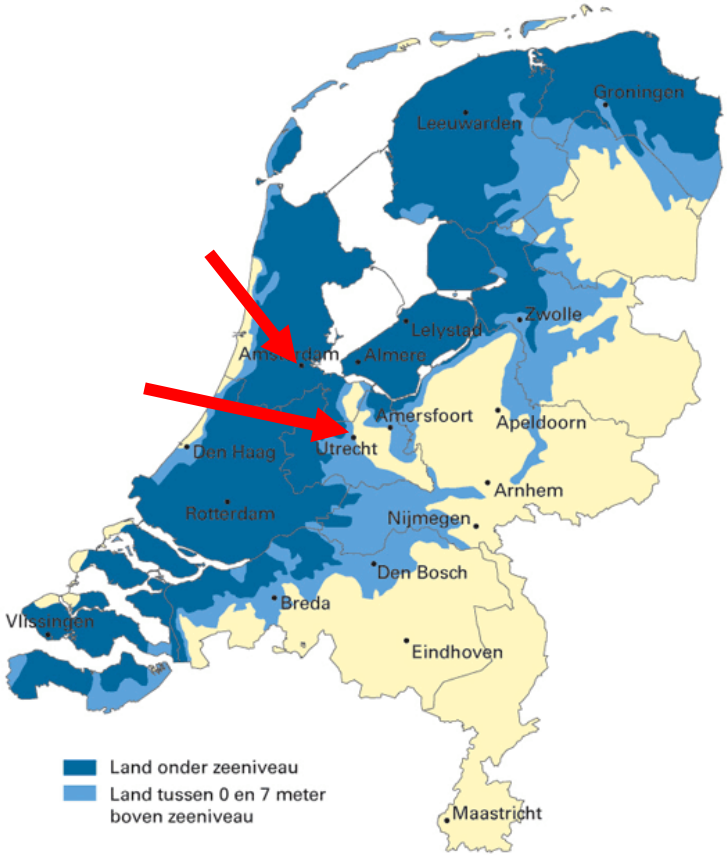
Overzicht verduurzaming v.d. OK

Niek Sperna Weiland, anesthesioloog Amsterdam UMC

‘I have no potential conflicts of interest to report’



Hans van der Maarel/Red Geographics
https://www.footprintcalculator.org

FOOTPRINT

→ HOW MUCH CO2 DID YOU GENERATE?

HANDPRINT

→ WHAT WILL YOU DO TO DECREASE FOOTPRINT OF YOURSELF AND OTHERS?

Surgery footprint

Scope 1

+

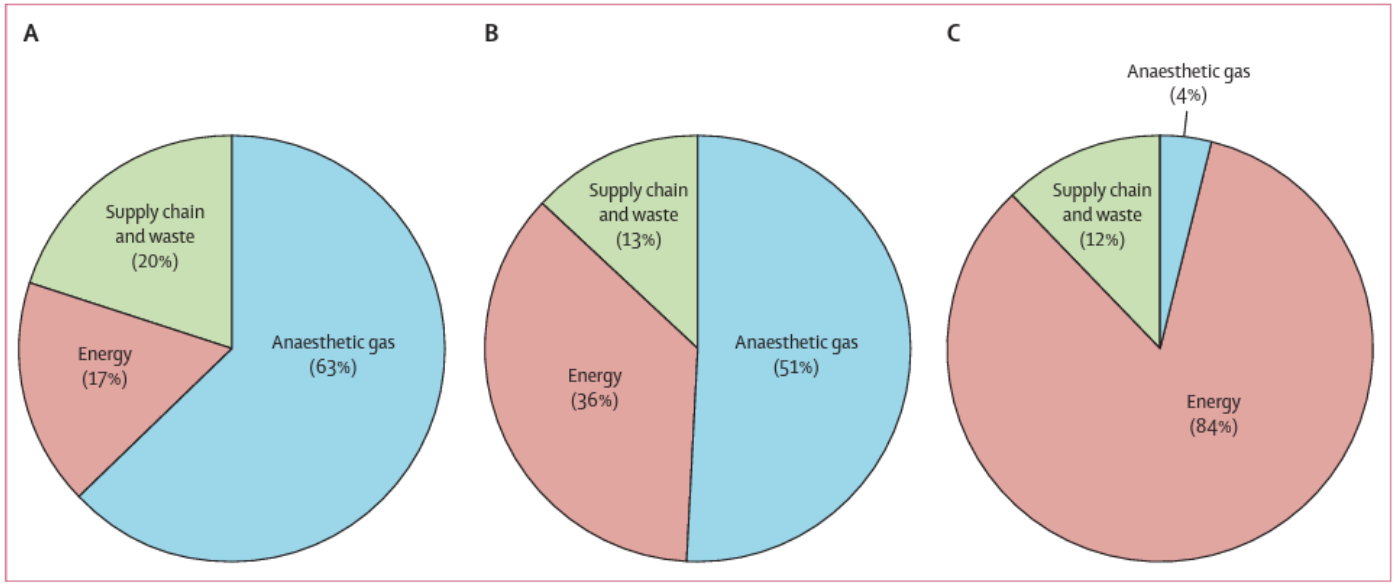
Scope 2

+

Scope 3

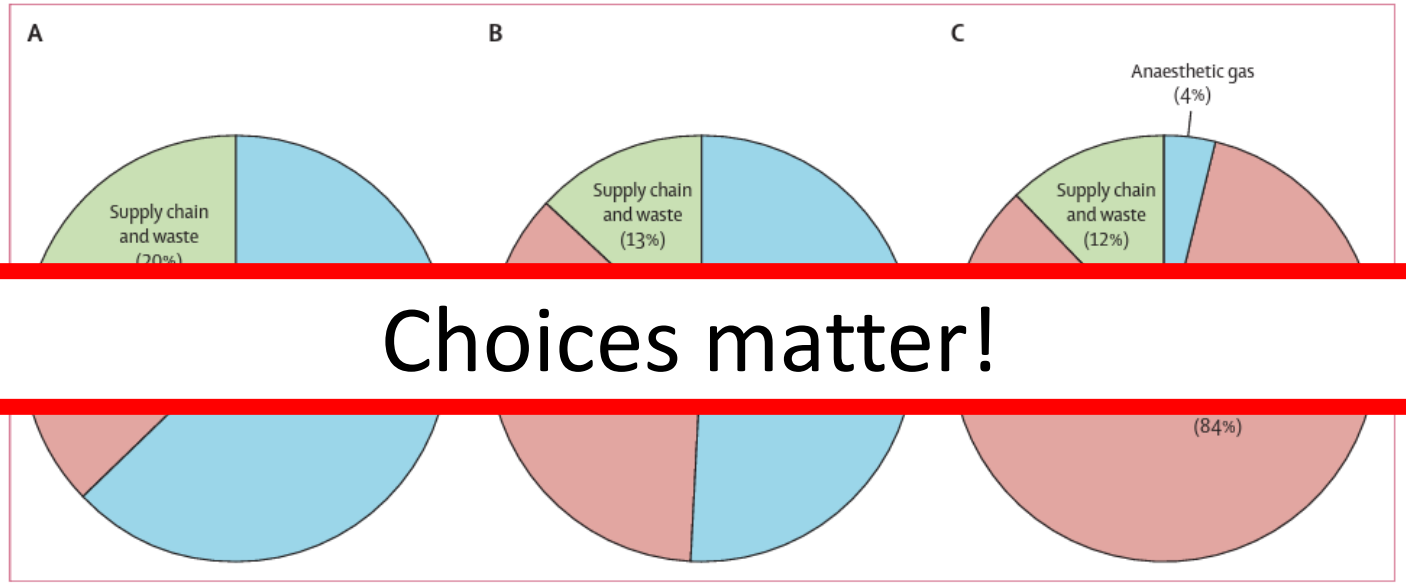
MacNeill et al. **Lancet Planet Health** (2017)

The impact of scopes varies greatly between systems



MacNeill et al. **Lancet Planet Health** (2017)

The impact of scopes varies greatly between systems



Choices matter!

