

Ophthalmology & Waste from the OR

Cassandra L Thiel, PhD

September 15, 2020

Medical Society Consortium for Climate & Health

Dr. Thiel is a paid consultant at the Stryker Corporation, unrelated to this work.

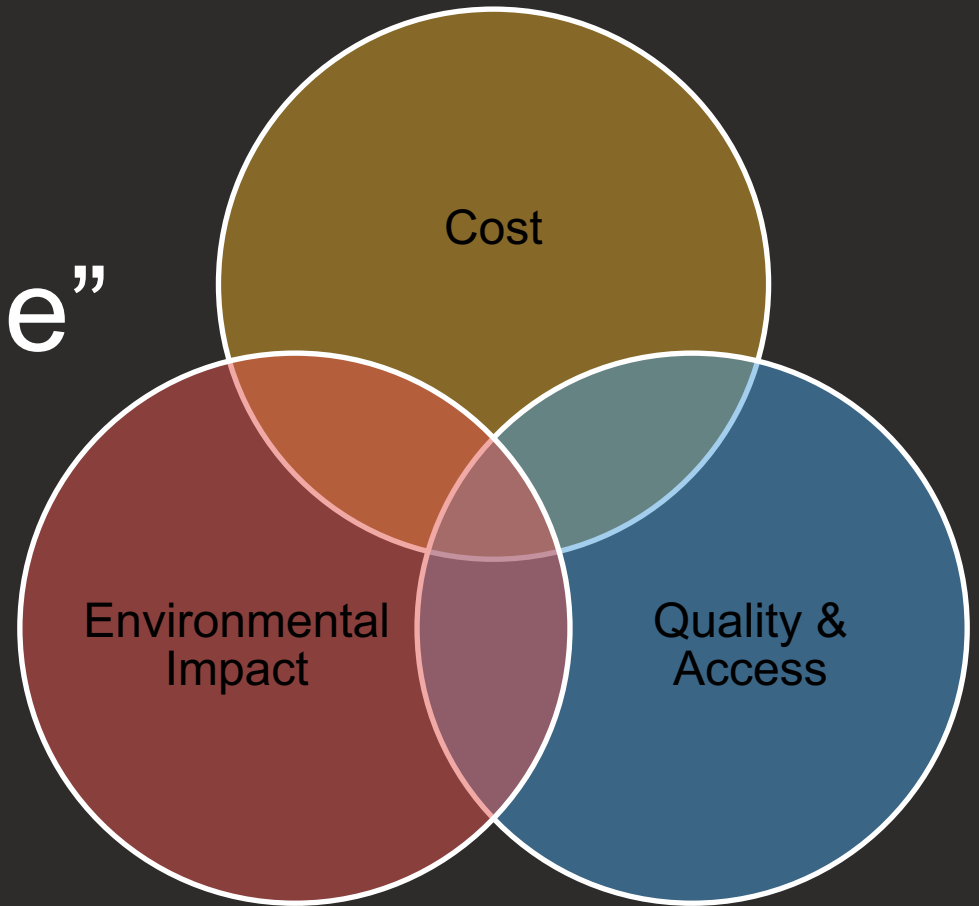
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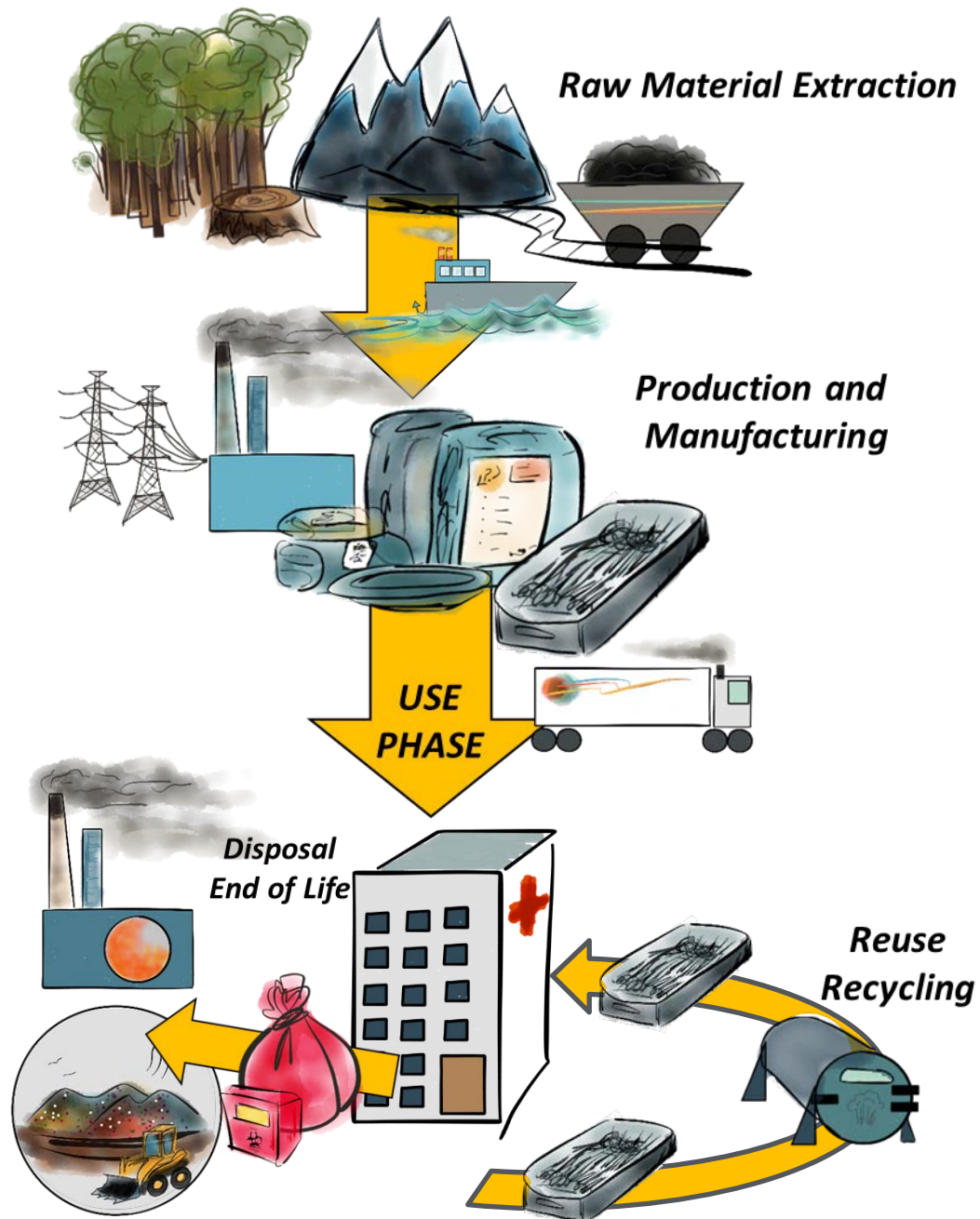


