


# Sustainability in Healthcare: from footprint to handprint

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# I have no potential conflicts of interest











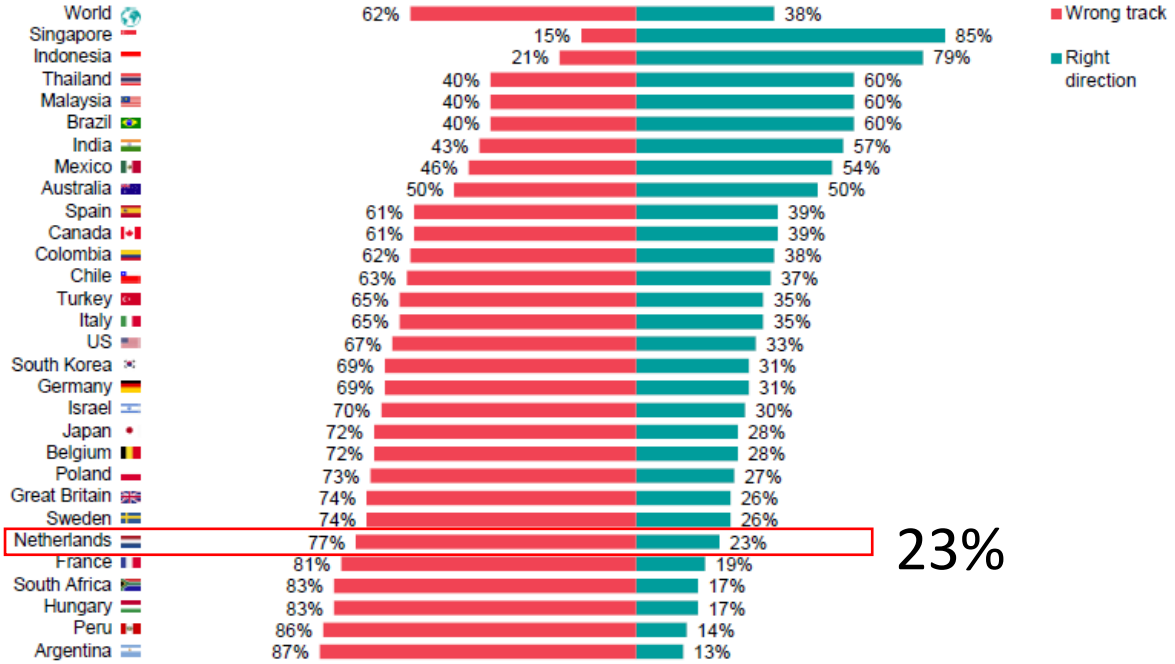
Hans van der Maarel/Red Geographics
https://www.footprintcalculator.org

# Two statements about the future

“All things considered, the world is getting better”

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"All things considered, the world is getting better"






**Ipsos**, What worries the world (2023)

# Two statements about the future

“All things considered, the world is getting better”

“My biggest worry is climate change”

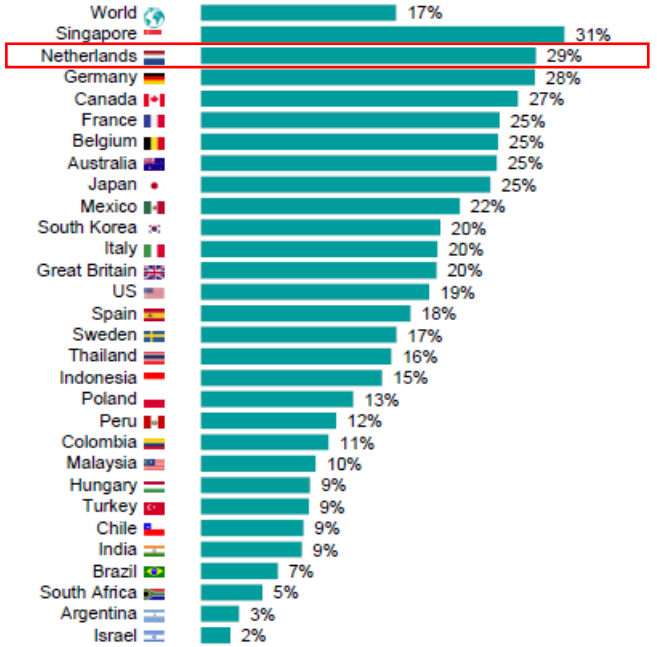


**Ipsos**, What worries the world (2023)

# Two statements about the future

“All things considered, the world is getting better”

“My biggest worry is climate change”

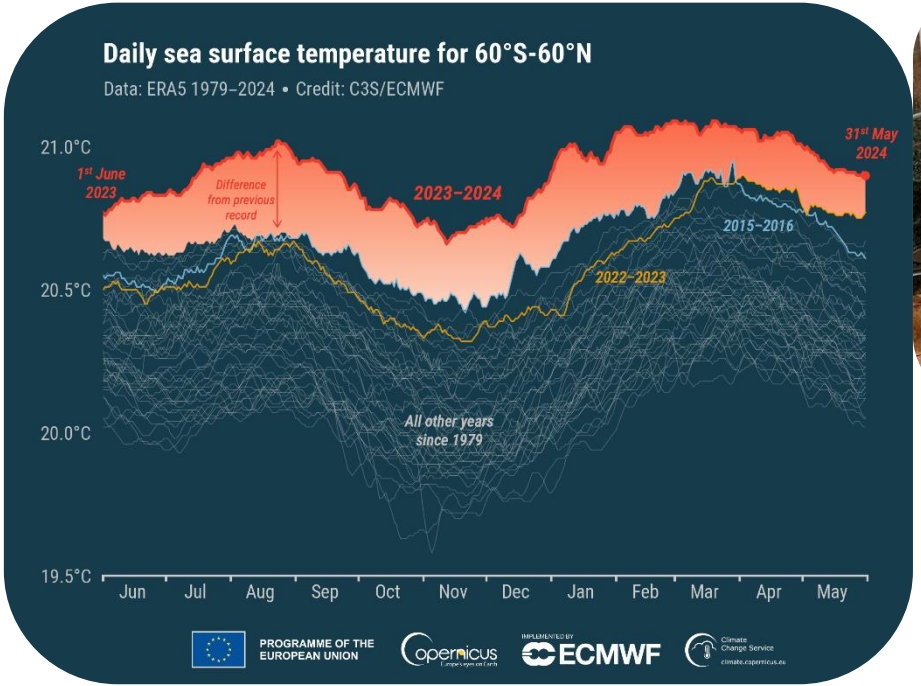



29%



**Ipsos**, What worries the world (2023)

# The news is worrying..



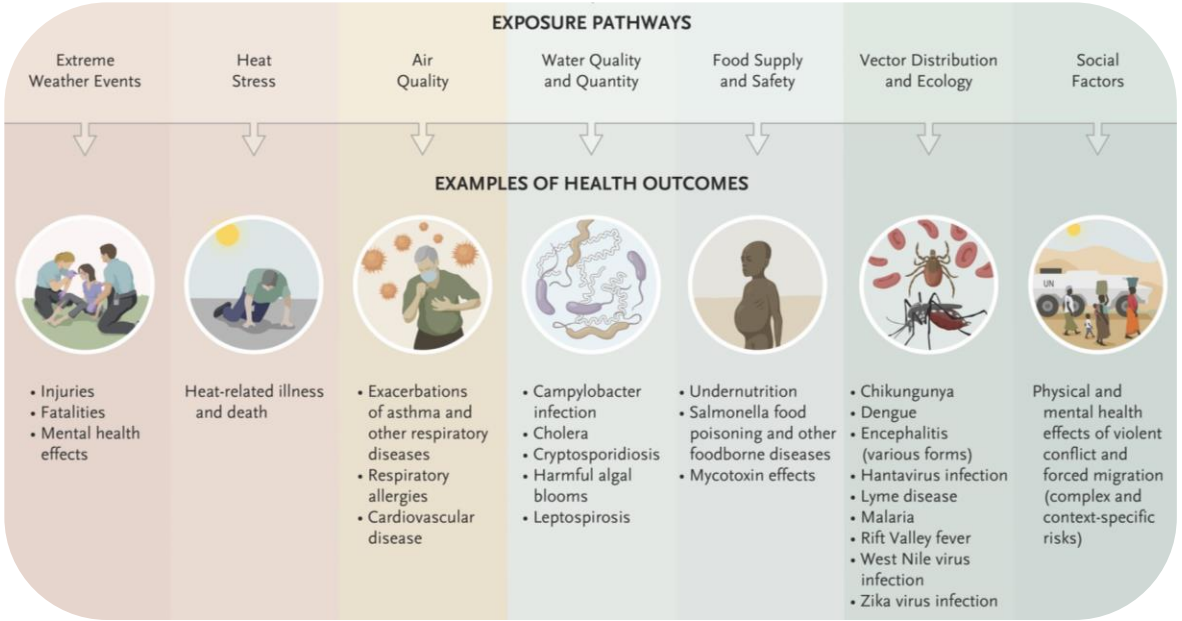





# Why care as a physician?

## Reason 1: climate change is a public health threat








Haines, **NEJM** (2019)

# Lancet countdown report

LANCET COUNTDOWN:
TRACKING PROGRESS
ON HEALTH AND
CLIMATE CHANGE





Hugh Montgomery

# Lancet Countdown (to zero)

2018: shaping the health of nations for centuries to come

2019: ensuring that the health of a child born today is not defined by a changing climate

2020: responding to converging crises

2021: code red for a healthy future

2022: health at the mercy of fossil fuels

2023: the imperative for a health-centred response in a world facing irreversible harms

# Lancet Countdown (to zero)

2018: shaping the health of nations for centuries to

2019: ensuring that the health of a child born today

2020:

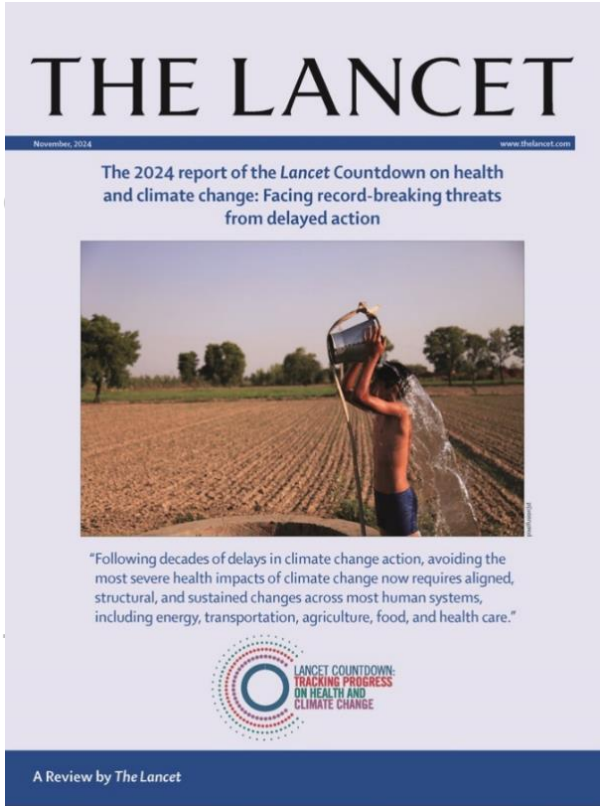
2021:

2022:

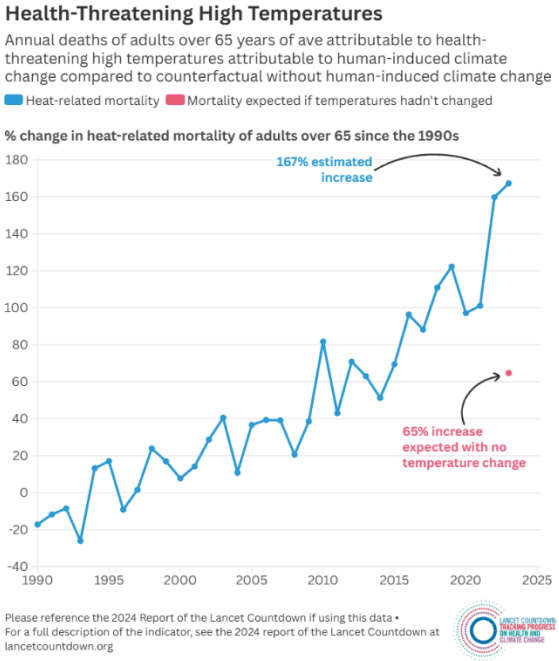
2023: the imperative for a health-centred response irreversible harms

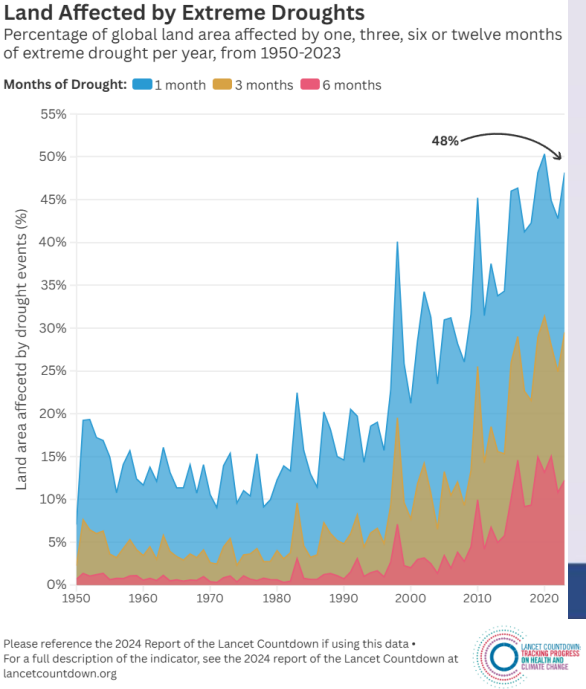
**2024:**

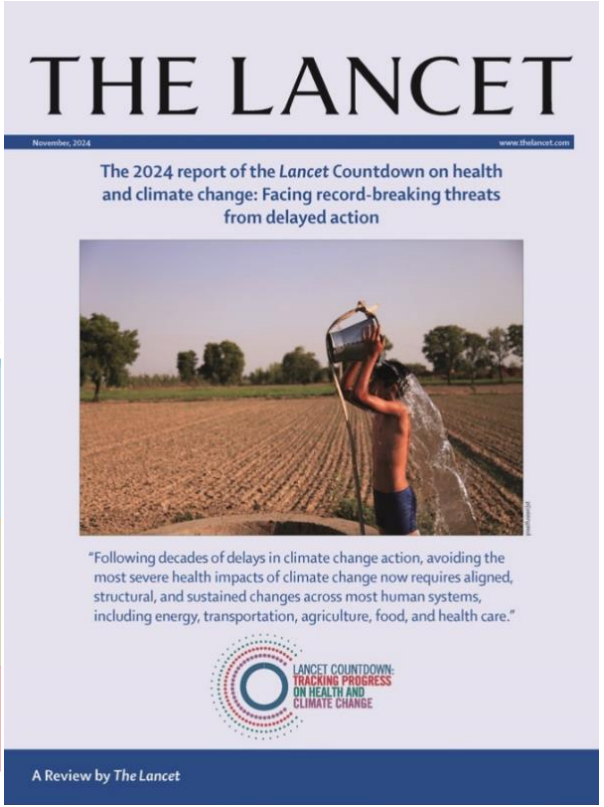
**Facing record-breaking threats from delayed action**



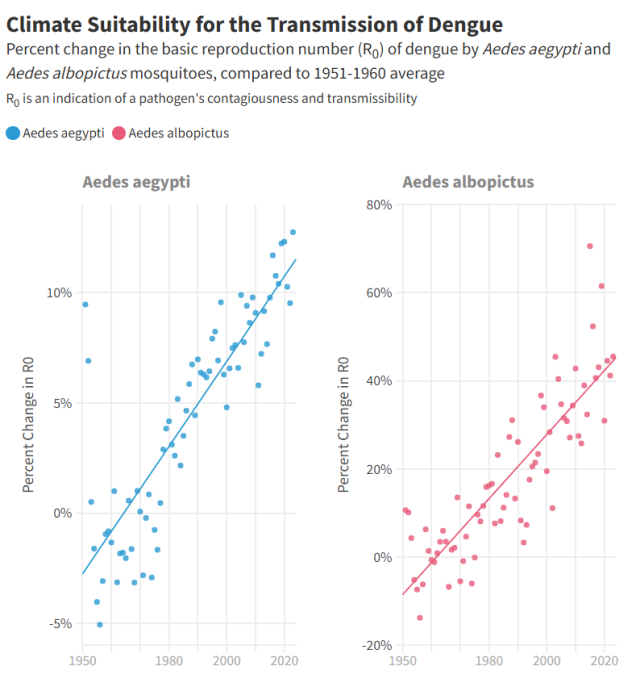
# Heat & Drought

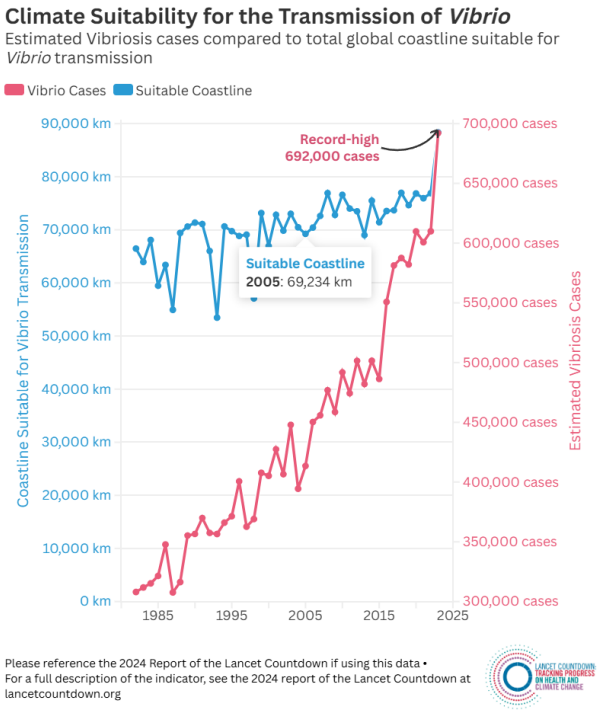


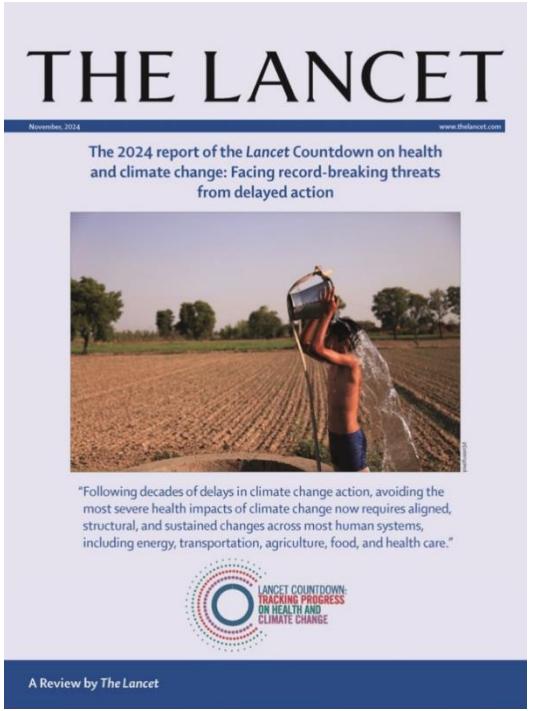



# Dengue & Vibrio



# Mortality vs emissions

Mortality through climate change

~250.000 deaths/y



Emissions causing climate change





Patz, **EcoHealth** (2017)

*“Climate change is the biggest threat to human health in the 21st century”*

World Health Organization

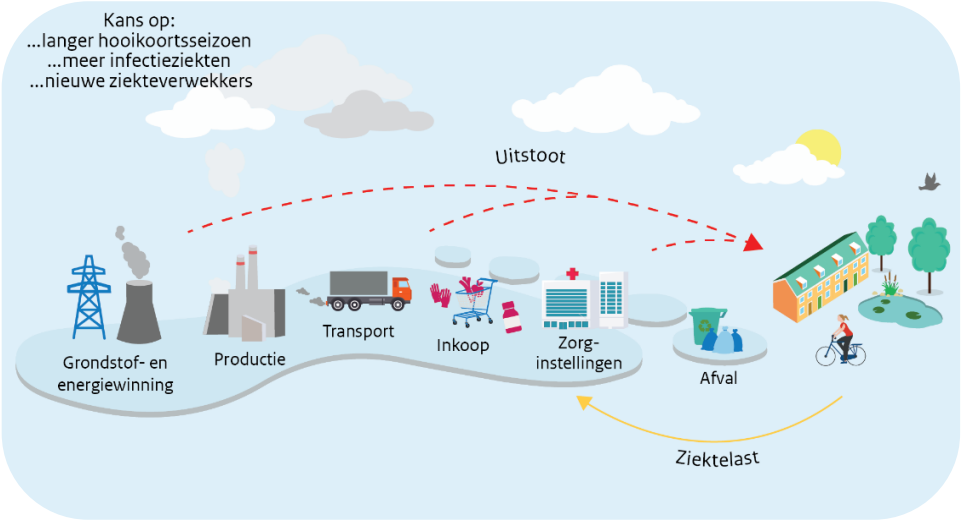


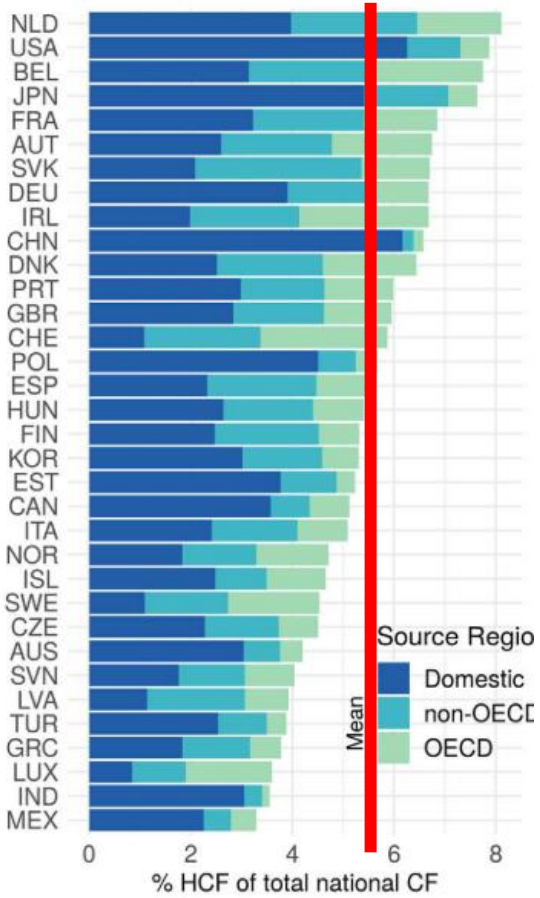
Ten threats to global health in 2019 (who.int)