MacNeill et al. **Lancet Planet Health** (2017)

Surgery & endoscopy footprint

Scope 1

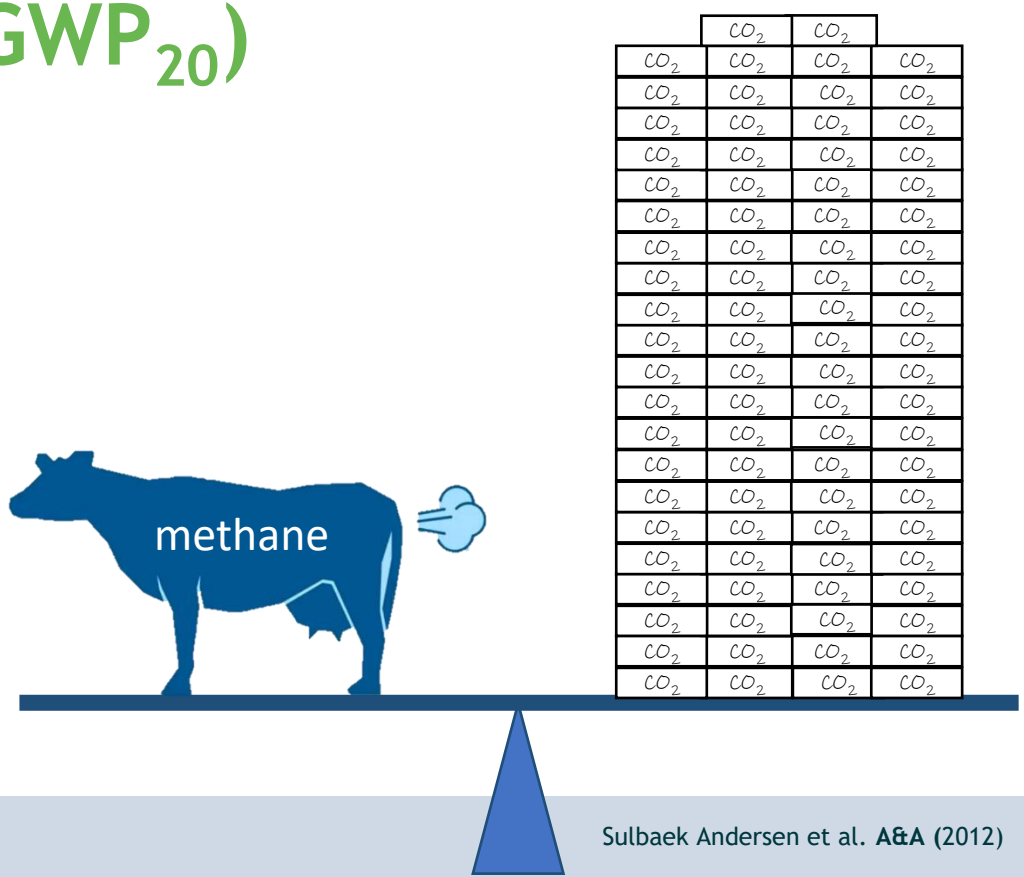
Scope 2

Scope 3

MacNeill et al. **Lancet Planet Health** (2017)

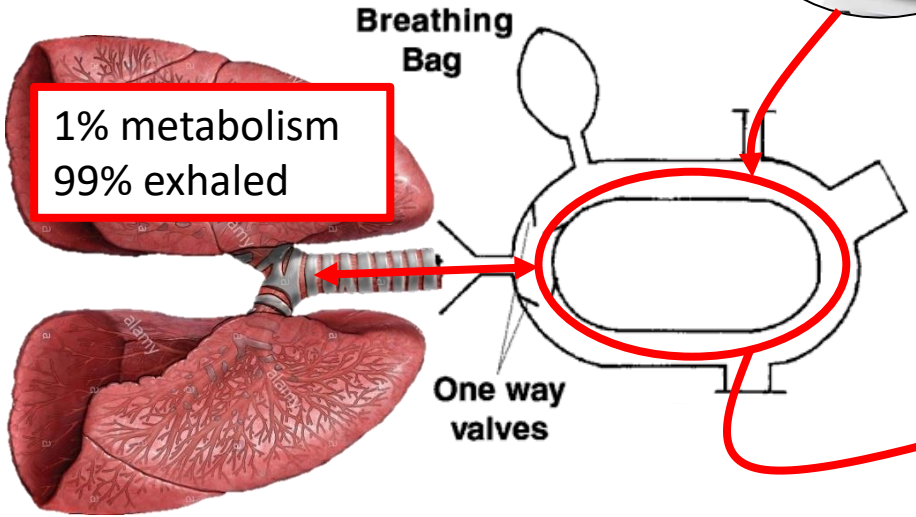
CO_2-equivalents (GWP_{20})

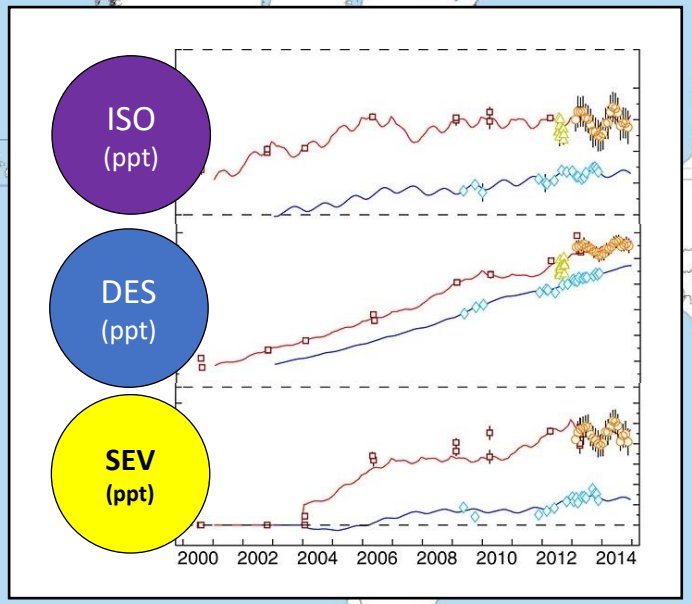
CO_2	= 1
Methane	= 86
N_2O	= 289
SEVO	= 508
ISO	= 1800
DES	= 6810



Sulbaek Andersen et al. **A&A** (2012)

