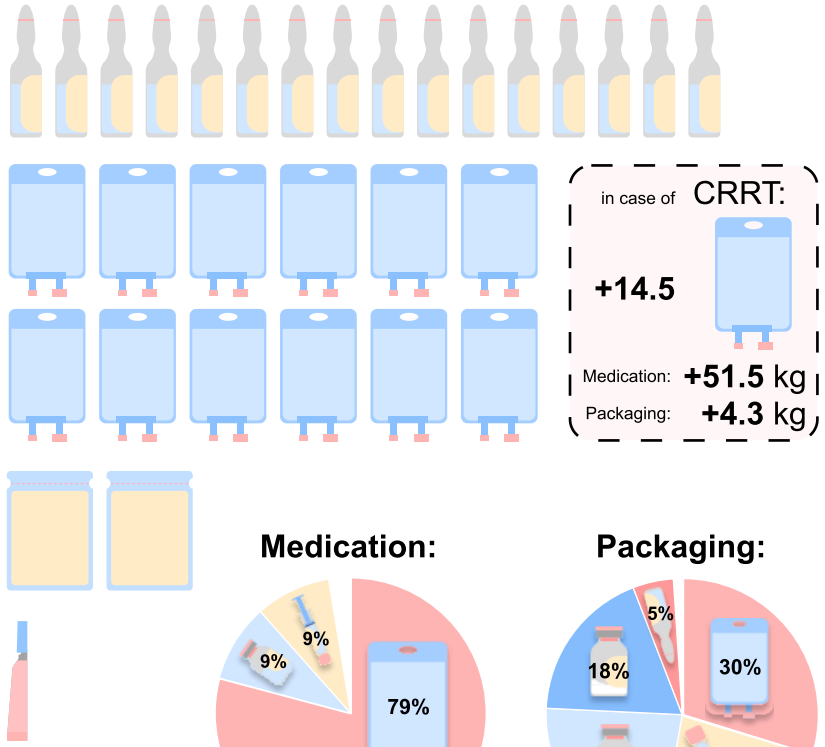


16
Ampoules

12
Infusion bags
(excluding CRRT)

2
Sachets

0.5
Other



in case of CRRT:
+14.5
Medication: **+51.5** kg
Packaging: **+4.3** kg

Total:
89.5 pieces

Medication:

Total : **5.0** kg

Packaging:

Total : **1.7** kg

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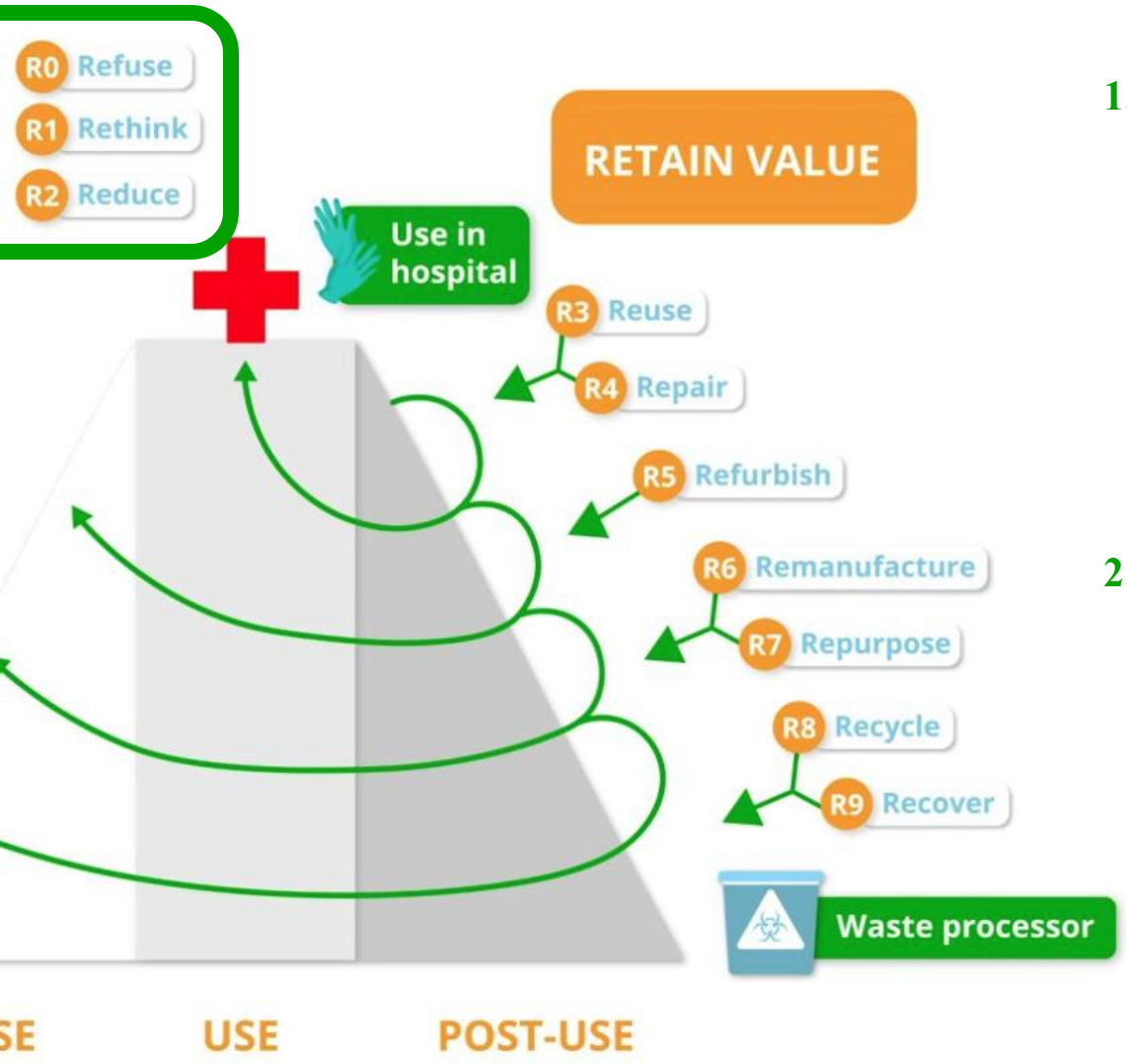
Conclusions

Potential sustainable interventions



1. **Medication-related strategies:**
   - Prioritize oral formulations (tablets and capsules) over intravenous formulations whenever clinically appropriate (Rethink).
   - Develop and promote the use of more concentrated fluid formulations to reduce transport, storage, and packaging waste (Refuse, Rethink, Reduce).
   - Explore and implement alternatives to traditional CRRT that minimize fluid and material use (Rethink, Reduce).
2. **Packaging-related strategies:**
   - Optimize packaging designs to minimize material use and waste (Reduce).
   - Reduce or eliminate the use of package inserts in ICU settings, leveraging electronic resources (Reduce, Refuse).
   - Expand recycling programs to include additional materials such as paper, glass vials, infusion bags, and other suitable packaging components, applying circular economy principles to ICU waste management (Recycle).