# Why care as a physician?

Reason 1: climate change is a public health threat

Reason 2: healthcare is a polluting sector






Pichler, **Env Res Lett** (2019)
RIVM (2022)

© Maria Koijck



# Lineair health economy

Raw materials
13 %







Waste
4.2 %





**Greenhouse gases**
**7.3 %**



Steenmeijer, **Lancet Planetary Health** (2022)

# Dutch Green Deal Sustainable Healthcare

1. Promote Health

2. Raise awareness
Education

3. GHG emission reduction
2030: 55% reduction
2050: net-zero

4. Circularity
2030: 50% less material use
2050: circular economy

5. Reduce eco-toxicity
of medication

# Awareness


Amel Namane
Voorzitter
Inspreker


KLIMAATCRISIS = GEZONDHEIDSCRISIS
HERGEBRUIK JIJ DE NIETMACHINE? WIJ NIET!
ZORG VOOR KLIMAAT
Amsterdam UMC
Universitair Medische Centra


VAN WIE IS DE LUCHT?
Fossiele reclames verzieken ons bestaan

# Awareness











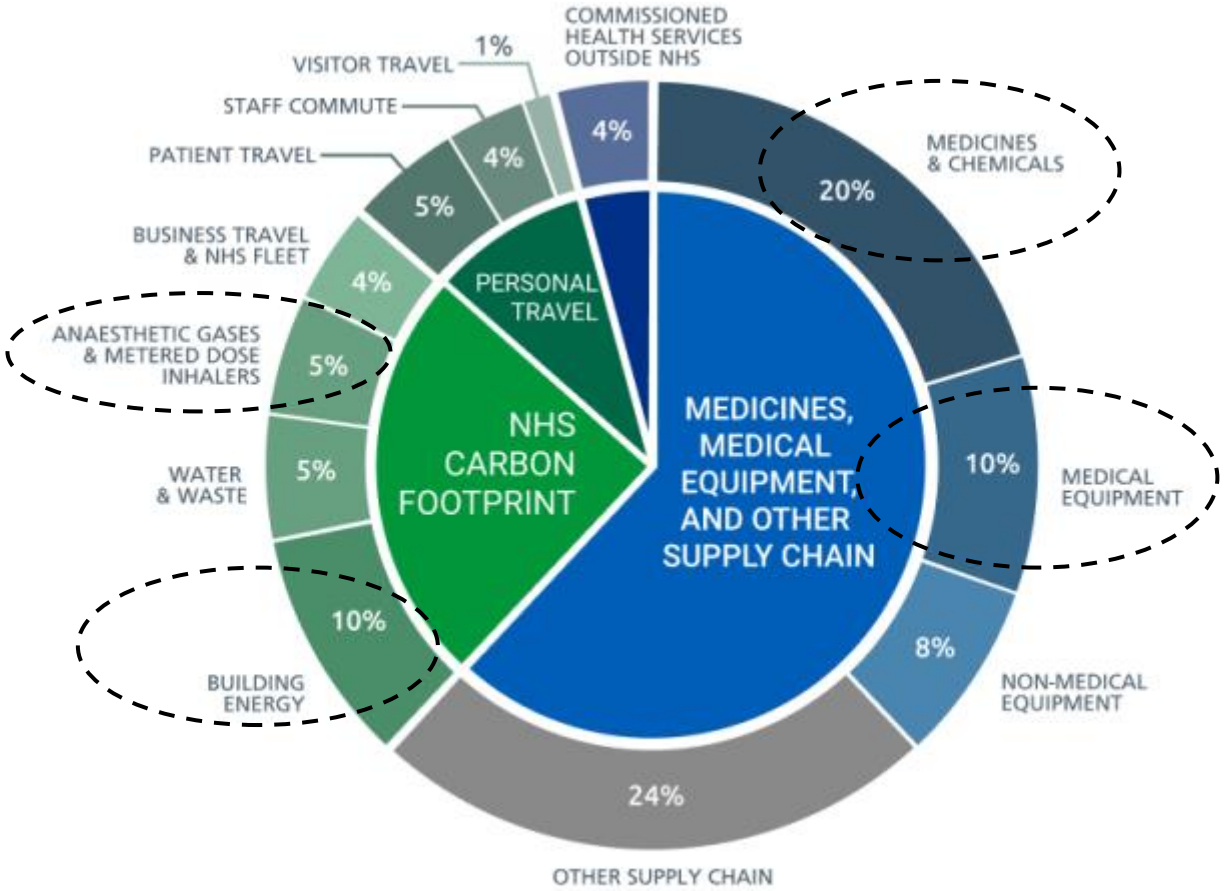
>65 Green Teams
>4000 communityleden










## One 3rd direct impact

- Anaesthetic gases ≈3%
- Building energy ≈10%

## Two 3rds supply chain

- Medical equipment ≈10%
- Pharmaceuticals ≈20%



Tennison et al. **Lancet Planetary Health** (2021)

# Surgery's footprint




Scope 1

Anaesthetics

+



Scope 2

HVAC

+



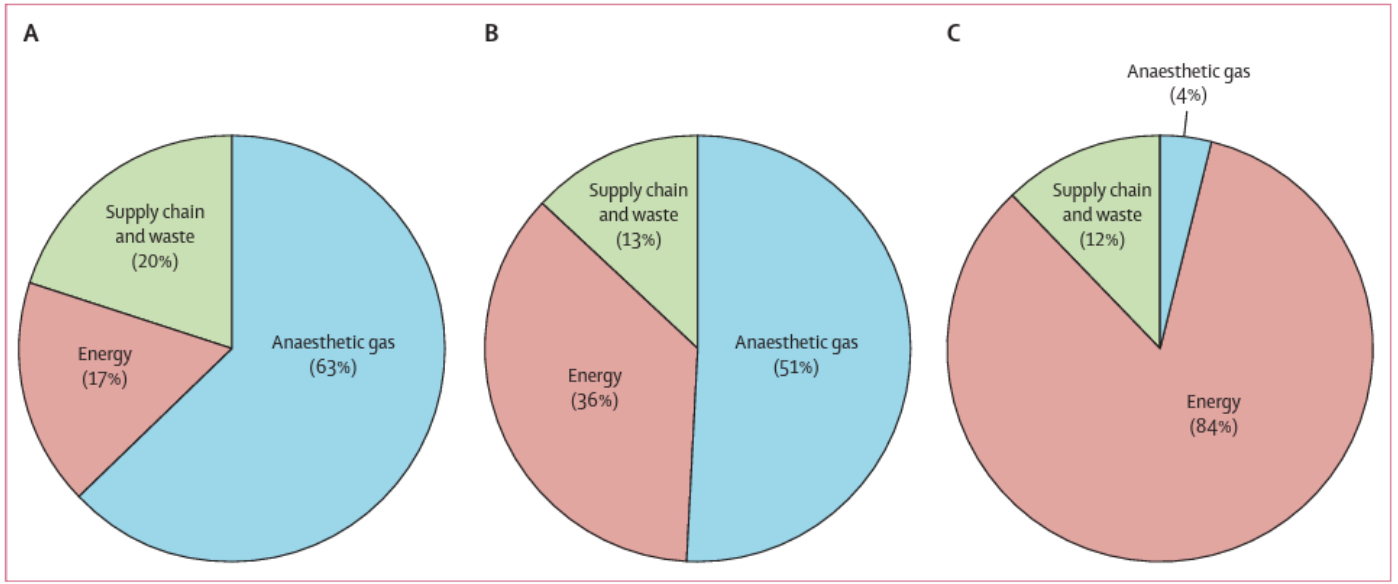
Scope 3

Disposables



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

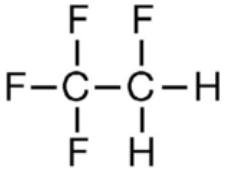
# The impact of scopes varies greatly between systems



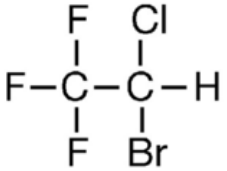



MacNeill et al. **Lancet Planet Health** (2017)