Volatile anaesthetics/N_2O

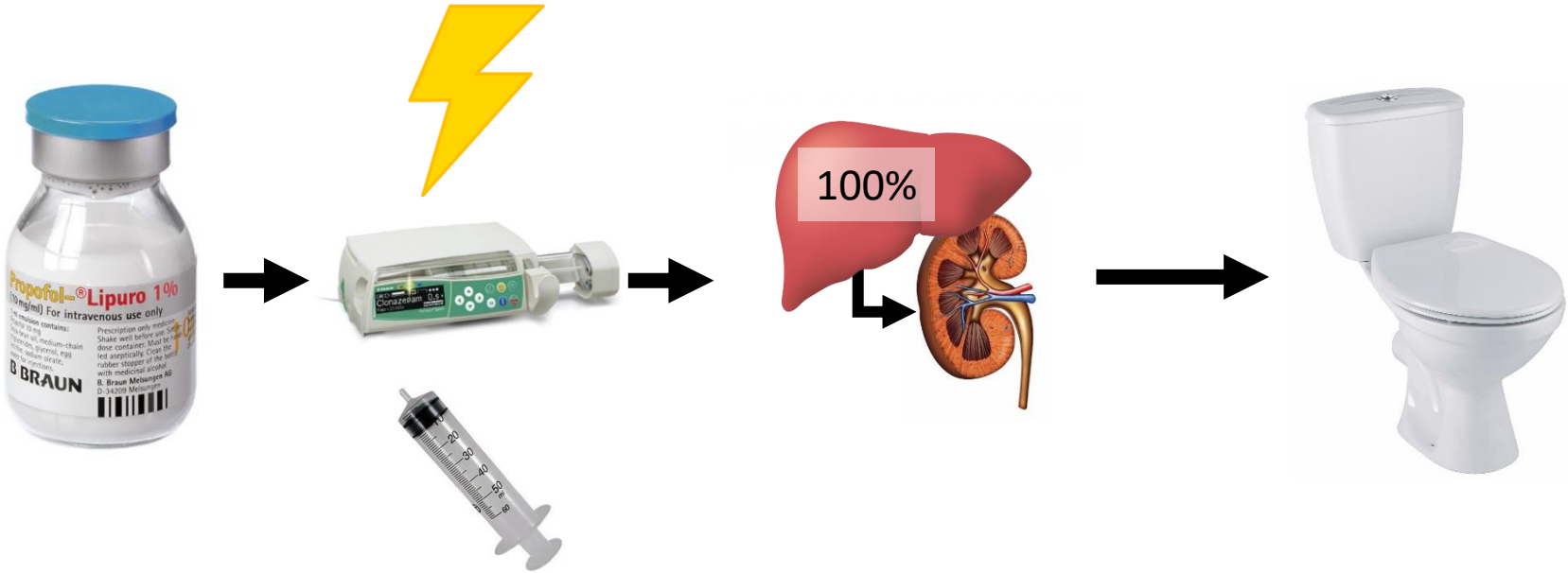




2000-2014

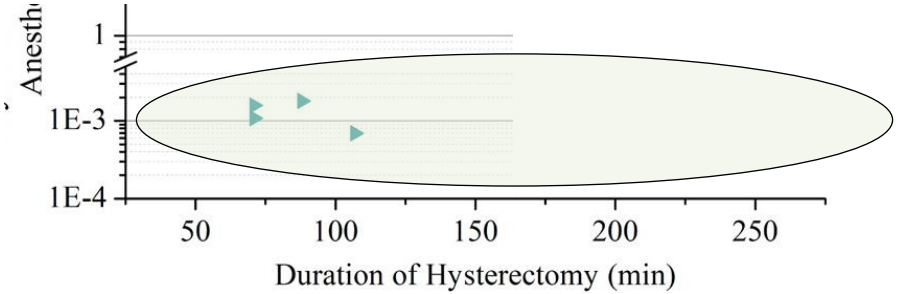
Vollmer et al. **GeoPhys Res Lett** (2015)

IV-medication



Sherman et al. **A&A** (2012)

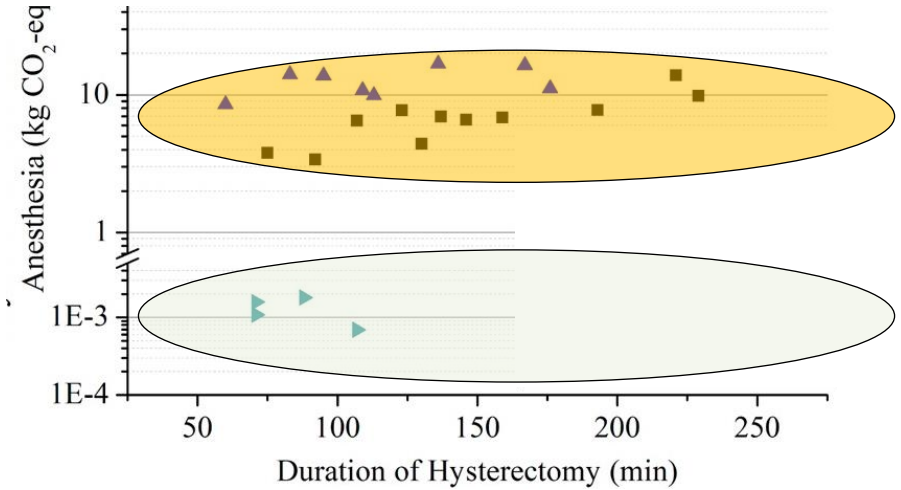
Choice of anaesthetic does matter



Propofol
0.1 kg CO_2 (1 km)

Thiel et al. **Envir Sci Tech** (2015)

Choice of anaesthetic does matter

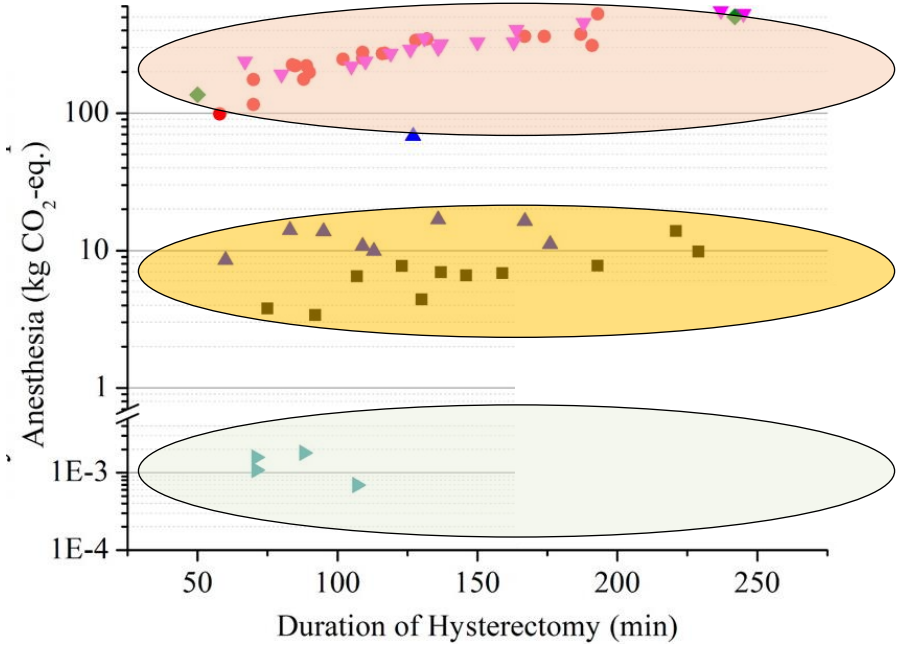


Sevoflurane
9 kg CO_2 (90 km)

Propofol
0.1 kg CO_2 (1 km)

Thiel et al. **Envir Sci Tech** (2015)

Choice of anaesthetic does matte



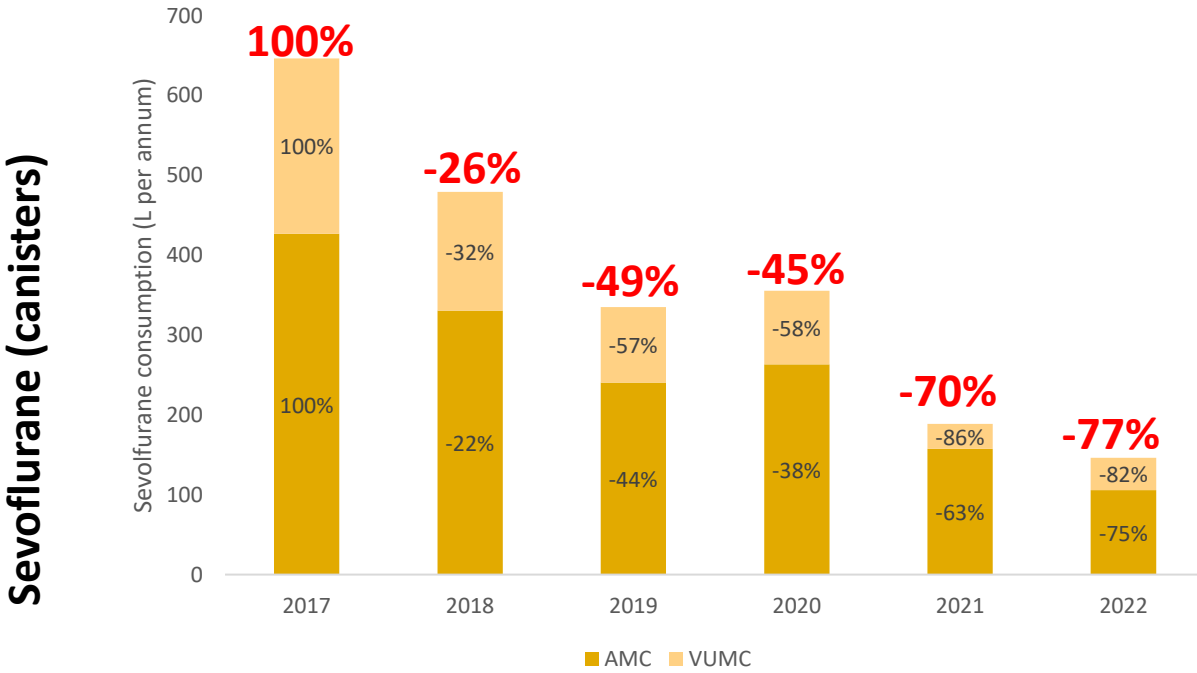
Desflurane
300 kg CO_2 (3000 km)

Sevoflurane
9 kg CO_2 (90 km)

Propofol
0.1 kg CO_2 (1 km)

Thiel et al. **Envir Sci Tech** (2015)

Practice what you preach @Amsterdam UMC



How?