What does
sustainability mean to
you?

The “Triple Bottom Line”

- People (Equity),
- Profit (Economy),
- Planet (Environment)





Life Cycle Assessment (LCA)

Tool to quantify the environmental impacts of a product or process. Sums up emissions (to land, air, and water) at each stage in a product's life cycle.

**Can *healthcare* and
sustainability overlap?**

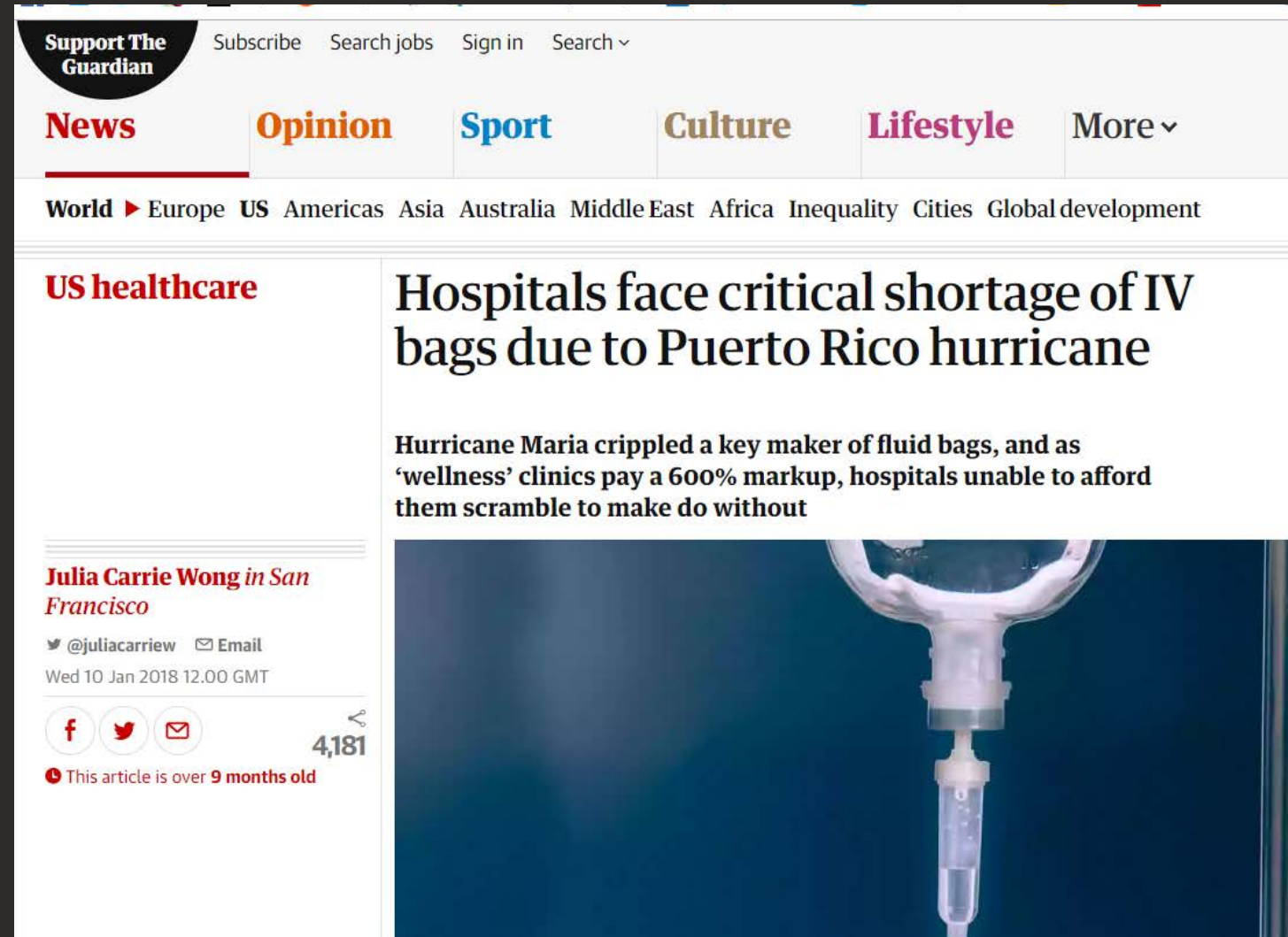
More Medical Facilities are Concerned with Climate Change Adaptation

Aiming for better resiliency in energy sourcing, procurement/supply chain, and waste management.



Climate Change and Other Environmental Issues Impact Supply Chain

There are many medical supply and drug shortages across the globe, and it is starting to impact wealthy countries as well.