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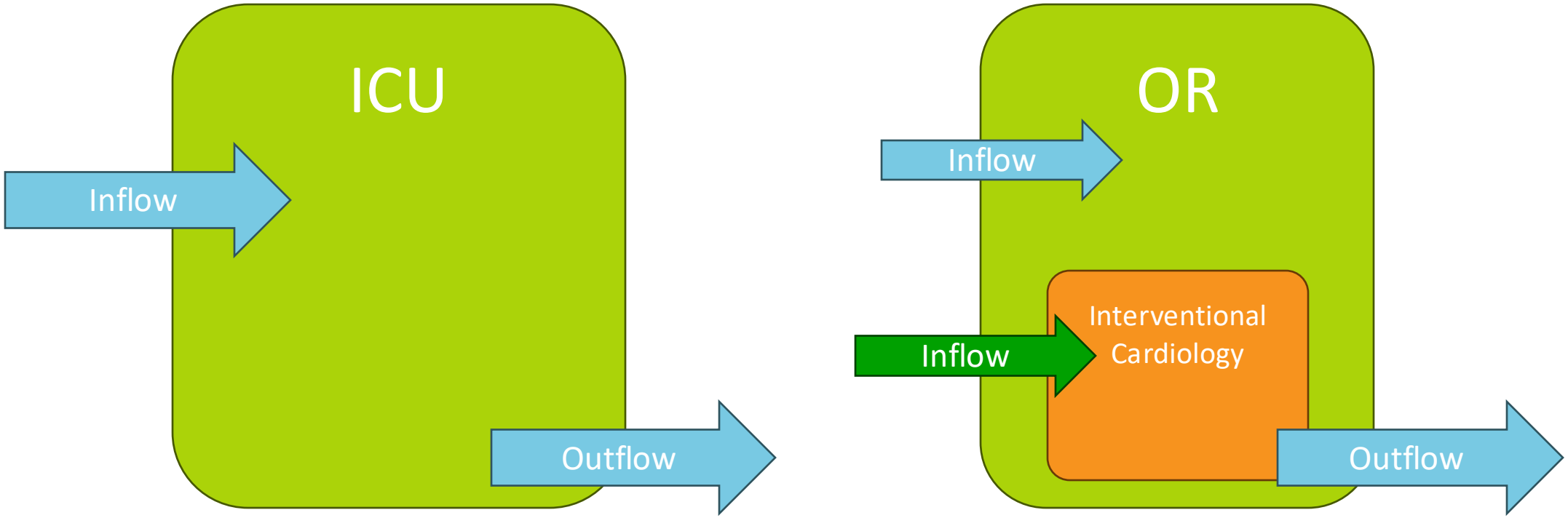
Looking ahead

MfA of Interventional Cardiology



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Thank you for your attention, are there questions?

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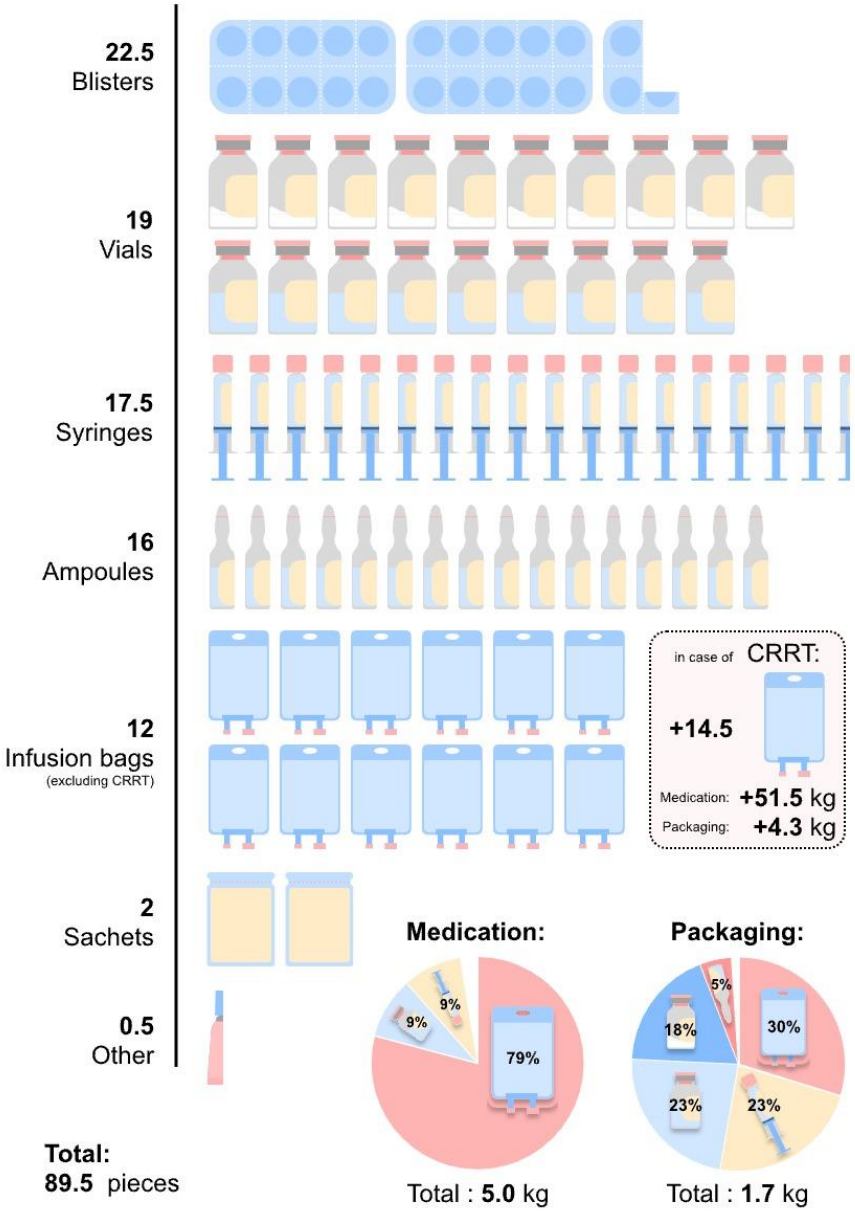
Medication (waste) per patient per day ICU