1. Stop desflurane/N_2O
2. Ultra low-flow sevo
3. Preferred use of TIVA and loco-regional options
4. (Capture and recycle)

Surgery & endoscopy footprint

Scope 1

Avoid volatile anaesthetics and N_2O

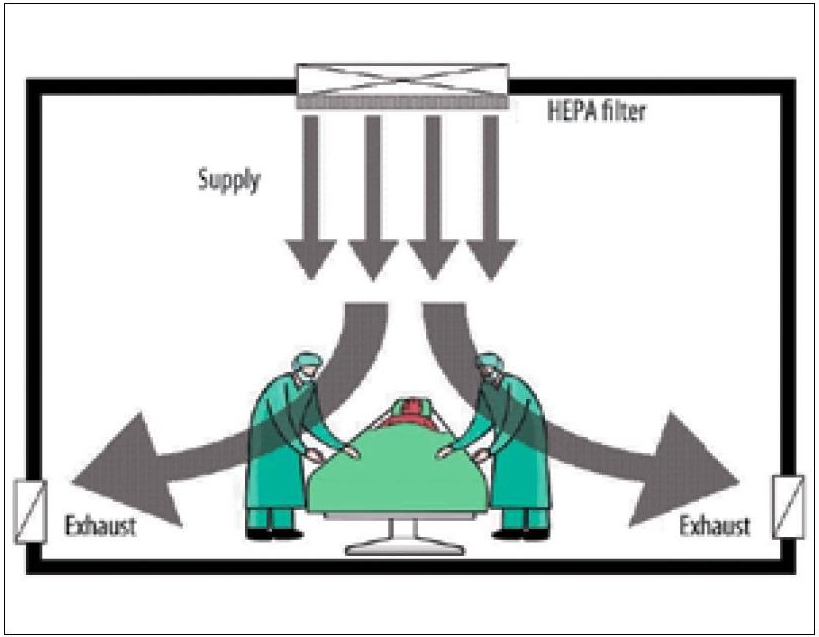
Scope 2

Scope 3

MacNeill et al. **Lancet Planet Health** (2017)

Energy consumption OR

- OR 3-6x more energy per m^2 than rest of the hospital
- 90% air treatment
- (Very limited evidence that this reduces surgical site infections)



MacNeill et al. **Lancet Planet Health** (2017)

Air treatment in Amsterdam UMC

Air treatment in Amsterdam UMC

	Energy use (kWh y^{-1})
Baseline	2.464.758
Off-hours stand-by (2018)	-810.583 (-33%)
+ Increase off-hours	-283.435 (-11%)
+ Reducton on-hours	-508.385 (-21%)
All	**-1.602.403 (-65%)**

Surgery & endoscopy footprint

Scope 1

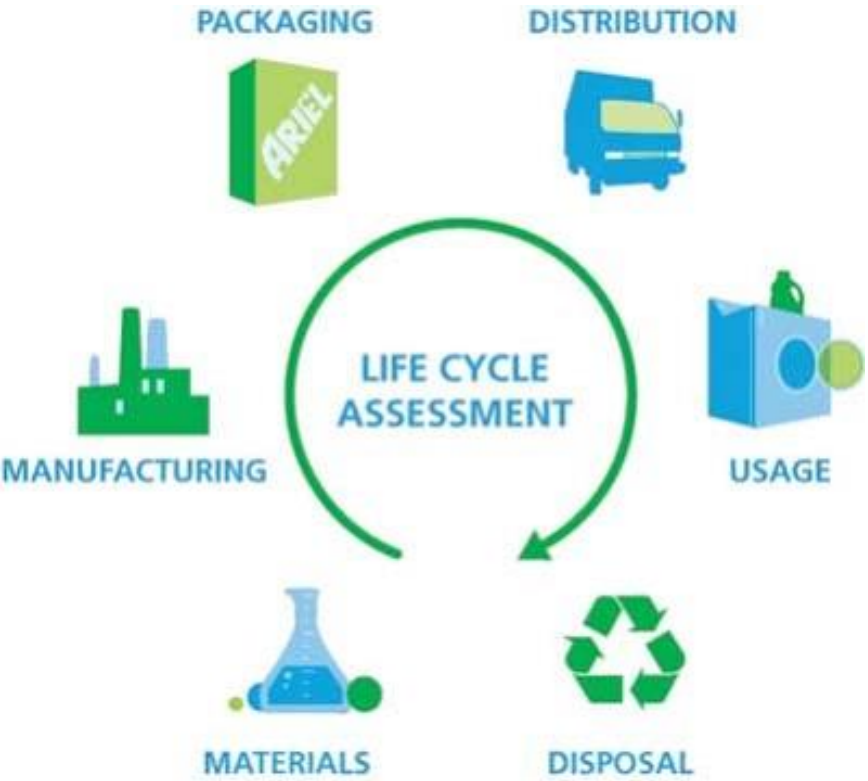
Avoid volatile anaesthetics and N_2O

Scope 2

Optimise air treatment

Scope 3

MacNeill et al. **Lancet Planet Health** (2017)



The impact of ‘stuff’

- Visible versus invisible impact
- Life cycle assessment

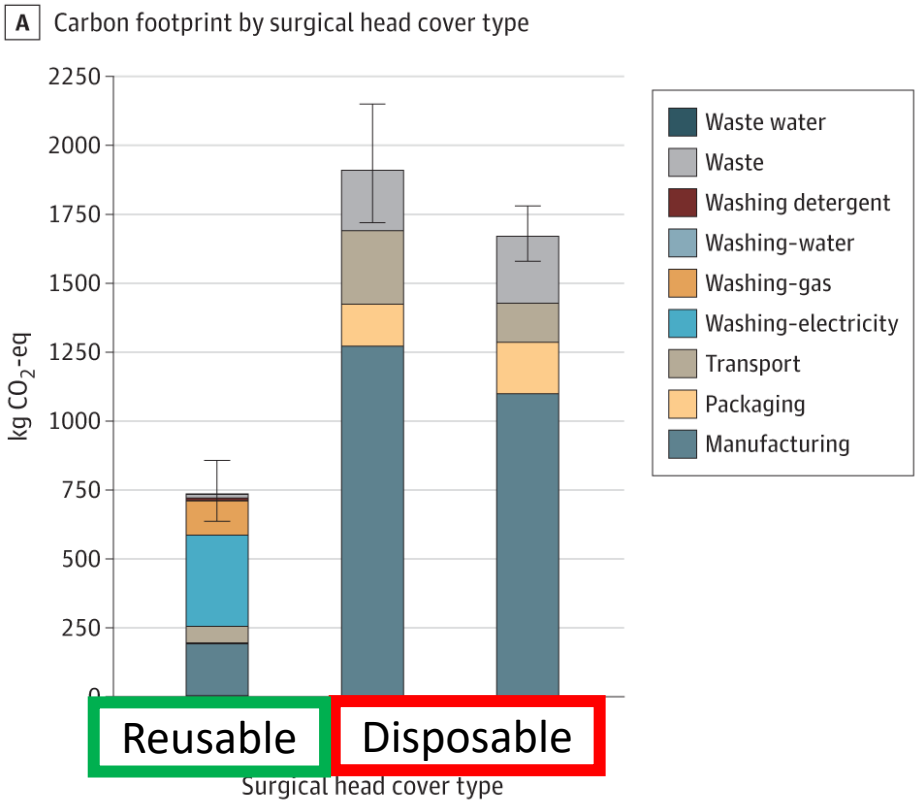
Disposable vs. reusable

2018

2023

Single use more than doubles carbon footprint

Despite energy use by washing/sterilization



Cohen et al. **JAMA Surgery** (2023)

Cohen et al. **JAMA Surgery** (2023)

1st Author	Year	Subject	Lowest impact
Adler	2004	Laparoscopy instruments	Reusable
Davis	2018	Ureteroscope	Similar
Donahue	2020	Vaginal speculum	Reusable
Eckelman	2012	Laryngeal Mask (LMA)	Reusable
Friedericy	2021	Sterilization container/wrap	Reusable
Grimmond	2020	Needle container	Reusable
Ibbotson	2013	Scissors	Reusable
Leiden	2020	Spinal fusion set	Disposable
McGain	2010	Anaesthetic tray	Reusable
McGain	2012	Central venous catheterization kit	Reusable
McGain	2017	Anaesthesia equipment	Reusable
Rodriguez	2022	Vaginal specula	Reusable
Sanchez	2020	Blood pressure cuffs	Reusable
Schaer	1995	Laparoscopy instruments	Reusable
Sherman	2018	Laryngoscope	Reusable
Snijder	2021	Delivery kit	Reusable
Vozzola	2018	Drapes and gowns	Reusable

REDUCE

REUSE

RECYCLE

"We are the first generation to feel the impact of climate change and the last generation that can do something about it."