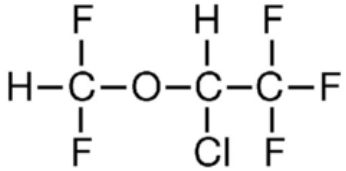
# Anaesthetics



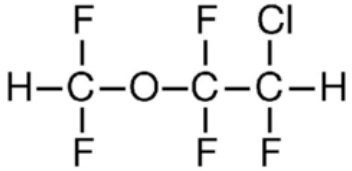
HFA 134a



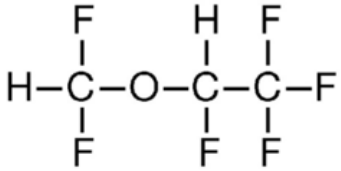
Halothane



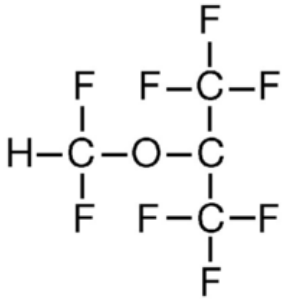
Isoflurane



Enflurane



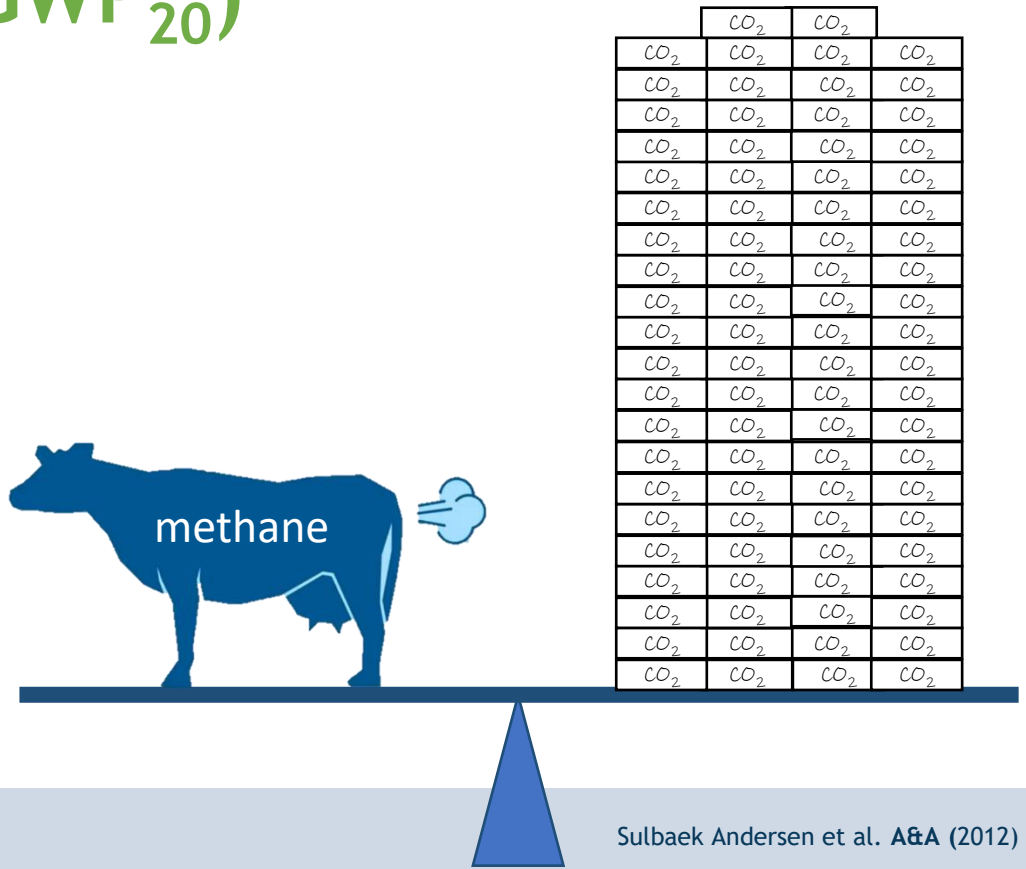
Desflurane



Sevoflurane

# $CO_2$-equivalents ($GWP_{20}$)

| | |
|---|---|
| $CO_2$ | = 1 |
| Methane | = 86 |
| $N_2O$ | = 289 |
| Sevoflurane | = 508 |
| Isoflurane | = 1800 |
| Desflurane | = 6810 |

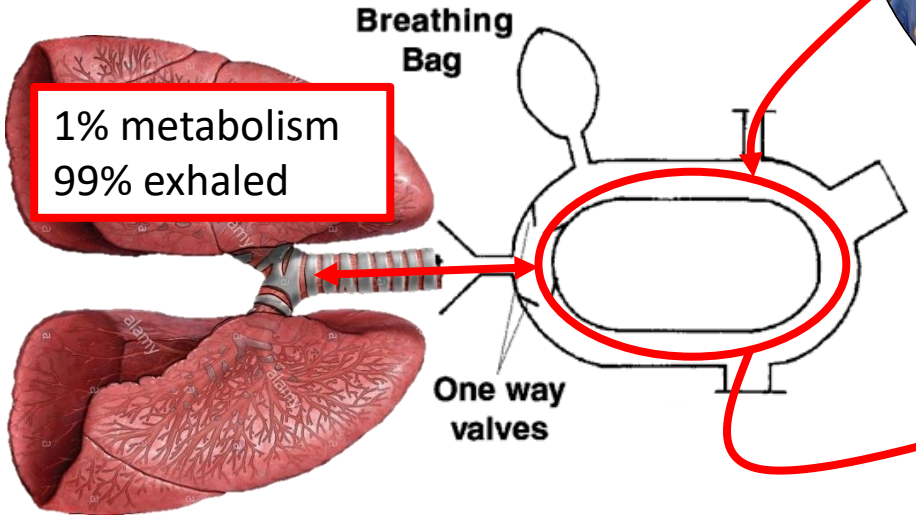




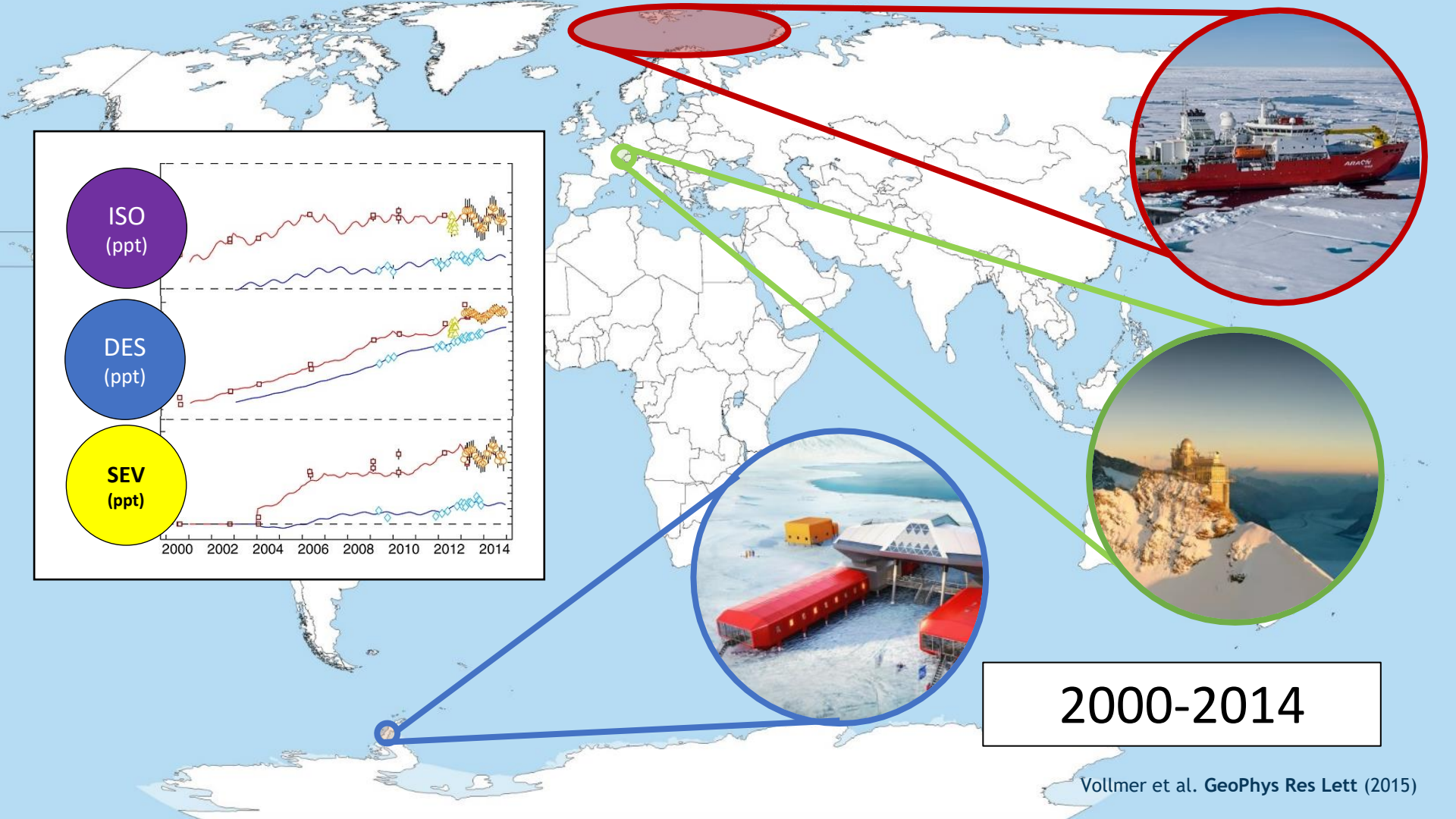

Sulbaek Andersen et al. **A&A** (2012)

# Volatile anaesthetics/$N_2O$



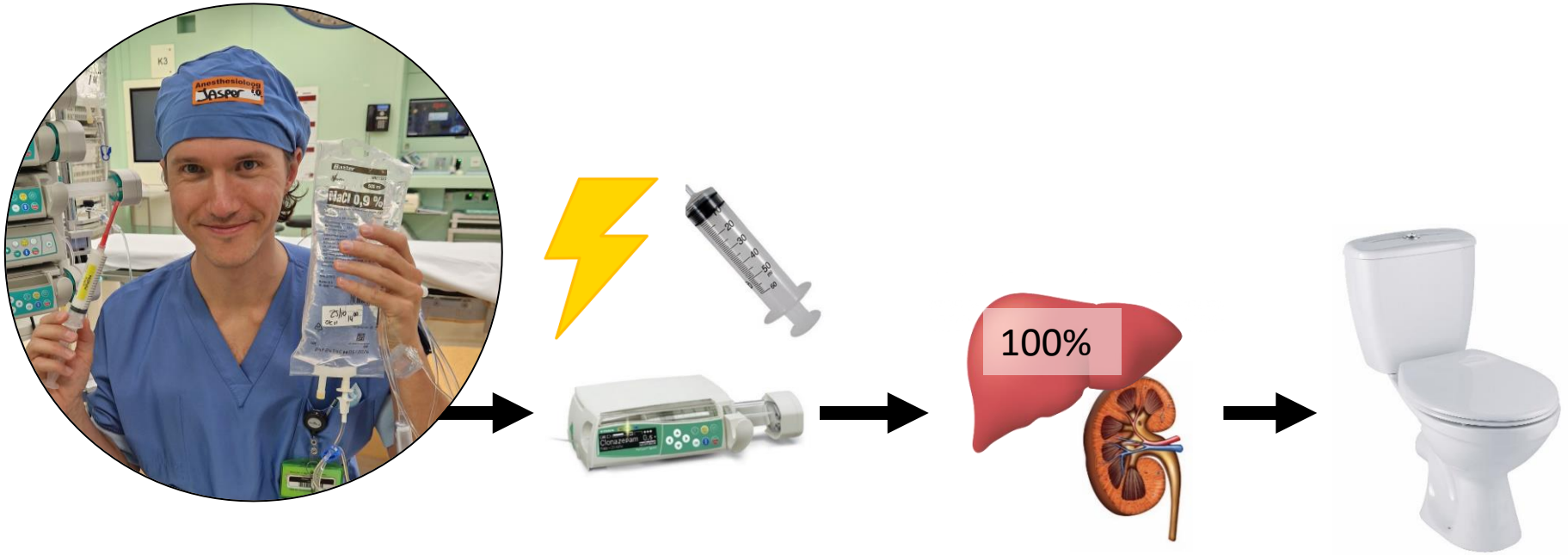






Vollmer et al. **GeoPhys Res Lett** (2015)