Source: Klasen J, Rijcks S, Gommers D, Diehl JC, Hunfeld N. Circular material flow of medication in the intensive care unit. Crit Care. 2025 May 20;29(1):205. doi: 10.1186/s13054-025-05434-3. PMID: 40394680; PMCID: PMC12093750.

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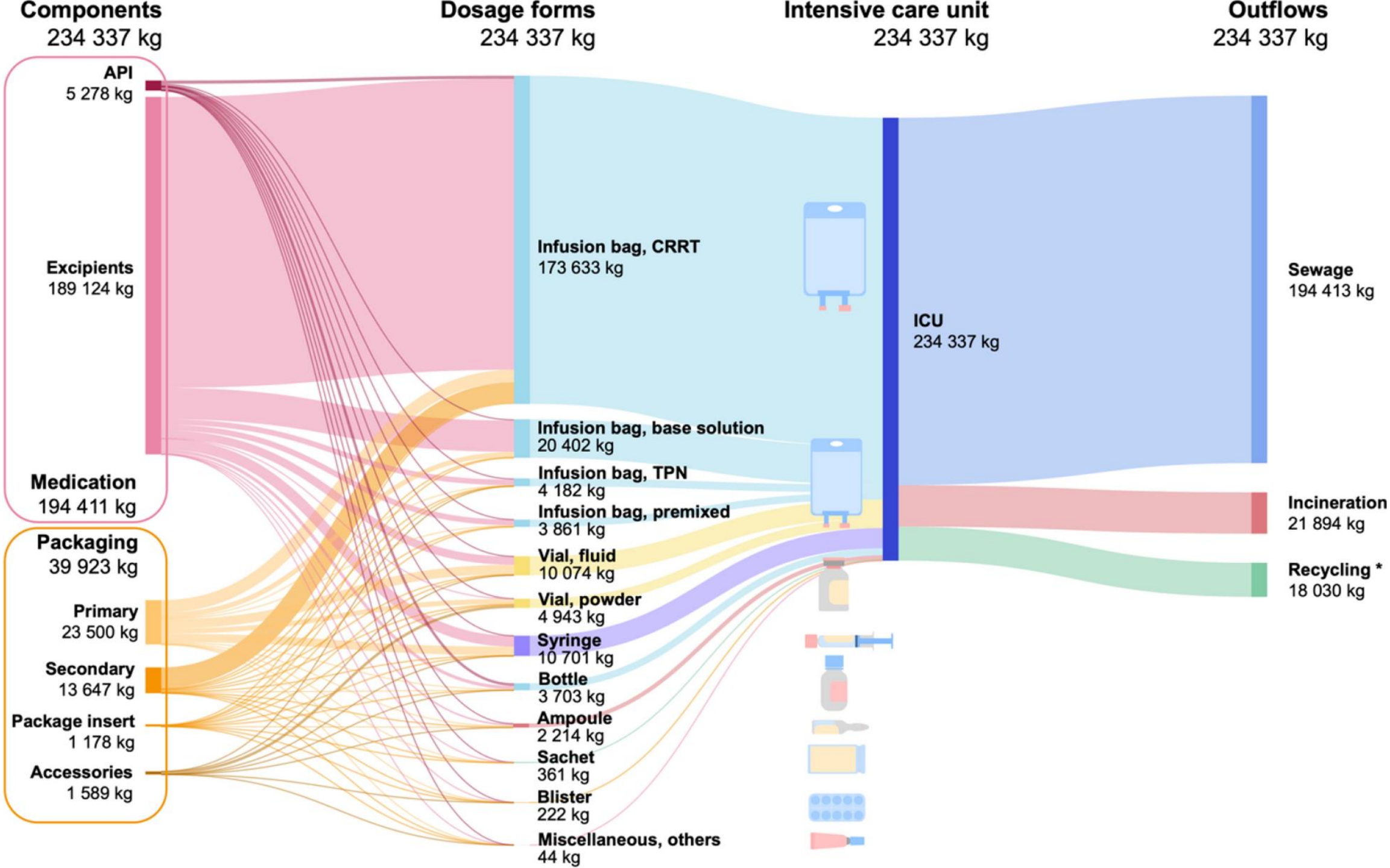
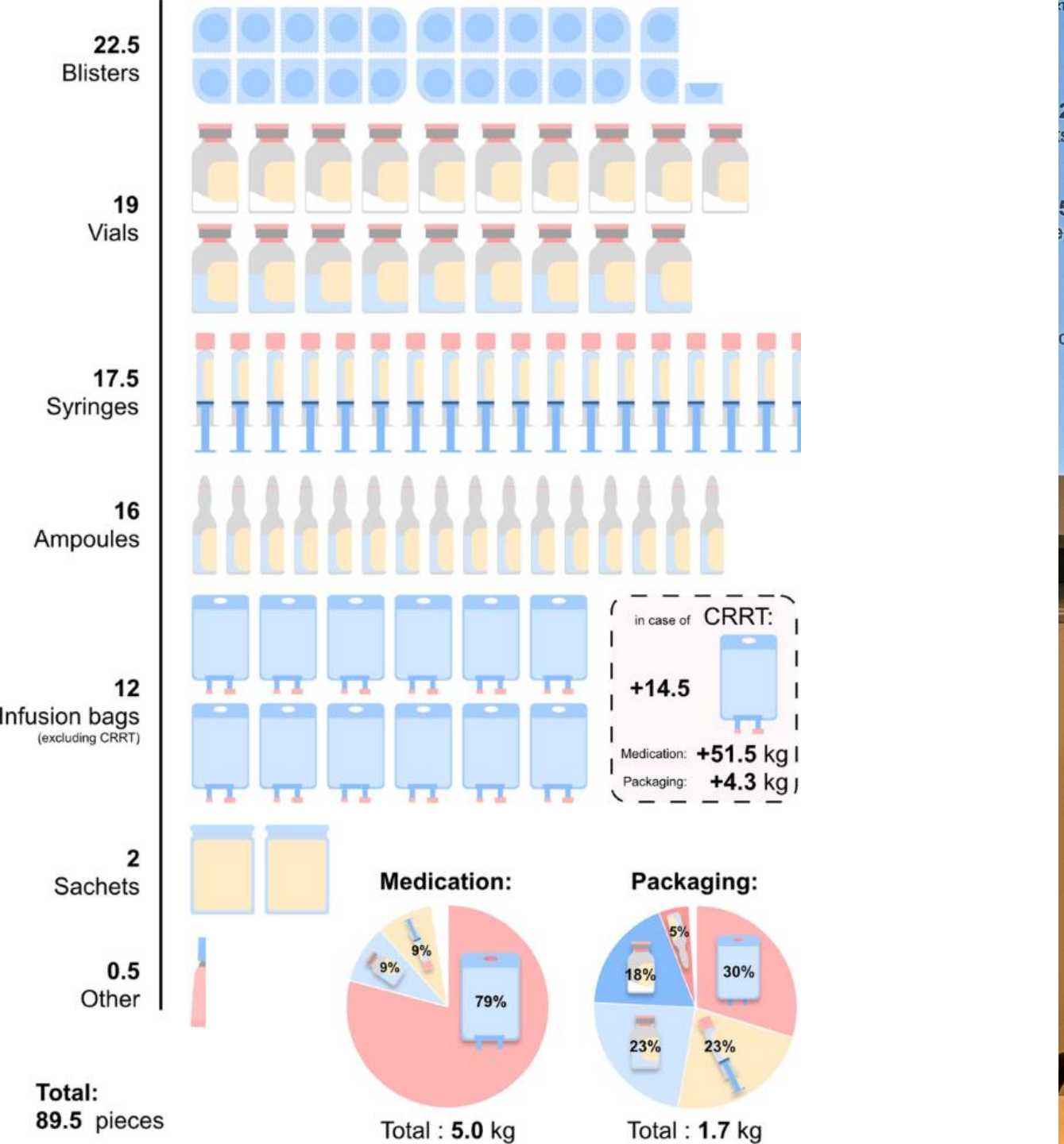
Circular material flow of medication in the intensive care unit