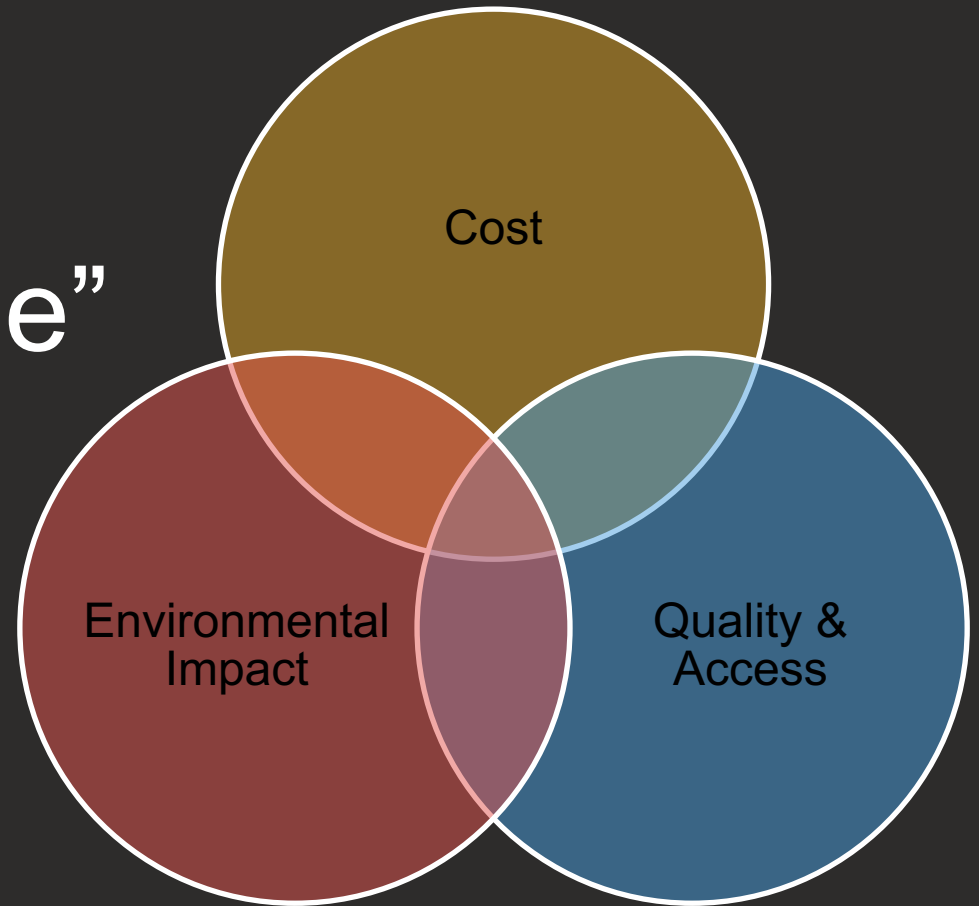
<https://www.theguardian.com/us-news/2018/jan/10/hurricane-maria-puerto-rico-iv-bag-shortage-hospitals>



Healthcare is not without Impact.

The “Triple Bottom Line”

- People (Equity),
- Profit (Economy),
- Planet (Environment)



Healthcare creates

- 10% of US's GHGs
- 5% of UK's GHGs
- 5% of Canada's GHGs
- 7% of Australia's GHGs



“If the US health care sector were itself a country, it would rank 13th in the world for GHG emissions, ahead of the entire U.K.”

Sustainable Development Unit. [2016]. Carbon Footprint update for NHS in England 2015. Retrieved from http://www.sduhealth.org.uk/documents/publications/2016/Carbon_Footprint_summary_NHS_update_2015_final_v2.pdf

Malik, A., Lenzen, M., McAlister, S., & McGain, F. [2018]. The carbon footprint of Australian health care. *The Lancet Planetary Health*, 2(1), e27-e35. doi:[https://doi.org/10.1016/S2542-5196\(17\)30180-8](https://doi.org/10.1016/S2542-5196(17)30180-8)

Eckelman, M. J. and J. Sherman (2016). "Environmental Impacts of the U.S. Health Care System and Effects on Public Health." *PLoS ONE* 11(6): e0157014

Eckelman, M. J., Sherman, J. D., & MacNeill, A. J. (2018). Life cycle environmental emissions and health damages from the Canadian healthcare system: An economic-environmental-epidemiological analysis. *PLoS Medicine*, 15(7), e1002623. doi:10.1371/journal.pmed.1002623

Health Impacts of the US Health Care Sector

Environment

Impact category	Unit / Reference Substance ^a	Health Care Total	National Total	% of National	DALYs Lost
GW	kg CO ₂ -e	6.6E+11	6.5E+12	9.8%	-
AP	kg SO ₂ -e	3.1E+09	2.6E+10	11.7%	-
PM	kg PM ₁₀ -e	1.0E+09	6.8E+09	8.9%	435,000
EP	kg N-e	9.4E+07	6.1E+09	1.5%	-
ODP	kg CFC-11-e	7.3E+05	4.5E+07	1.6%	770
POP	kg O ₃ -e	4.0E+10	3.9E+11	10.0%	9,400
ETP	kg 2,4-D-e	6.9E+07	-	-	-
HH canc	kg benzene-e	2.5E+08	2.6E+10	1.0%	84
HH non-canc	kg toluene-e	6.9E+11	3.3E+13	2.2%	25,300

Trafficking and exploitation in focus

Employment

Trafficking and exploitation in focus is supported by

About this content

Karen McVeigh and Haroon Janjua in Sialkot

Mon 29 Jan 2018 02:00 EST



692

This article is over 1 year old

NHS admits doctors may be using tools made by children in Pakistan

Closer scrutiny demanded as NHS supplier concedes surgical instruments in routine use could be product of child labour



▲ A child in a surgical instrument workshop in Sialkot, Pakistan, shows a spoon-shaped curette he has just finished polishing. Photograph: Haroon Janjua

Children as young as 12 are making surgical instruments in hazardous conditions in **Pakistan**, prompting fears that the tools could be used in the NHS, the Guardian has discovered.