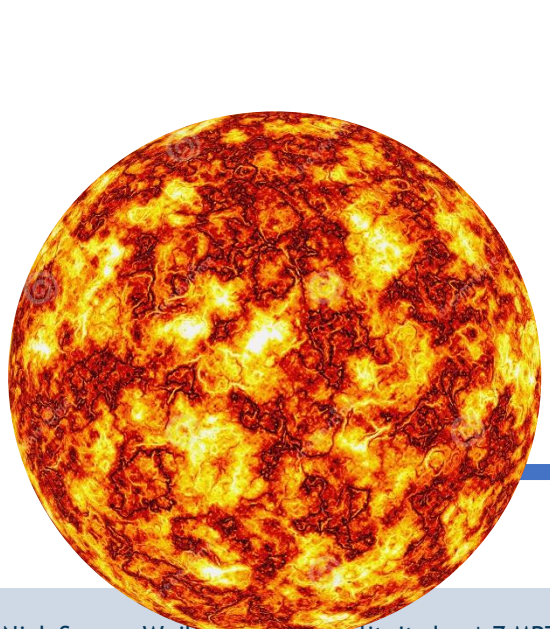
Focus on your HANDprint!

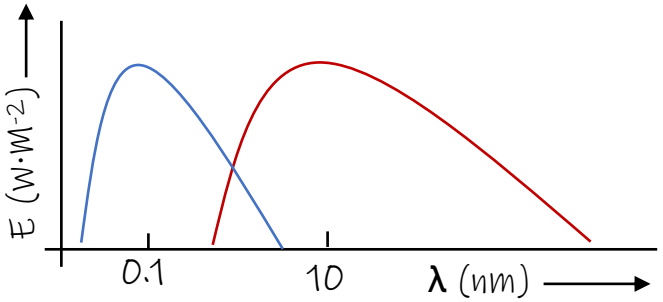
Niek Sperna Weiland

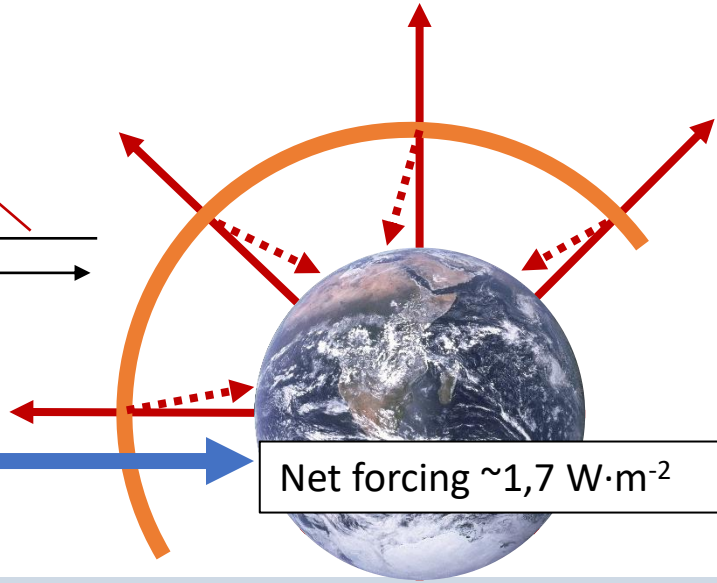
N.H.SpernaWeiland@AmsterdamUMC.nl

How does a greenhouse gas work?

Green house physiology







Net forcing ~1,7 W·m^{-2}

Campbell et al. **BJA Edu** (2015)

What about capture and recycling?

The technology - adsorption

Photo L: Sara Rönnberg, Herjedalen, Sweden
Photo R: Robert Ebertsch, Bamberg

The technology - desorption

Photo: Zeosys Medical, Baxter

Early results – 3 OR's, 80 procedures

6902 g
administered

-63%

2509 g
adsorbed

Hinterberg et al. **BJA** (2022)
Shelton et al. **BJA** (2022)

Early results - 3 OR's, 80 procedures

6902 g
administered

-63%

2509 g
adsorbed

-31%

1727 g
recaptured

25%

Hinterberg et al. **BJA** (2022)
Shelton et al. **BJA** (2022)

Lower capturing rate during longer procedures

Table 1 Patient characteristics and distribution of variables for the overall cohort, and patients with a low and high percentage of recaptured desflurane (based on the median in the cohort). Data are expressed as frequency (prevalence in %) or median (inter-quartile range [25th–75th percentile]).

	Total (*n*=80)	Recaptured desflurane ≤52.3% (*n*=40)	Recaptured desflurane >52.3% (*n*=40)	P-value
BMI (kg m^{-2})	26.4 (24.6–28.7)	26.4 (24.4–28.5)	26.2 (24.6–29.1)	0.54
Duration of desflurane administration (min)	238.0 (105.0–349.0)	340.0 (240.0–381.5)	112.5 (73.5–231.5)	<0.001
Circuit leak at incision (L min^{-1})	0.0 (0.0–0.1)	0.0 (0.0–0.0)	0.0 (0.0–0.2)	0.025
Minute ventilation (L min^{-1})	6.5 (5.5–7.5)	6.7 (5.8–8.1)	6.2 (4.9–7.0)	0.010
Ventilatory frequency (breaths per min^{-1})	12.0 (12.0–14.0)	13.0 (12.0–15.0)	12.0 (10.5–14.0)	0.012
Fresh gas flow (L min^{-1})	0.8 (0.5–0.8)	0.7 (0.5–0.8)	0.8 (0.7–0.9)	0.095
End-tidal concentration of desflurane (%)	4.6 (4.2–5.0)	4.8 (4.3–5.3)	4.5 (4.1–4.8)	0.051
Minimum alveolar concentration of desflurane	0.8 (0.8–0.9)	0.9 (0.8–0.9)	0.8 (0.7–0.9)	0.002
End-tidal concentration of desflurane at extubation (%)	0.8 (0.6–1.0)	0.9 (0.8–1.1)	0.8 (0.6–0.9)	0.010
Operating room				<0.001
1	13 (16%)	1 (3%)	12 (30%)	
2	28 (35%)	1 (3%)	27 (68%)	
3	39 (49%)	38 (95%)	1 (3%)	

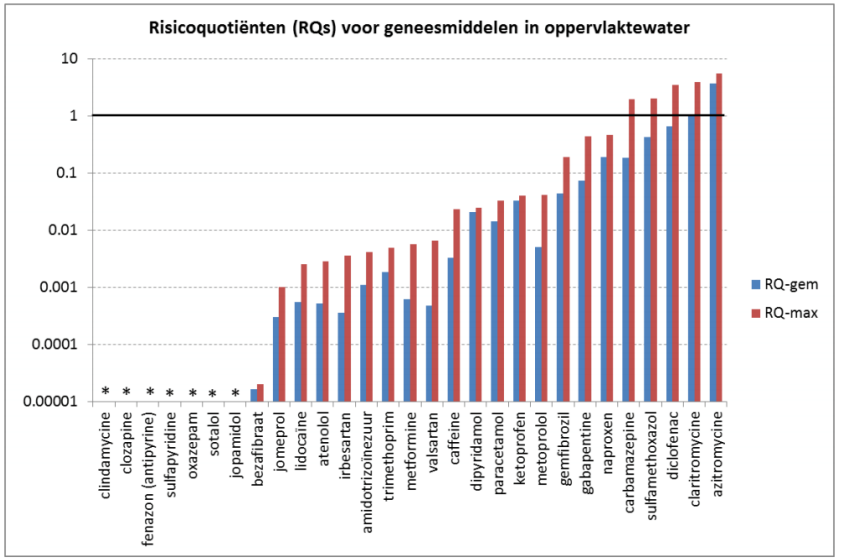
Hinterberg et al. **BJA** (2022)
Shelton et al. **BJA** (2022)

What about water pollution with propofol?