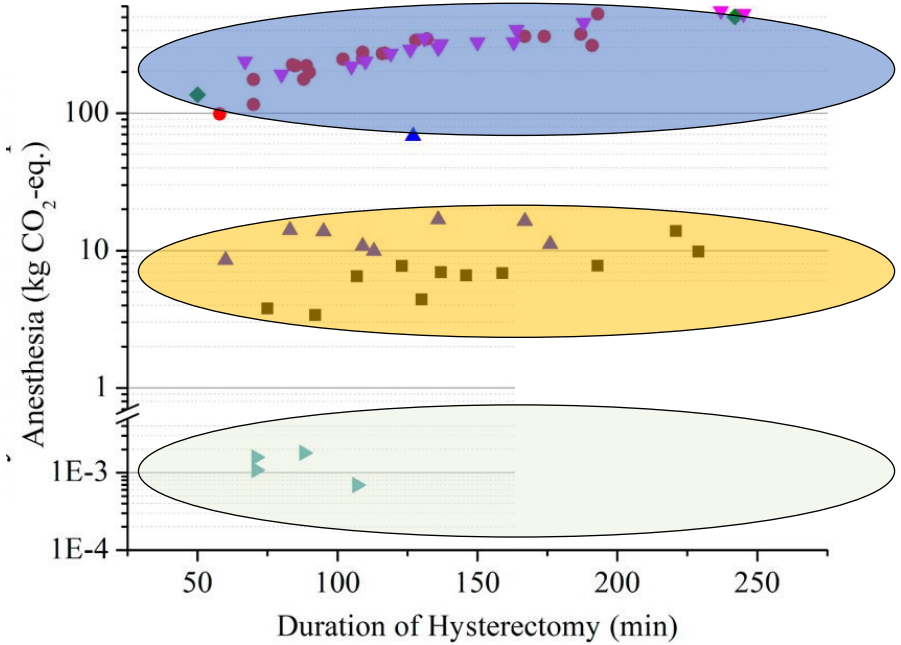
# Total intravenous anaesthesia






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

# Choice of anaesthetic does matter




Desflurane
~$10^2$-$10^3$ kg $CO_2$ (3000 km)

Sevoflurane
~$10^1$ kg $CO_2$ (90 km)

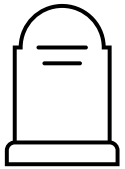
Propofol
~$10^{-1}$ kg $CO_2$ (1 km)



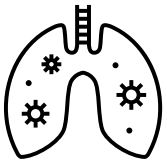



Thiel et al. **Envir Sci Tech** (2015)

# And apart from environmental damage?



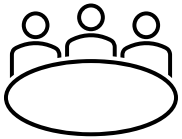
Mortality



Morbidity

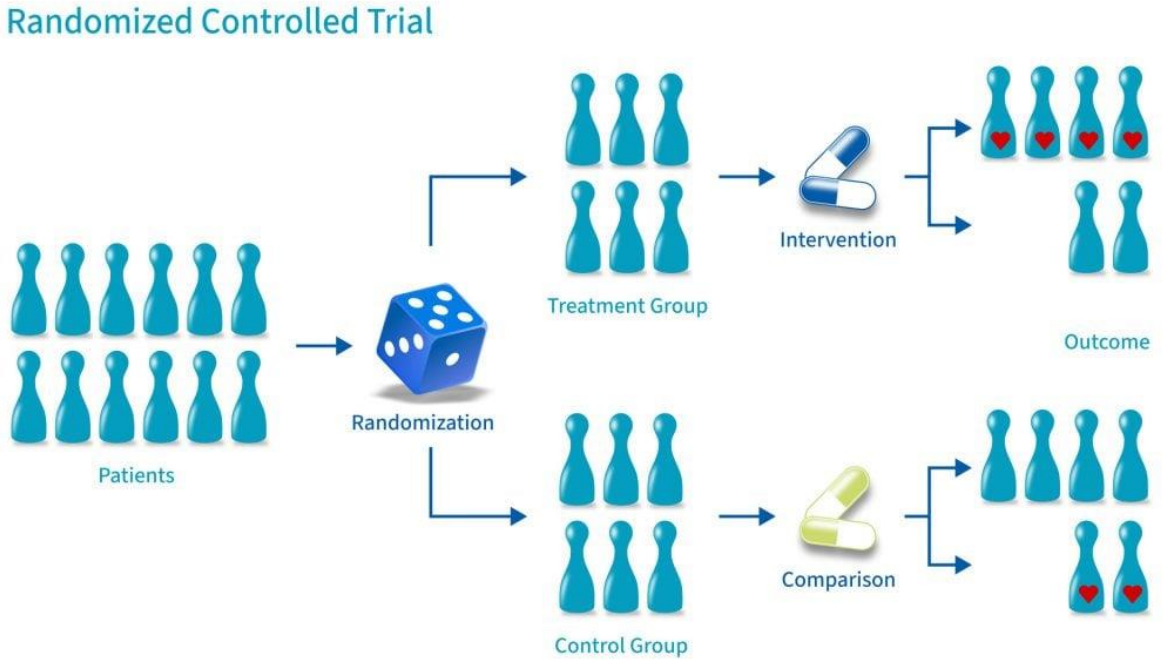


Comfort



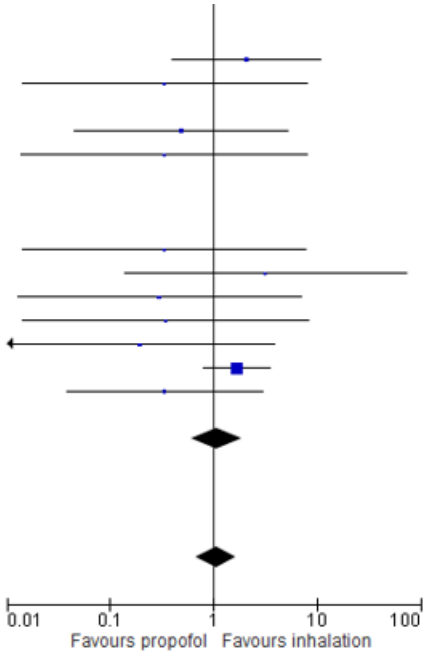
Efficiency

# Randomised controlled trial (RCT)



# Meta-analysis: mortality

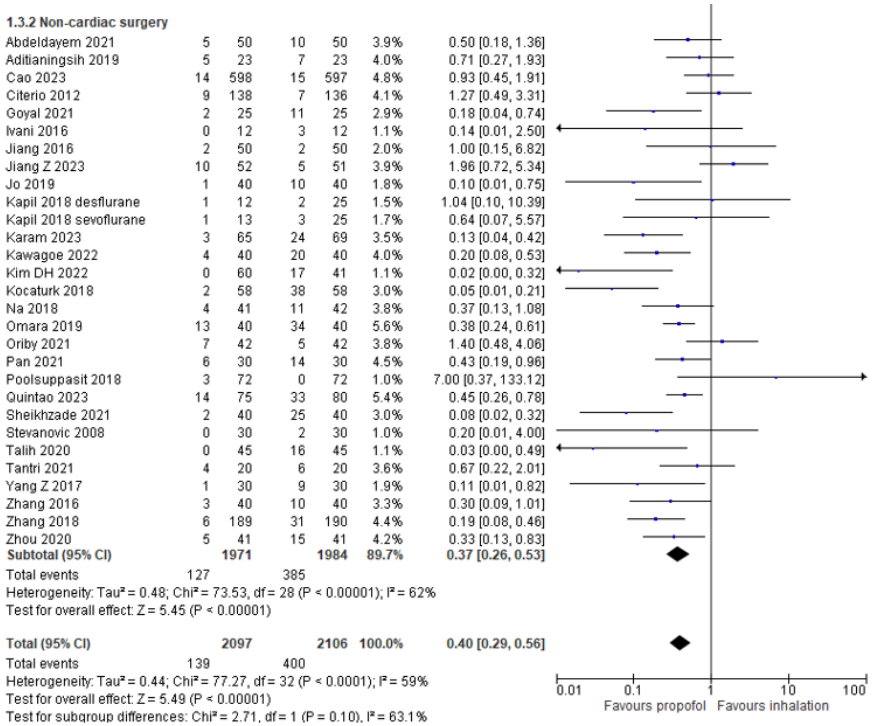
| | | | | | | |
|---|---|---|---|---|---|---|
| **1.2.2 Non-cardiac surgery** | | | | | | |
| Beck-Schimmer 2015 | 4 | 48 | 2 | 50 | 7.6% | 2.08 [0.40, 10.85] |
| Chang 2022 | 0 | 35 | 1 | 35 | 2.1% | 0.33 [0.01, 7.91] |
| Citerio 2012 | 0 | 138 | 0 | 136 | | Not estimable |
| Dai Z 2021 | 1 | 83 | 2 | 81 | 3.6% | 0.49 [0.05, 5.28] |
| Guo 2020 | 0 | 117 | 1 | 117 | 2.0% | 0.33 [0.01, 8.10] |
| Kawanishi 2022 | 0 | 24 | 0 | 26 | | Not estimable |
| Li XF 2021 desflurane | 0 | 83 | 0 | 177 | | Not estimable |
| Li XF 2021 sevoflurane | 0 | 84 | 0 | 169 | | Not estimable |
| Margarit 2014 | 0 | 30 | 1 | 30 | 2.1% | 0.33 [0.01, 7.87] |
| Nieuwenhuijs-Moeke 2017 | 1 | 18 | 0 | 19 | 2.1% | 3.16 [0.14, 72.84] |
| Sharma 2020 | 0 | 26 | 1 | 23 | 2.1% | 0.30 [0.01, 6.94] |
| Shin 2020 | 0 | 58 | 1 | 60 | 2.0% | 0.34 [0.01, 8.29] |
| Song 2022 | 0 | 30 | 2 | 29 | 2.3% | 0.19 [0.01, 3.87] |
| Wan Hassan 2017 | 15 | 55 | 9 | 55 | 37.9% | 1.67 [0.80, 3.48] |
| Xu 2014 | 1 | 20 | 3 | 20 | 4.3% | 0.33 [0.04, 2.94] |
| Zhang 2018 | 0 | 189 | 0 | 190 | | Not estimable |
| **Subtotal (95% CI)** | | **1038** | | **1217** | **68.1%** | **1.07 [0.62, 1.86]** |
| Total events | 22 | | 23 | | | |
| Heterogeneity: Tau² = 0.00; Chi² = 8.07, df = 10 (P = 0.62); I² = 0% | | | | | | |
| Test for overall effect: Z = 0.25 (P = 0.80) | | | | | | |
| **Total (95% CI)** | | **1792** | | **2054** | **100.0%** | **1.05 [0.67, 1.66]** |
| Total events | 34 | | 34 | | | |
| Heterogeneity: Tau² = 0.00; Chi² = 13.59, df = 17 (P = 0.70); I² = 0% | | | | | | |
| Test for overall effect: Z = 0.22 (P = 0.82) | | | | | | |
| Test for subgroup differences: Chi² = 0.01, df = 1 (P = 0.91), I² = 0% | | | | | | |






Kampman & Sperna Weiland, **Lancet eClinicalMedicine** (2024)