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Could 'alcosynth' provide all the joy of booze – without the dangers?



Nasa cancels all-female spacewalk, citing lack of spacesuit in right size



Jussie Smollett: prosecutors drop charges against actor accused of fabricating attack



Live Brexit: DUP says one-year delay better than May's deal - live news



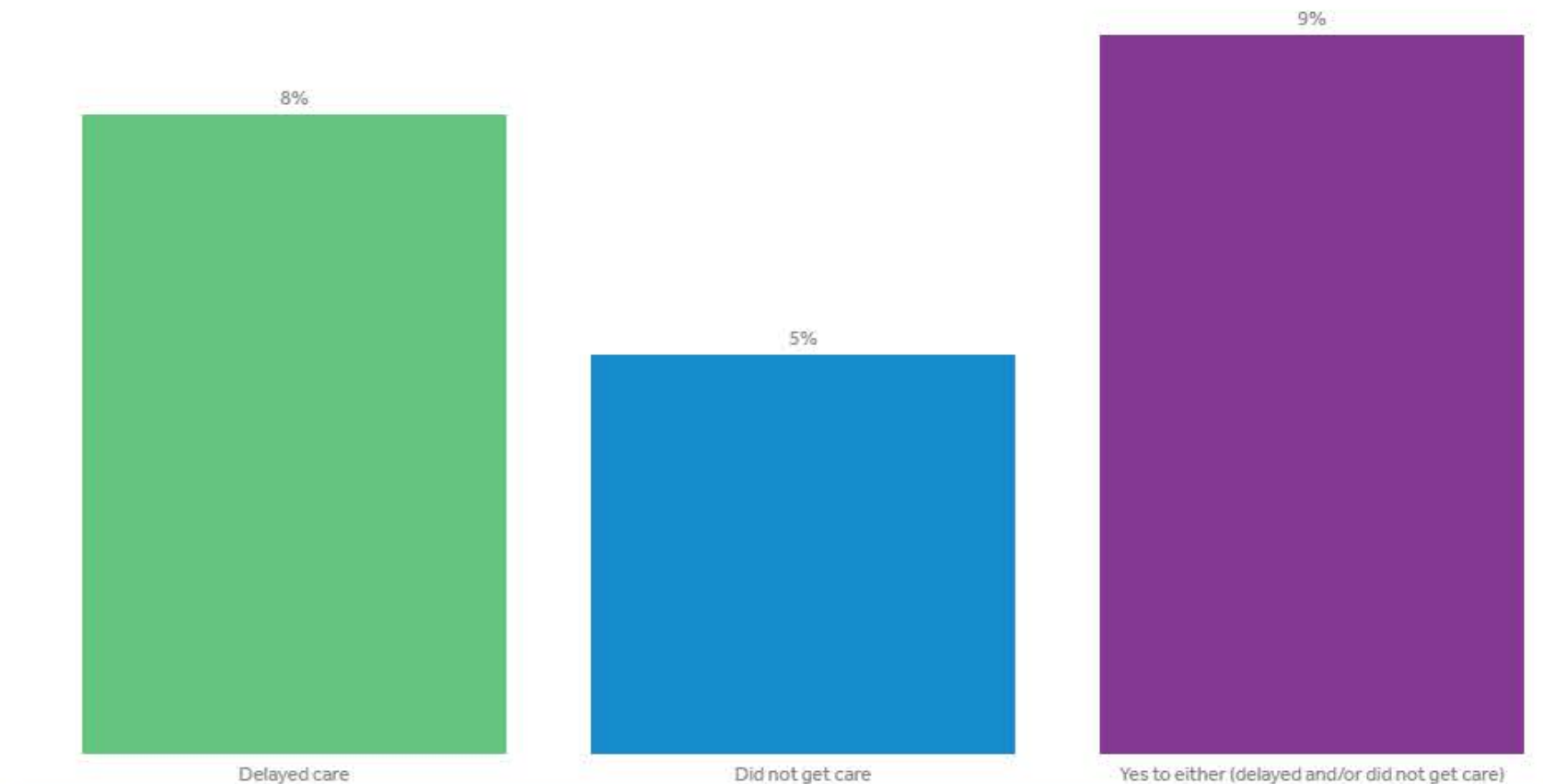
'Horror, fear, despair': Venezuela's oil capital