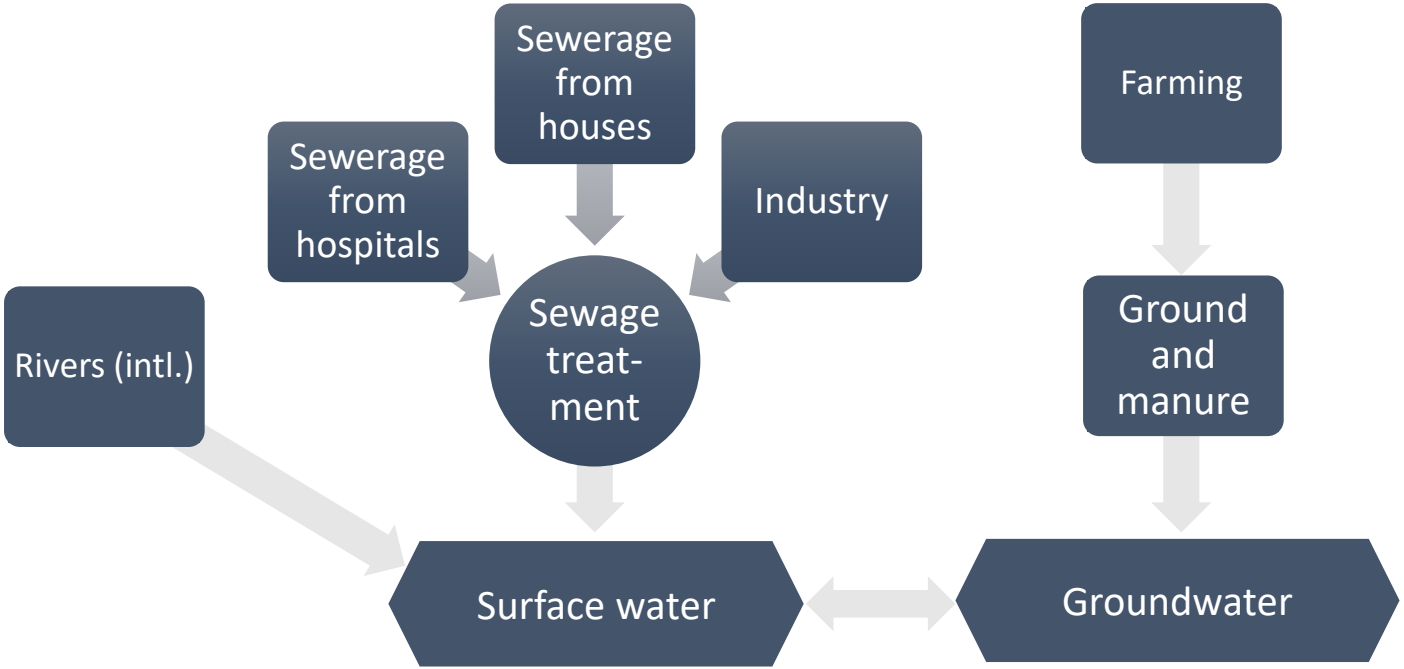
Environmental risk

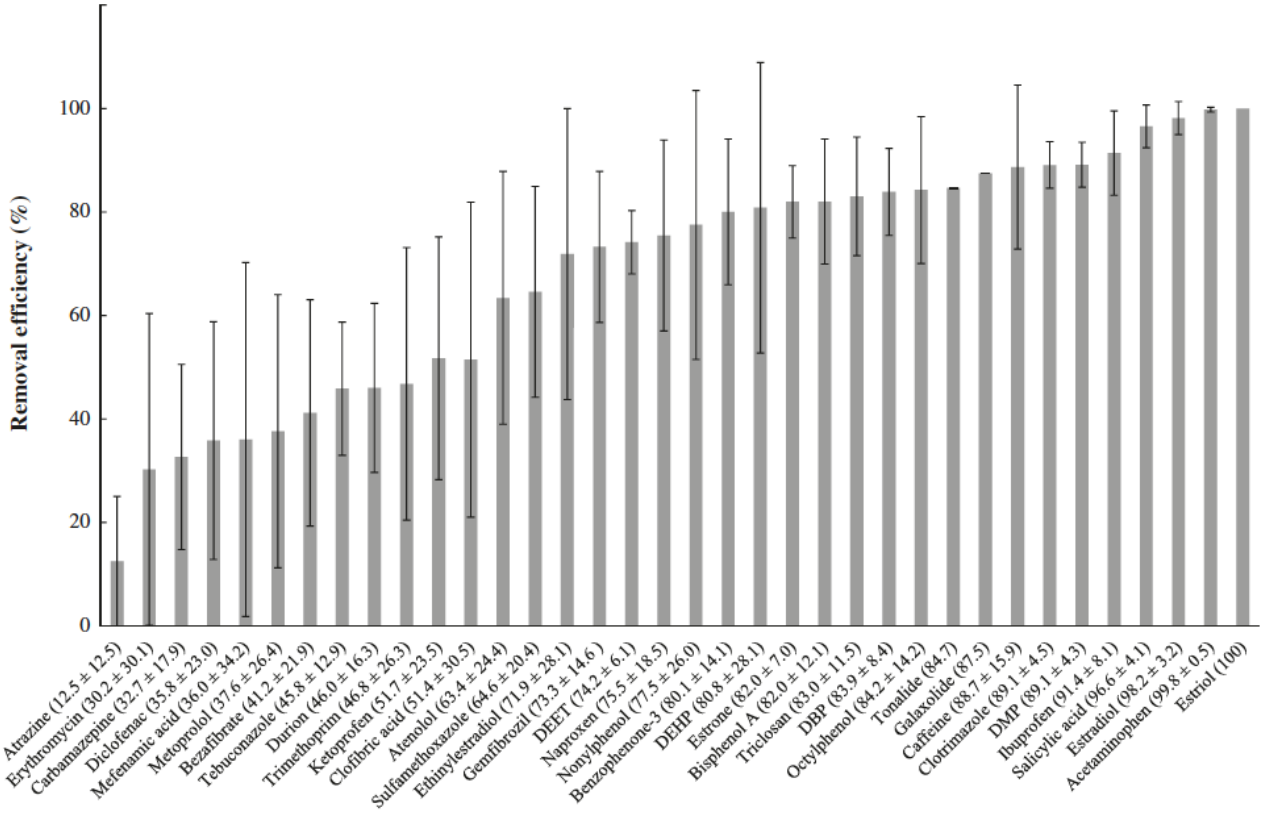
- Persistence
  Degradation in the aquatic environment
- Bioaccumulation
  Accumulate in fatty tissue of organisms
- Toxicity
  Toxic effects on algae, crustaceans, fish