# Meta-analysis: emergence delirium



| 1.3.2 Non-cardiac surgery | | | | | | |
|---|---|---|---|---|---|---|
| Abdeldayem 2021 | 5 | 50 | 10 | 50 | 3.9% | 0.50 [0.18, 1.36] |
| Aditianingsih 2019 | 5 | 23 | 7 | 23 | 4.0% | 0.71 [0.27, 1.93] |
| Cao 2023 | 14 | 598 | 15 | 597 | 4.8% | 0.93 [0.45, 1.91] |
| Citerio 2012 | 9 | 138 | 7 | 136 | 4.1% | 1.27 [0.49, 3.31] |
| Goyal 2021 | 2 | 25 | 11 | 25 | 2.9% | 0.18 [0.04, 0.74] |
| Ivani 2016 | 0 | 12 | 3 | 12 | 1.1% | 0.14 [0.01, 2.50] |
| Jiang 2016 | 2 | 50 | 2 | 50 | 2.0% | 1.00 [0.15, 6.82] |
| Jiang Z 2023 | 10 | 52 | 5 | 51 | 3.9% | 1.96 [0.72, 5.34] |
| Jo 2019 | 1 | 40 | 10 | 40 | 1.8% | 0.10 [0.01, 0.75] |
| Kapil 2018 desflurane | 1 | 12 | 2 | 25 | 1.5% | 1.04 [0.10, 10.39] |
| Kapil 2018 sevoflurane | 1 | 13 | 3 | 25 | 1.7% | 0.64 [0.07, 5.57] |
| Karam 2023 | 3 | 65 | 24 | 69 | 3.5% | 0.13 [0.04, 0.42] |
| Kawagoe 2022 | 4 | 40 | 20 | 40 | 4.0% | 0.20 [0.08, 0.53] |
| Kim DH 2022 | 0 | 60 | 17 | 41 | 1.1% | 0.02 [0.00, 0.32] |
| Kocaturk 2018 | 2 | 58 | 38 | 58 | 3.0% | 0.05 [0.01, 0.21] |
| Na 2018 | 4 | 41 | 11 | 42 | 3.8% | 0.37 [0.13, 1.08] |
| Omara 2019 | 13 | 40 | 34 | 40 | 5.6% | 0.38 [0.24, 0.61] |
| Oriby 2021 | 7 | 42 | 5 | 42 | 3.8% | 1.40 [0.48, 4.06] |
| Pan 2021 | 6 | 30 | 14 | 30 | 4.5% | 0.43 [0.19, 0.96] |
| Poolsuppasit 2018 | 3 | 72 | 0 | 72 | 1.0% | 7.00 [0.37, 133.12] |
| Quintao 2023 | 14 | 75 | 33 | 80 | 5.4% | 0.45 [0.26, 0.78] |
| Sheikhzade 2021 | 2 | 40 | 25 | 40 | 3.0% | 0.08 [0.02, 0.32] |
| Stevanovic 2008 | 0 | 30 | 2 | 30 | 1.0% | 0.20 [0.01, 4.00] |
| Talih 2020 | 0 | 45 | 16 | 45 | 1.1% | 0.03 [0.00, 0.49] |
| Tantri 2021 | 4 | 20 | 6 | 20 | 3.6% | 0.67 [0.22, 2.01] |
| Yang Z 2017 | 1 | 30 | 9 | 30 | 1.9% | 0.11 [0.01, 0.82] |
| Zhang 2016 | 3 | 40 | 10 | 40 | 3.3% | 0.30 [0.09, 1.01] |
| Zhang 2018 | 6 | 189 | 31 | 190 | 4.4% | 0.19 [0.08, 0.46] |
| Zhou 2020 | 5 | 41 | 15 | 41 | 4.2% | 0.33 [0.13, 0.83] |
| **Subtotal (95% CI)** | | **1971** | | **1984** | **89.7%** | **0.37 [0.26, 0.53]** |
| Total events | 127 | | 385 | | | |
| Heterogeneity: Tau² = 0.48; Chi² = 73.53, df = 28 (P < 0.00001); I² = 62% | | | | | | |
| Test for overall effect: Z = 5.45 (P < 0.00001) | | | | | | |
| **Total (95% CI)** | | **2097** | | **2106** | **100.0%** | **0.40 [0.29, 0.56]** |
| Total events | 139 | | 400 | | | |
| Heterogeneity: Tau² = 0.44; Chi² = 77.27, df = 32 (P < 0.0001); I² = 59% | | | | | | |
| Test for overall effect: Z = 5.49 (P < 0.00001) | | | | | | |
| Test for subgroup differences: Chi² = 2.71, df = 1 (P = 0.10), I² = 63.1% | | | | | | |





Kampman & Sperna Weiland, **Lancet eClinicalMedicine** (2024)

# Patient safety, comfort and efficiency

| Meta-analysis of RCTs 1:<br>TIVA vs inhaled anaesthesia | Meta-analysis of RCTs 2:<br>with vs without $N_2O$ |
|---|---|
| 51,107 patients, 317 studies | 22,147 patients, 71 studies |
| No difference in mortality, nor organ related morbidity | |
| Clear reduction in nausea and vomiting, enhanced quality of recovery<br>& less emergence delirium with TIVA | |

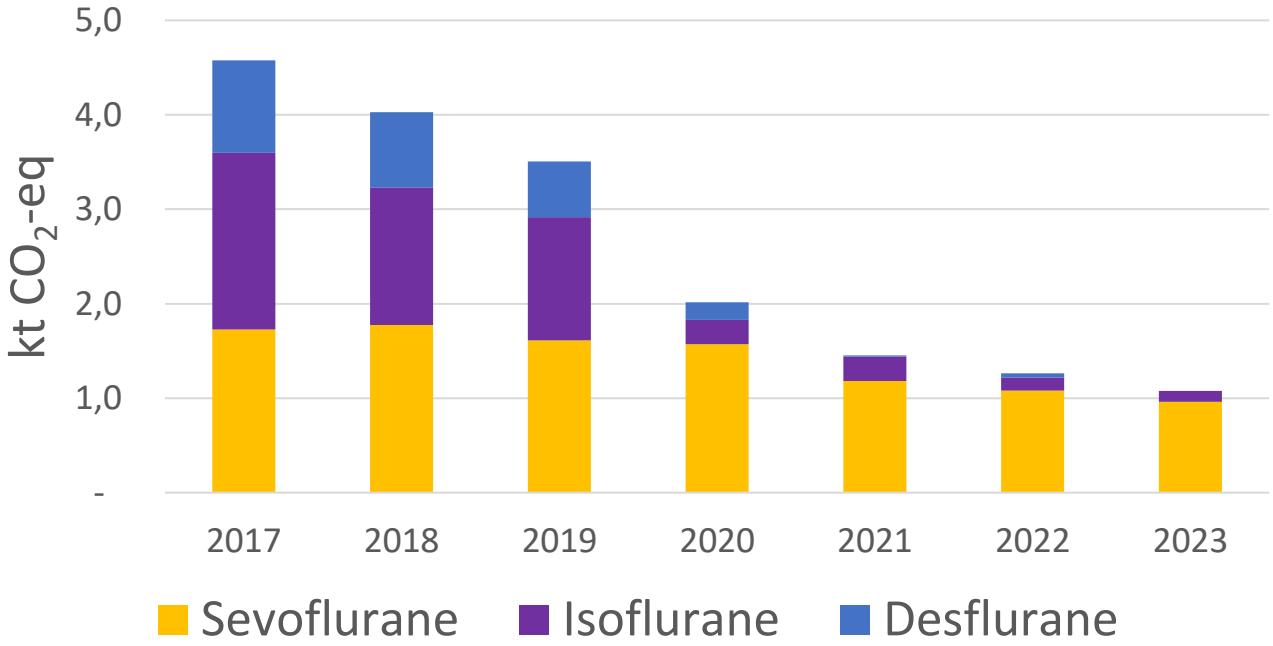


Kampman & Sperna Weiland, **Lancet eClinical Medicine** (2024)
Kampman & Sperna Weiland, **British Journal of Anaesthesia** (2024)




*“IV als het kan, damp als het moet”*

# Anaesthetic gases footprint of Dutch UMCs




Desflurane: -100%
Isoflurane: -94%

Sevoflurane: -44% +

**Total: -76%**

**Saved >3,400,000 kg $CO_2$e**



Kampman & Sperna Weiland, **BJA** (2024)

# Desflurane will be prohibited

EUROPEAN COMMISSION

Proposal for a

**REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL**

**on fluorinated greenhouse gases, amending Directive (EU) 2019/1937 and repealing Regulation (EU) No 517/2014**

The use of desflurane as inhalation anaesthetic is prohibited as from 1 January 2026, except when such use is strictly required and no other anaesthetic can be used on medical grounds. The user shall provide evidence, upon request, on the medical justification to the competent authority of the Member State and the Commission.





Bas Eickhout, Groenen/EVA

# Sino-Dutch Green Hospital Partnership



# Surgery's footprint




Scope 1

Anaesthetics

+



Scope 2

HVAC

+



Scope 3

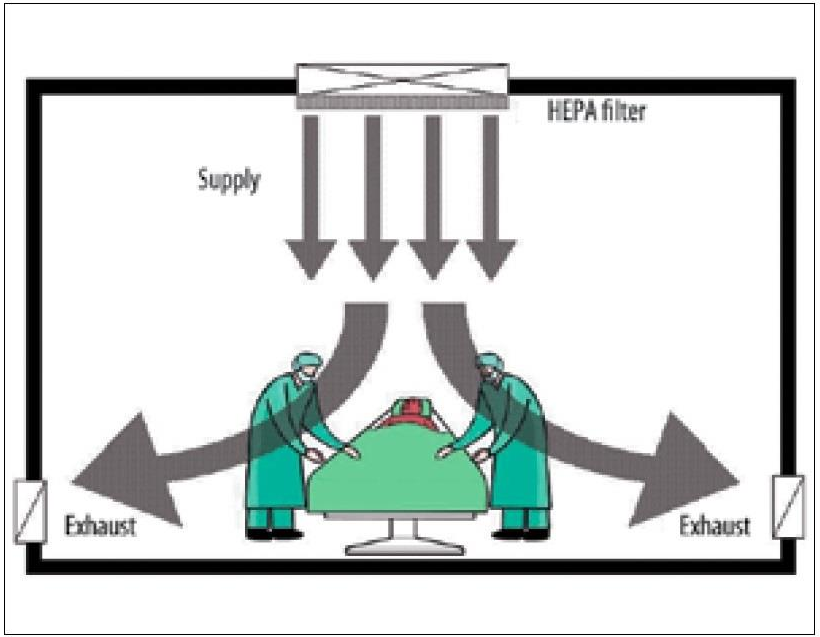
Disposables



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
- (No evidence that this reduces surgical site infections↓)