Jasper Klasen[1*], Silke Rijcks[2], Diederik Gommers[1], Jan Carel Diehl[1,2] and Nicole Hunfeld[1,3]

Table 1 Baseline characteristics of medication delivered to the ICU in 2023

Variable	All medication deliveries		Medication with 250 or more deliveries	
	Different medications	Sum of deliveries	Different medications	Sum of deliveries
	N = 1800	*N* = 1 098 736	*n* = 395	*n* = 1 033 498
Total, n. (%)				
Registered packaging type, n. (%)				
Blister	838 (46.6%)	251 715 (22.9%)	171 (43.3%)	211 769 (20.5%)
Ampoule	170 (9.4%)	200 665 (18.3%)	57 (14.4%)	193 927 (18.8%)
Vial	291 (16.2%)	218 454 (19.9%)	71 (18.0%)	211 322 (20.4%)
Infusion bag	69 (3.8%)	177 600 (16.2%)	34 (8.6%)	175 160 (16.9%)
Syringe	92 (5.1%)	201 669 (18.4%)	37 (9.4%)	200 228 (19.4%)
Sachet	45 (2.5%)	24 858 (2.3%)	3 (0.8%)	23 172 (2.2%)
Miscellaneous	295 (16.4%)	23 775 (2.2%)	22 (5.6%)	17 920 (1.7%)
ATC-code anatomical main group, n. (%)				
A—Alimentary tract and metabolism	258 (14.3%)	137 239 (12.5%)	66 (16.7%)	127 664 (12.4%)
B—Blood and blood forming organs	185 (10.3%)	296 672 (27.0%)	63 (15.9%)	289 932 (28.1%)
C—Cardiovascular system	286 (15.9%)	201 618 (18.3%)	90 (22.8%)	188 221 (18.2%)
D—Dermatologicals	67 (3.7%)	3 640 (0.3%)	4 (1.0%)	2 893 (0.3%)
G—Genito urinary system and sex hormones	48 (2.7%)	6 256 (0.6%)	8 (2.0%)	4 502 (0.4%)
H—Systemic hormonal preparations, excl. Sex hormones and insulins	77 (4.3%)	35 946 (3.3%)	19 (4.8%)	32 563 (3.2%)


Components
234 337 kg
Dosage forms
234 337 kg
Intensive care unit
234 337 kg
Outflows
234 337 kg
API
5 278 kg
Excipients
189 124 kg
Medication
194 411 kg
Packaging
39 923 kg
Primary
23 500 kg
Secondary
13 647 kg
Package insert
1 178 kg
Accessories
1 589 kg
Infusion bag, CRRT
173 633 kg
Infusion bag, base solution
20 402 kg
Infusion bag, TPN
4 182 kg
Infusion bag, premixed
3 861 kg
Vial, fluid
10 074 kg
Vial, powder
4 943 kg
Syringe
10 701 kg
Bottle
3 703 kg
Ampoule
2 214 kg
Sachet
361 kg
Blister
222 kg
Miscellaneous, others
44 kg
ICU
234 337 kg
Sewage
194 413 kg
Incineration
21 894 kg
Recycling *
18 030 kg