Risk

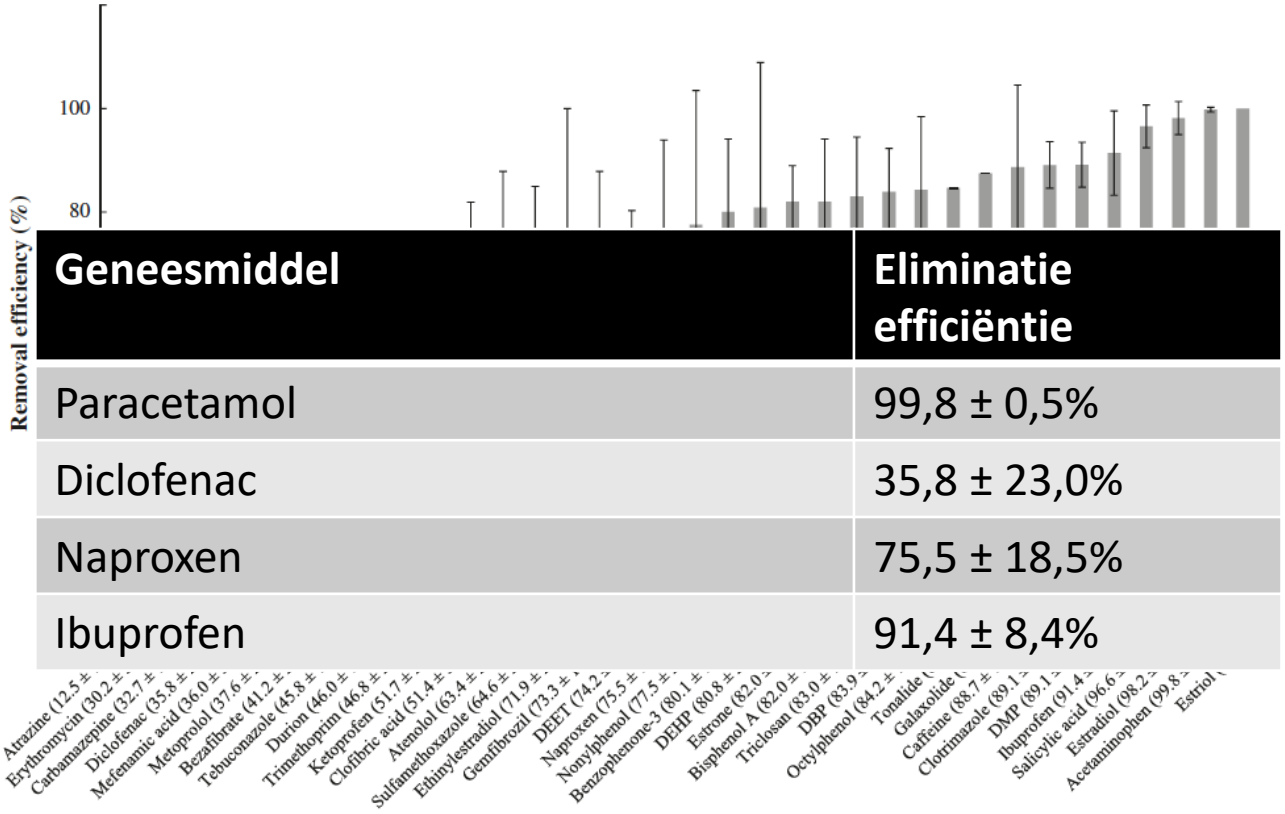


Sources of pollution





Luo et al. **Sci Tot Envir** 2014

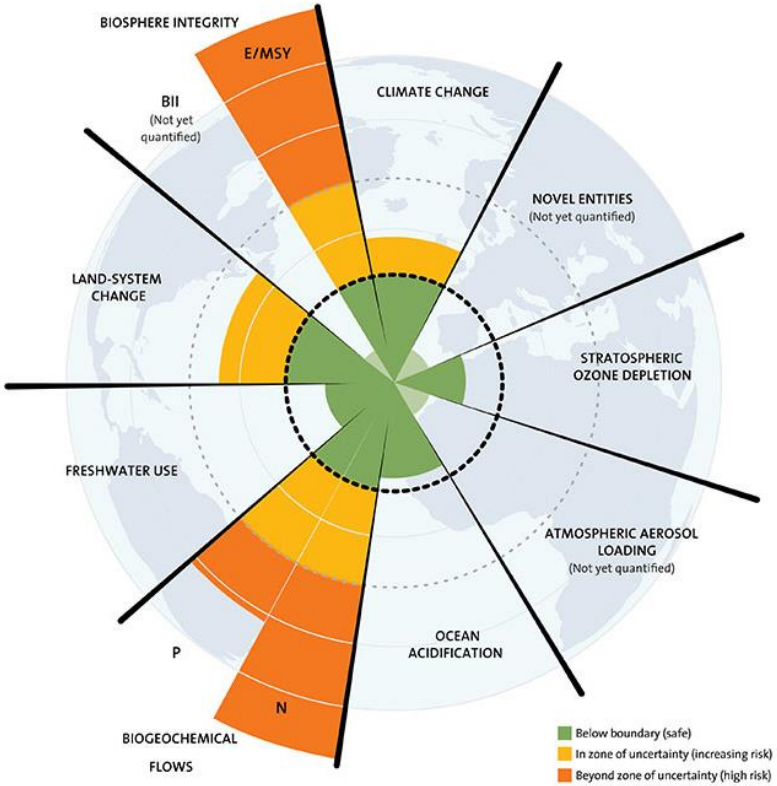


Geneesmiddel	Eliminatie efficiëntie
Paracetamol	99,8 ± 0,5%
Diclofenac	35,8 ± 23,0%
Naproxen	75,5 ± 18,5%
Ibuprofen	91,4 ± 8,4%

Luo et al. **Sci Tot Envir** 2014

Weighing risk

- Climate impact vs water pollution



Steffen et al. **Science** 2015
Waspe and Orr **Anaesthesia** 2023

More info

Review Article

Environmental risk assessment of propofol in wastewater: a narrative review of regulatory guidelines

J. Waspe[1] and T. Orr[2]

Editorial

Propofol waste and the aggregation of marginal gains in green anaesthesia

S. White,[1] L. Fang[2] and C. Shelton[3,4]

Waspe et al. **Anaesthesia** 2023

Why do you distrust the study of Leiden et al.?

LCA deep fake?

- Industry sponsored study
- 45 kg reusable / 2 kg disposable set
- Reusable: also 1.4 kg disposable wrap

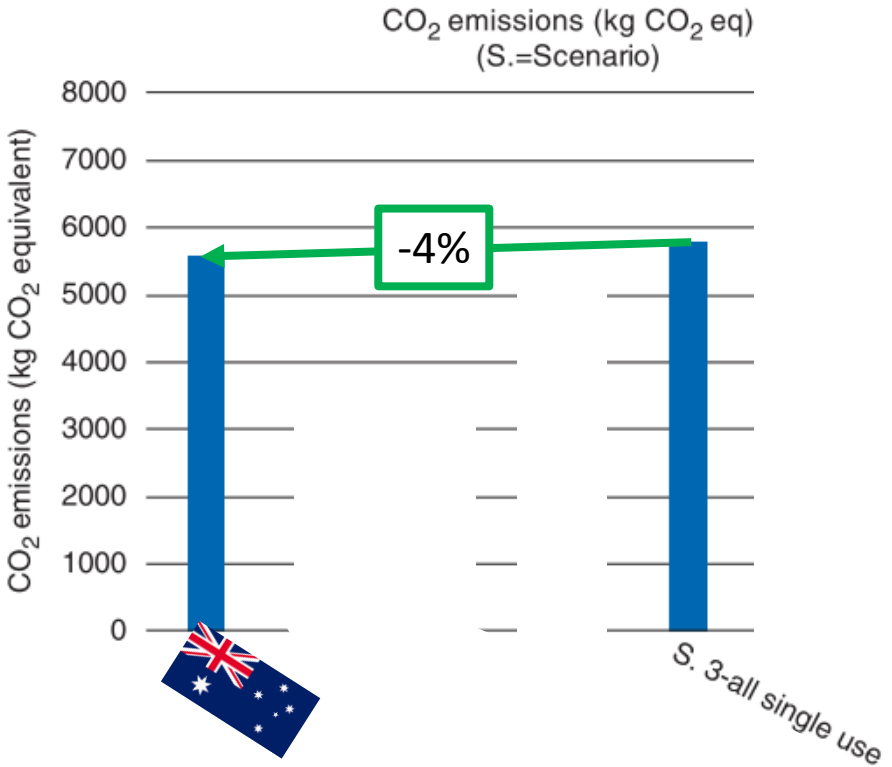
<u>Assumptions</u>

- 10% loss of reusable instruments y^{-1}
- 0% recycling
- Sterilization before AND after surgery?

Leiden et al. **Resources, Conservation & Recycling** 2020

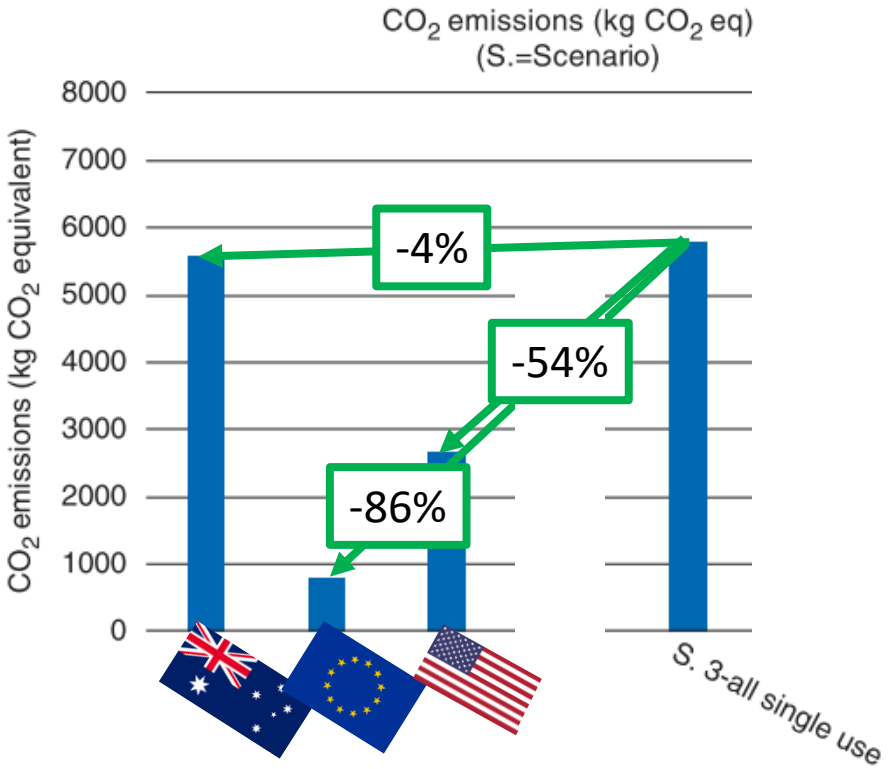
Why is energy consumption so important in Life Cycle Assessment?