# HVAC in Amsterdam UMC



# HVAC 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's footprint




Scope 1

Anaesthetics

+



Scope 2

HVAC

+



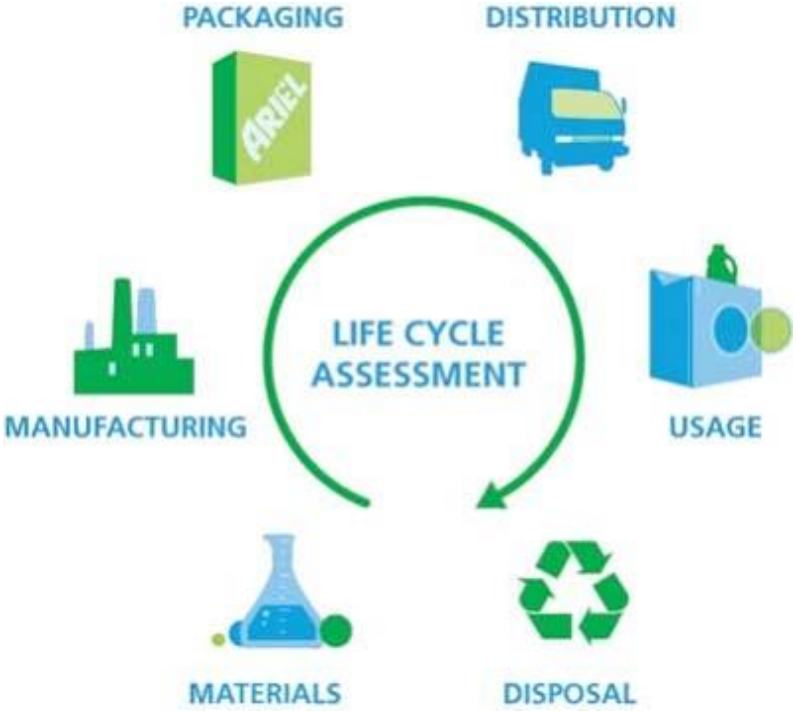
Scope 3

Disposables



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

# LCA to quantify hidden emissions



# Cost is usually reduced

| First author | Publication year | Subject | Lowest environmental impact | Lowest cost |
|---|---|---|---|---|
| Adler [66] | 2004 | Laparoscopy instruments | Reusable | Reusable −94% |
| Davis [63] | 2018 | Ureteroscope | Australia: similar impact | N/A |
| Donahue [67] | 2020 | Vaginal specula | Reusable | N/A |
| Eckelman [68] | 2012 | Laryngeal mask airway | Reusable | Reusable −17% |
| Friedericy [69] | 2022 | Sterilization canister | Reusable | N/A |
| Grimmond [70] | 2020 | Needle container | Reusable | Reusable −19% |
| Ibbotson [71] | 2013 | Scissors | Reusable | Reusable −45% |
| Leiden [72] | 2020 | Spinal fusion set | Disposable | N/A |
| McGain [73] | 2010 | Anaesthetic tray | Reusable | Reusable −51% |
| McGain [63] | 2012 | Central venous catheterisation kits | Australia: disposable; USA/Europe: reusable | Reusable -27% |
| McGain [64] | 2017 | Anaesthesia equipment (face mask, | Australia: disposable; USA/Europe: reusable | Reusable −46% |
| Rodriguez [74] | 2022 | Vaginal specula | Reusable | N/A |
| Sanchez [75] | 2020 | Blood Pressure Cuffs | Reusable | Reusable −89% |
| Sherman [76] | 2018 | Laryngoscope | Reusable | Reusable blades −59%; handles −78% |
| Vozzola [77] | 2018 | Surgical drapes and gowns | Reusable | N/A |



Kampman & Sperna Weiland **Curr Opin Anaest** (2023)