22.5
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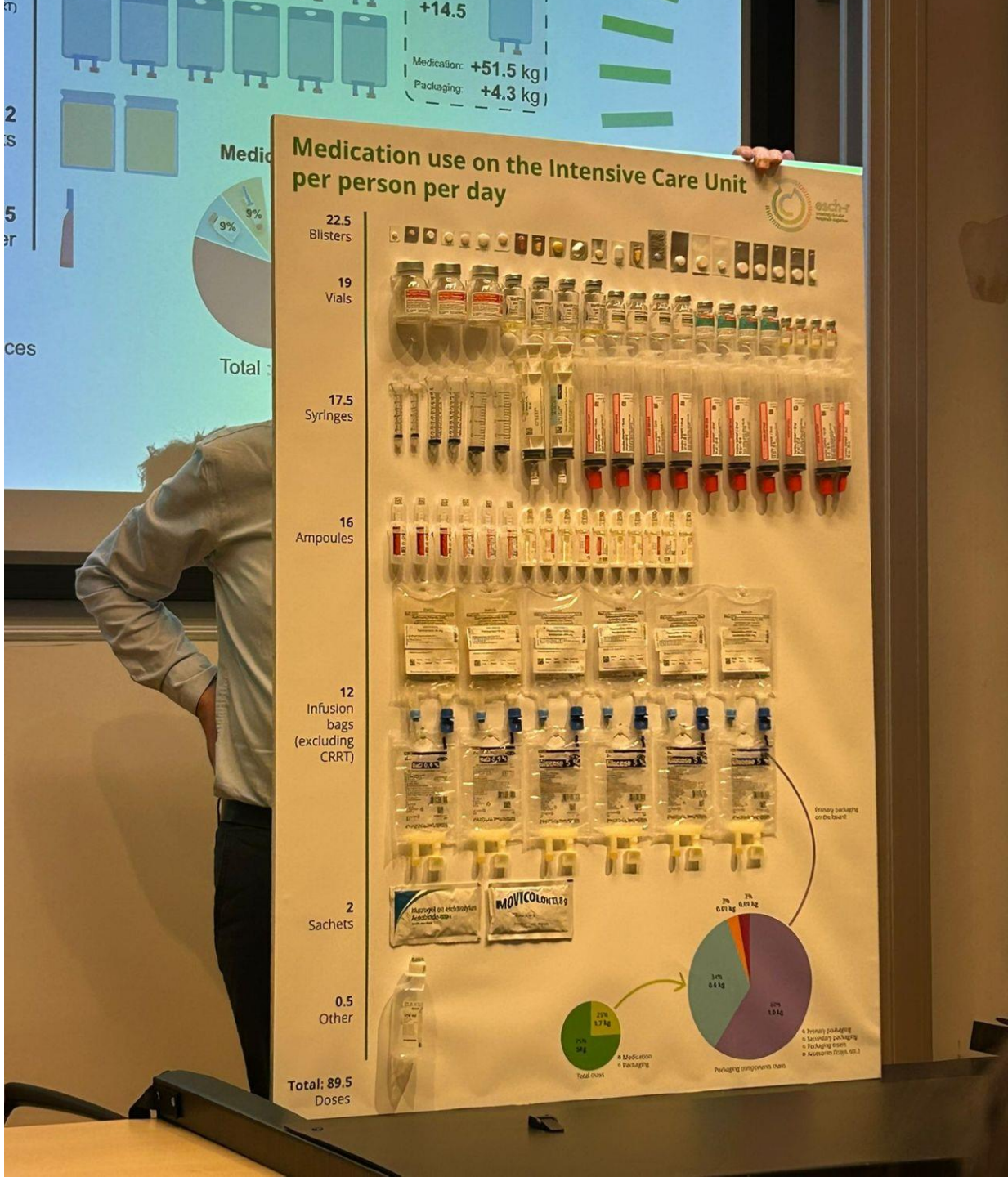
Infusion bags
(excluding CRRT)
2
Sachets
0.5
Other
Total:
89.5 pieces
in case of CRRT:
+14.5
Medication: +51.5 kg
Packaging: +4.3 kg
Medication:
9%
9%
79%
Total : 5.0 kg
Packaging:
5%
18%
30%
23%
23%
Total : 1.7 kg


+14.5
Medication: +51.5 kg
Packaging: +4.3 kg
Medication use on the Intensive Care Unit
per person per day
22.5
Blisters
19
Vials
17.5
Syringes
16
Ampoules
12
Infusion
bags
(excluding
CRRT)
2
Sachets
0.5
Other
Total: 89.5
Doses