Per operation



McGain et al. **BJA** (2017)

Per operation



McGain et al. **BJA** (2017)

TOP

(a) (b) (c)

Figure 2.1: Pictures of the current reusable surgical instrument composition on the (a) *Wertheim*, (b) *Gynaecologisch Buik*, and (c) *Basis Groot* tray

Table 2: GHG-emission of 1 DIN, ½ DIN and ¼ DIN trays

Tray	Sterilization (95% CI)	Tray procuring
1 DIN (kg CO_2-eq)	2,43 (2,23 - 2,77)	0,0183
½ DIN (kg CO_2-eq)	1,47 (1,37 - 1,65)	0,0173
¼ DIN (kg CO_2-eq)	0,799 (0,74 - 0,89)	0,0167

Surgical Trays

Integer Linear Prog.

$$objective:$$
$$Min \sum_t (Te_d * A_{t,d} + \sum_p Se_d * f_p * C_{p,t,d})$$

$$\sum_{t,d} D_{p,i,t,d} \geq req_{p,i} \quad \forall p,i \quad (2)$$
$$\sum_i (Size_i * B_{i,t,d}) \leq din_d \quad \forall t,d \quad (3)$$
$$\sum_i (Weight_i * B_{i,t,d}) \leq 7500 \quad \forall t,d \quad (4)$$

Constraint (5) uses *M to* ensure that if instruments that are placed on a tray (*D*) that are needed for a procedure, the tray is available for the procedure by setting *C* to 1. *C* equals 0 if none of the instruments on the tray are needed for the procedure. However, to ensure that no more instruments are available of a type than are placed on the tray, constraint (6) and constraint (7) are formulated. Constraint (8) ensures that instruments are placed only on trays that are assembled.

$$D_{p,i,t,d} \leq M * C_{p,t,d} \quad \forall p,i,t,d \quad (5)$$
$$D_{p,i,t,d} \geq B_{i,t,d} + (M * C_{p,t,d} - 1) \quad \forall p,i,t,d \quad (6)$$
$$D_{p,i,t,d} \leq B_{i,t,d} \quad \forall p,i,t,d \quad (7)$$
$$\sum_i B_{i,t,d} \leq M * A_{t,d} \quad \forall t,d \quad (8)$$

Constraint (9) ensures that trays are made in an ascending order and limits the number of possible solutions [28]. Subsequently, this is also a way to ensure that output is easily retrieved. To ensure that all instruments are placed on trays in sets of two if at least two are needed, constraint (10) is added. Lastly, to limit the decision space, constraint (11) ensures that a maximum number of trays for each DIN size can be created. Variables A and C are binary variables and the rest are integers, which is stated in constraint (12).

$$A_{t,d} \geq A_{t+1,d} \quad \forall d,t \quad (9)$$
$$If\ req_{p,i} > 2\ then\ B_{i,t,d} = 2 * q \quad \forall p,i,t,d \quad (10)$$
$$\sum_t A_{t,d} \leq trays_d \quad \forall d \quad (11)$$
$$A_{t,d}, C_{p,t,d} \in B; B_{i,t,d}, D_{p,i,t,d}, q_{i,t,d}, r_{i,t,d} \in Z \quad (12)$$

The ILP model was formulated using *Gurobi Python* Interface. The code employed is displayed in Appendix A.

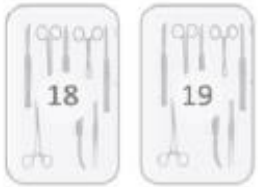
Current	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Current situation	≥ 50% utilization	≥ 50% utilization combined	≥ 50% utilization reducing total tray size by ½ DIN	>60% utilization rate
				
70 instruments	37 instruments	37 instruments	37 instruments	31 instruments

Figure 2.2 Current situation of *Gynaecologisch buik* and *Wertheim* tray and different optimization scenario's

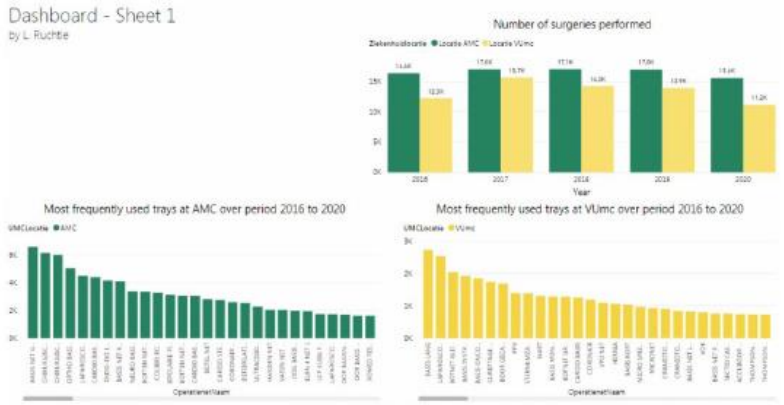


Figure 5.2 Screenshot of the first sheet of the dashboard. Green: AMC, yellow: VUmc.

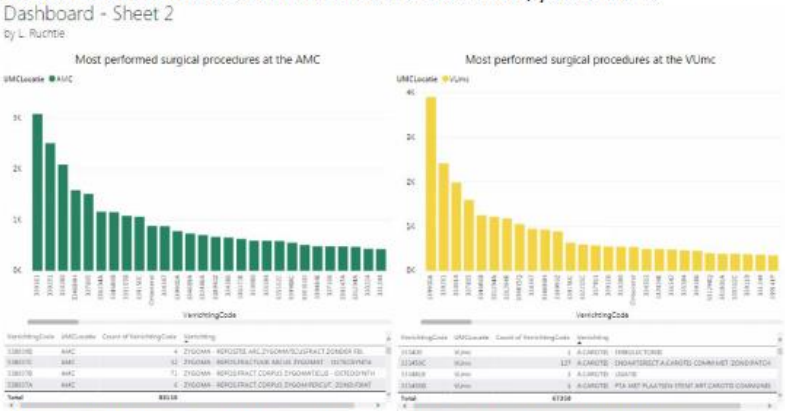


Figure 5.3 Screenshot of the second sheet of the dashboard. Green: AMC, yellow: VUmc.

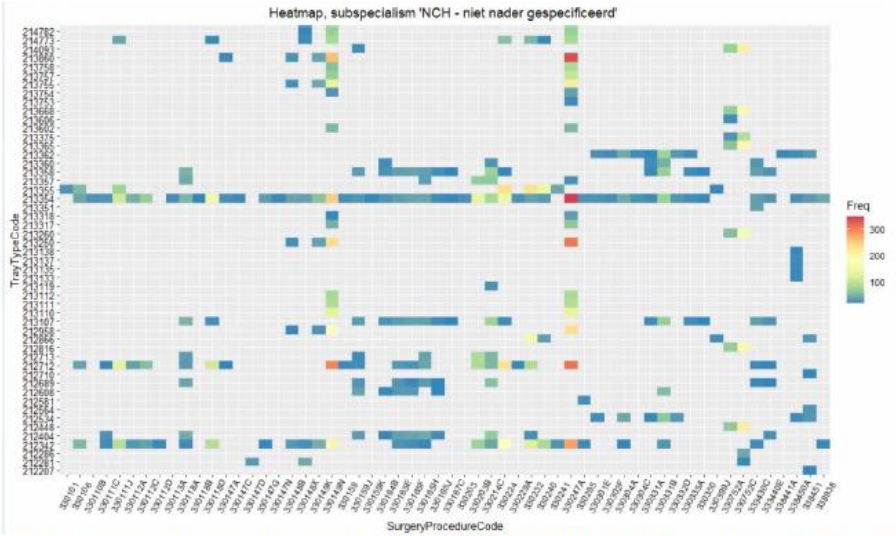


Figure 5.6 Heatmap of trays used* per surgical procedure for the *'NCH - niet nader gespecificeerd'* discipline