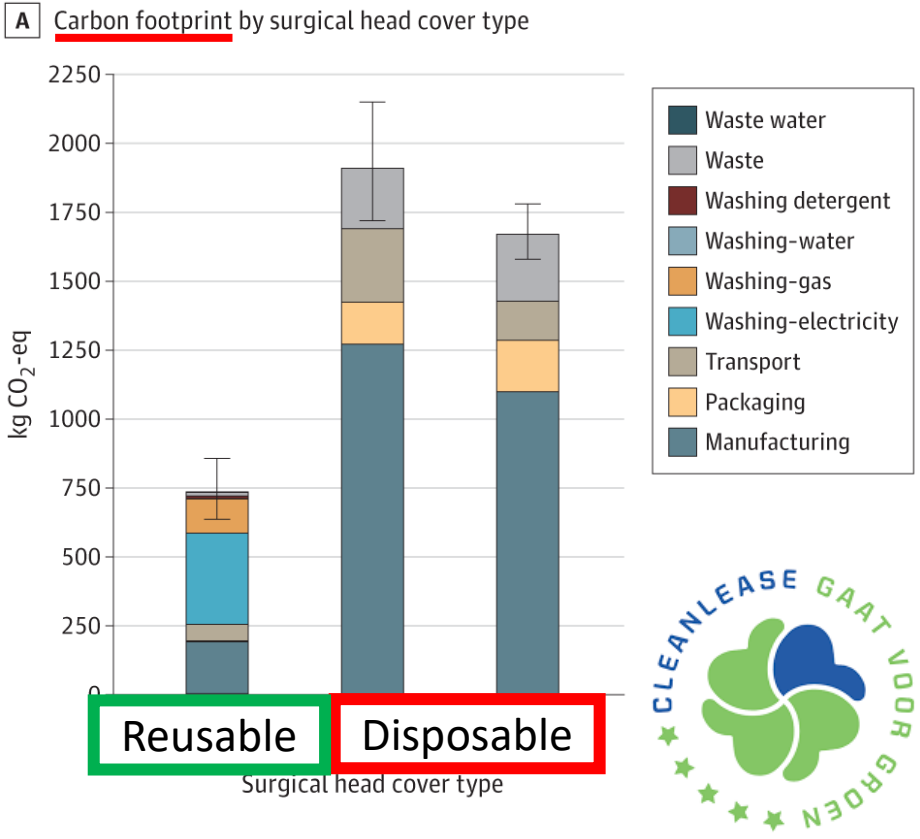
# Reuse: textile

2018

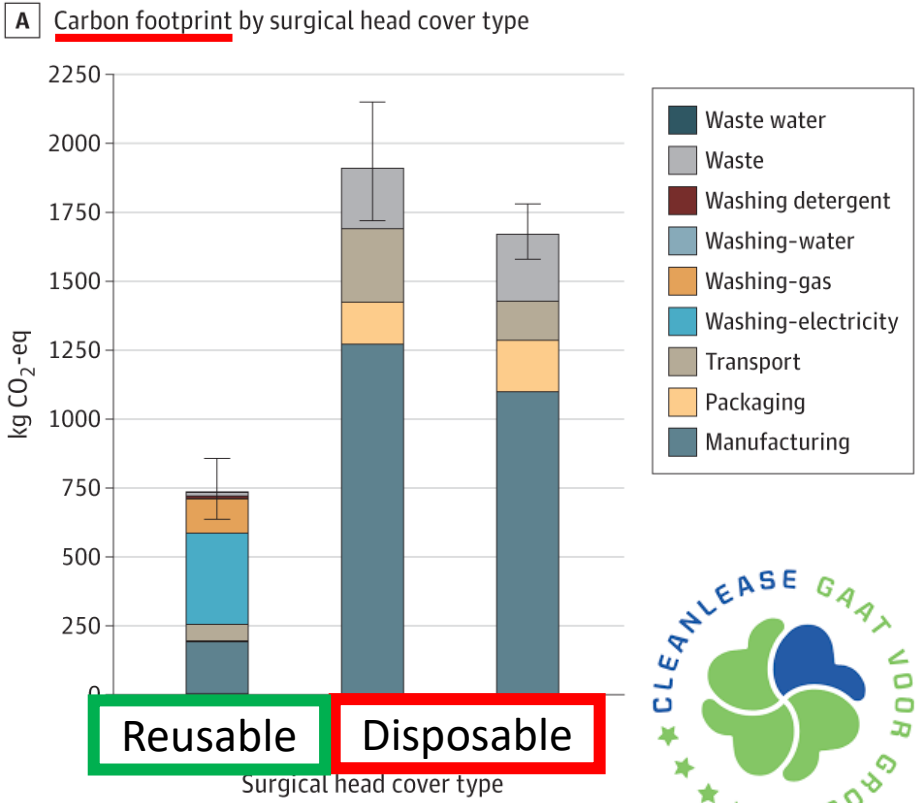


2023

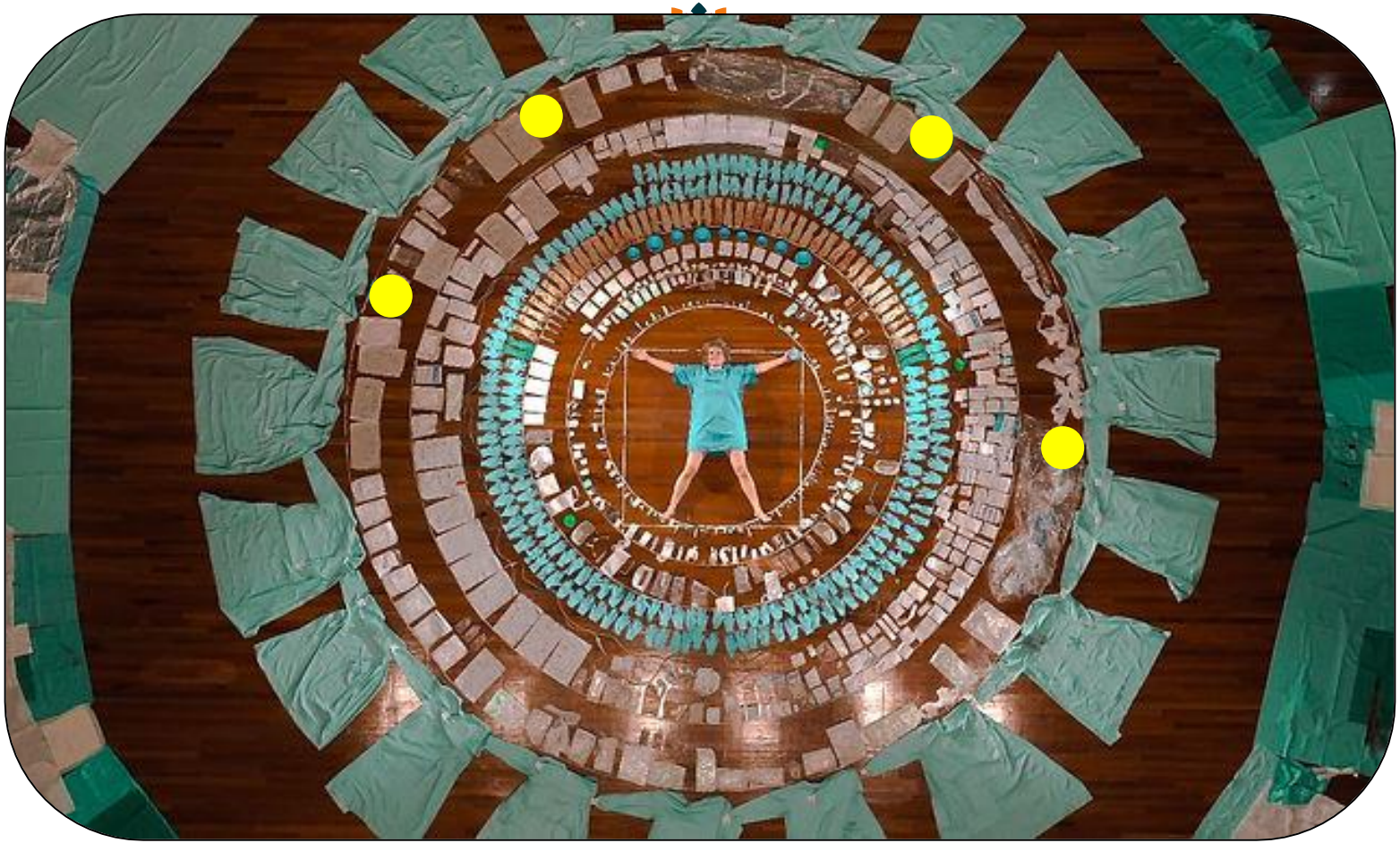




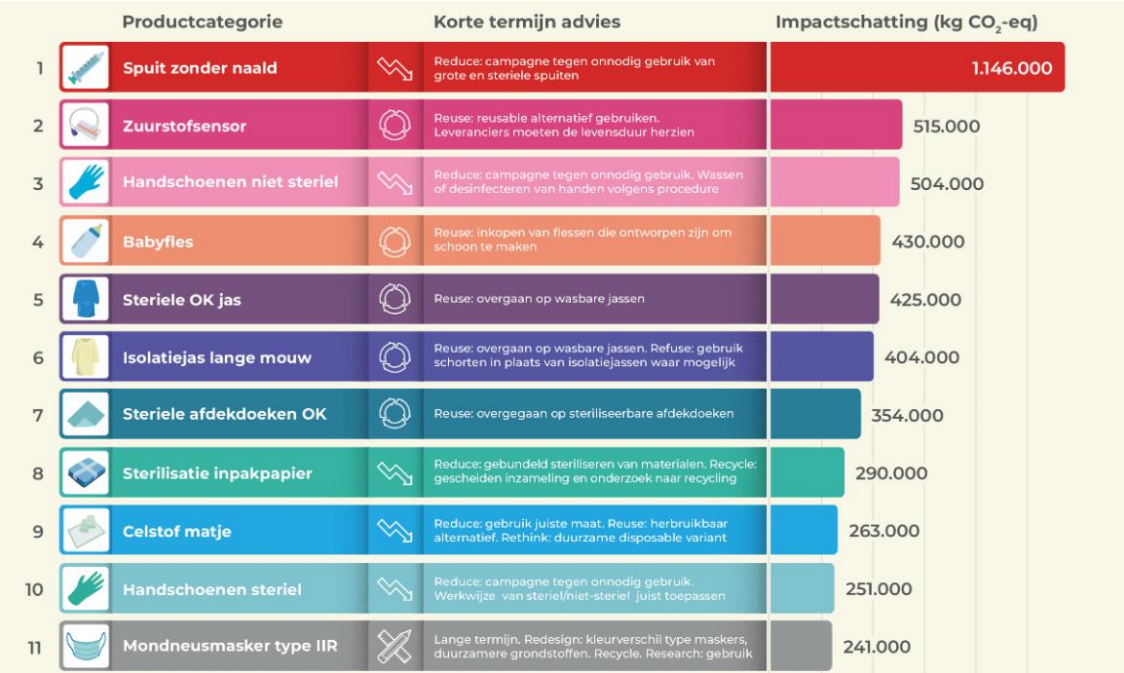



A Carbon footprint by surgical head cover type
2250
2000
1750
1500
1250
1000
750
500
250
0
kg $CO_2$-eq
Waste water
Waste
Washing detergent
Washing-water
Washing-gas
Washing-electricity
Transport
Packaging
Manufacturing
Reusable
Disposable
Surgical head cover type





# Dutch Disposable procurement assessment



# No risk? No glove!

**REDUCE**

**REUSE**

**RECYCLE**



HEINTEL GRUPPE

MVO NEDERLAND

ASKER HEALTHCARE GROUP

Textile

CLEANLEASE GAAT VOOR GROEN

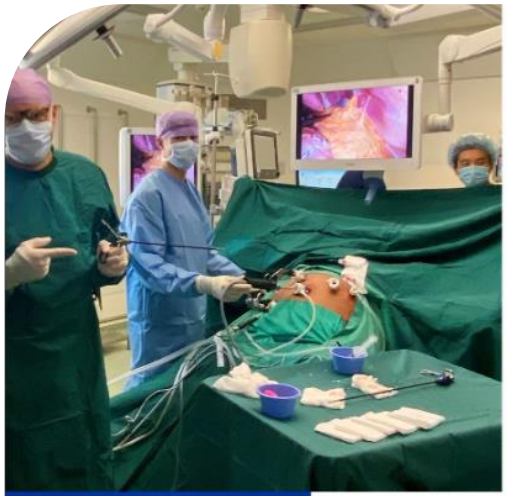
evercare®

Amsterdam UMC



LUMC

olvg





THCS TRANSFORMING HEALTH AND CARE SYSTEM

ZonMw

FFG Promoting Innovation.

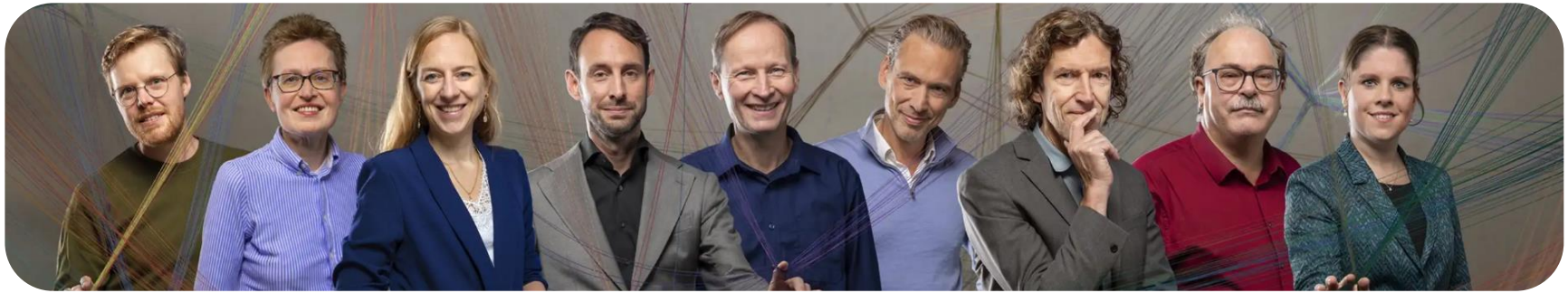
VINNOVA

# It's not easy being GREEN

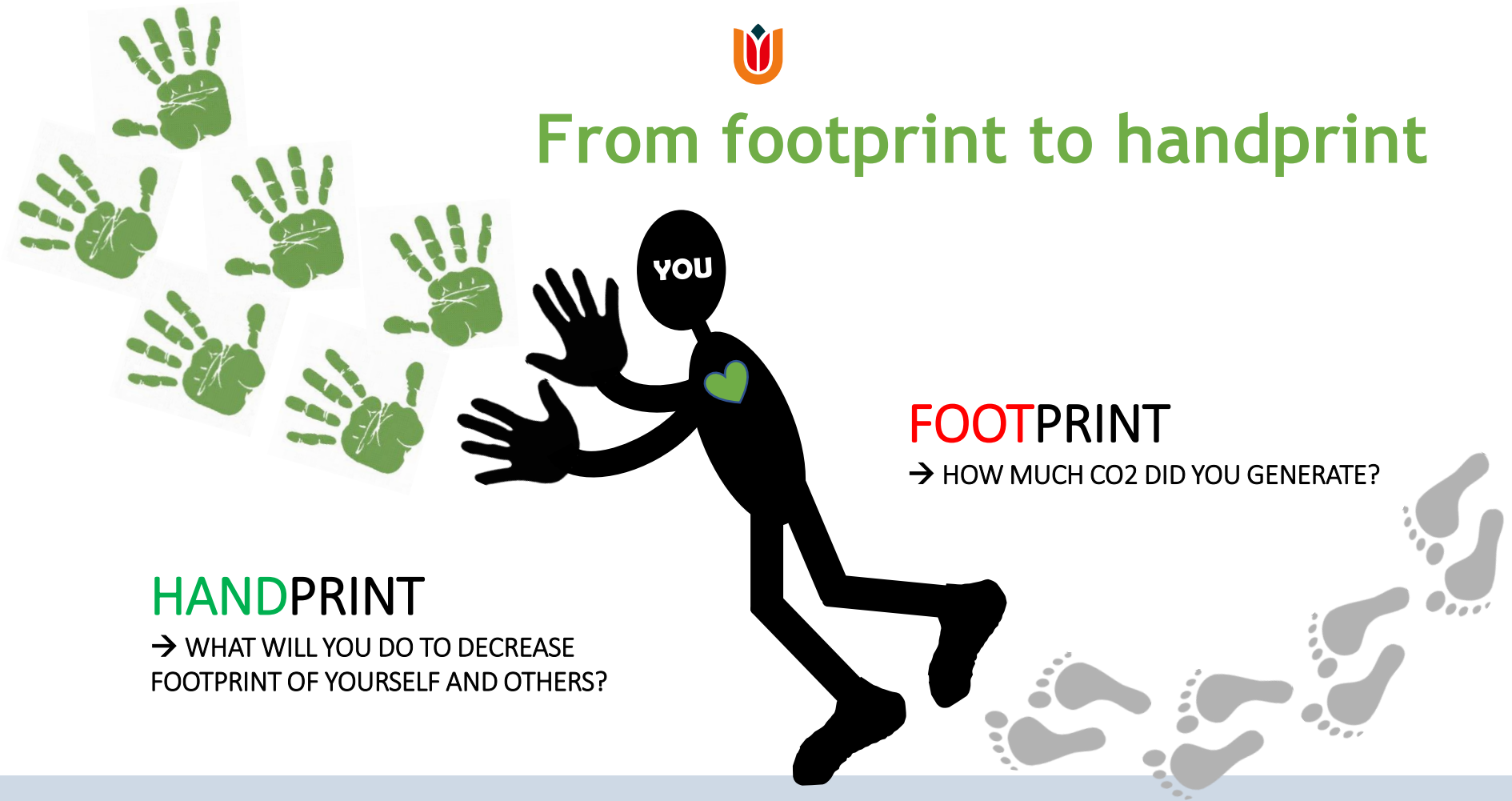


# Future perspectives

- Optimisation of current system (incremental change) can reduce carbon footprint ~50% (Centre for Sustainable Healthcare)
- Sustainable transformation of the healthcare system and associated financial models, mental models and supply chain requires transformative multi- and transdisciplinary research (UvA-SEVEN)



# From footprint to handprint




## FOOTPRINT

→ HOW MUCH CO2 DID YOU GENERATE?

## HANDPRINT

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

# Why we need more handprint!

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



Barrack Obama

Amsterdam UMC




# What is your handprint?

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