Equity

<https://www.theguardian.com/global-development/2018/jan/29/nhs-admits-doctors-may-be-using-tools-made-by-children-in-pakistan>

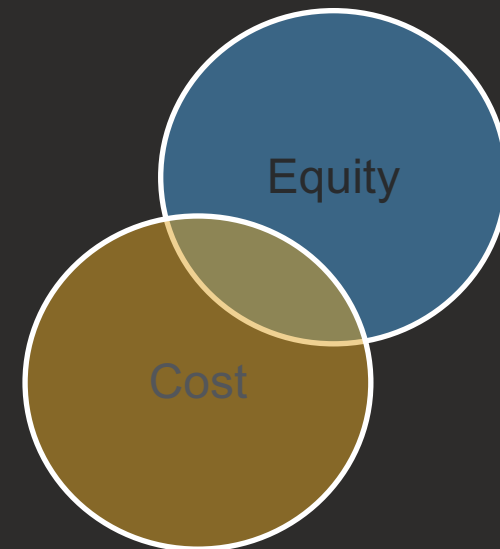
About 1 in 10 adults report that they delayed or did not get care because of its cost

Percent of adults who reported delaying or going without care due to costs, 2017



Source: Kaiser Family Foundation analysis of National Health Interview Survey • [Get the data](#) • PNG

Peterson-Kaiser
Health System Tracker



<https://www.healthsystemtracker.org/chart-collection/cost-affect-access-care/#item-about-1-in-10-adults-report-that-they-delayed-or-did-not-get-care-because-of-its-cost-2017>

TUESDAY MAR. 26, 2019

SPORTS BREAKING BUSINESS ELECTION 2019 OPINION ENTERTAINMENT BEST REVIEWS ADVERTISING

Highest levels of cancer-causing gas found in communities near Sterigenics since U.S. EPA began testing



Amid a public outcry, Gov. J.B. Pritzker directed the Illinois EPA on Feb. 15 to block the Sterigenics plant in Willowbrook, shown in September 2018, from using ethylene oxide. (Zbigniew Bzdak/Chicago Tribune)

By **Michael Hawthorne**
Chicago Tribune

MARCH 8, 2019, 7:30 PM

During the month before Gov. J.B. Pritzker's administration shuttered Sterigenics in Willowbrook, air monitors recorded the highest levels of ethylene oxide in nearby

Nearly ALL single-use disposable medical supplies and instruments are sterilized using Ethylene Oxide (EtO)

<https://www.chicagotribune.com/news/local/breaking/ct-met-sterigenics-epa-ethylene-oxide-testing-20190307-story.html>

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Guide - Free
Step-by-Step
Guide

graphicproducts.com/5S

Environment

27-Page Expert 5S Guide. "This is a great guide! I read it from cover to cover!"

Equity

Matt Haller, 45, Is First Litigant To Pass Away After Filing A Lawsuit Against Sterigenics: 'To Think This Company Could Have Literally Been Behind My Death Is Shocking'

By Dave Savini March 22, 2019 at 2:25 pm Filed Under: 2 Investigators, cancer, Chicago, Dave Savini, EPA, ethylene oxide, Illinois EPA, lawsuit, Local TV, Matt Haller, Sterigenics, Willowbrook



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- 3 Chicago Police Superintendent Eddie

CHICAGO (CBS) — He battled cancer and fought to get the word out about a

<https://chicago.cbslocal.com/2019/03/22/sterigenics-ethylene-oxide-matt-haller-death/>

HOW CAN WE CHANGE MEDICAL PRACTICE?

It's a **SYSTEMS** issue. Especially for healthcare



Lighting and
Ventilation

Payment and
Reimbursement

Reusable
Supplies and
Sterilization

Contracts

Food Services

Travel of Staff
and Patients

Technology
Development and
Suppliers

Disposable and
Single Use
Materials

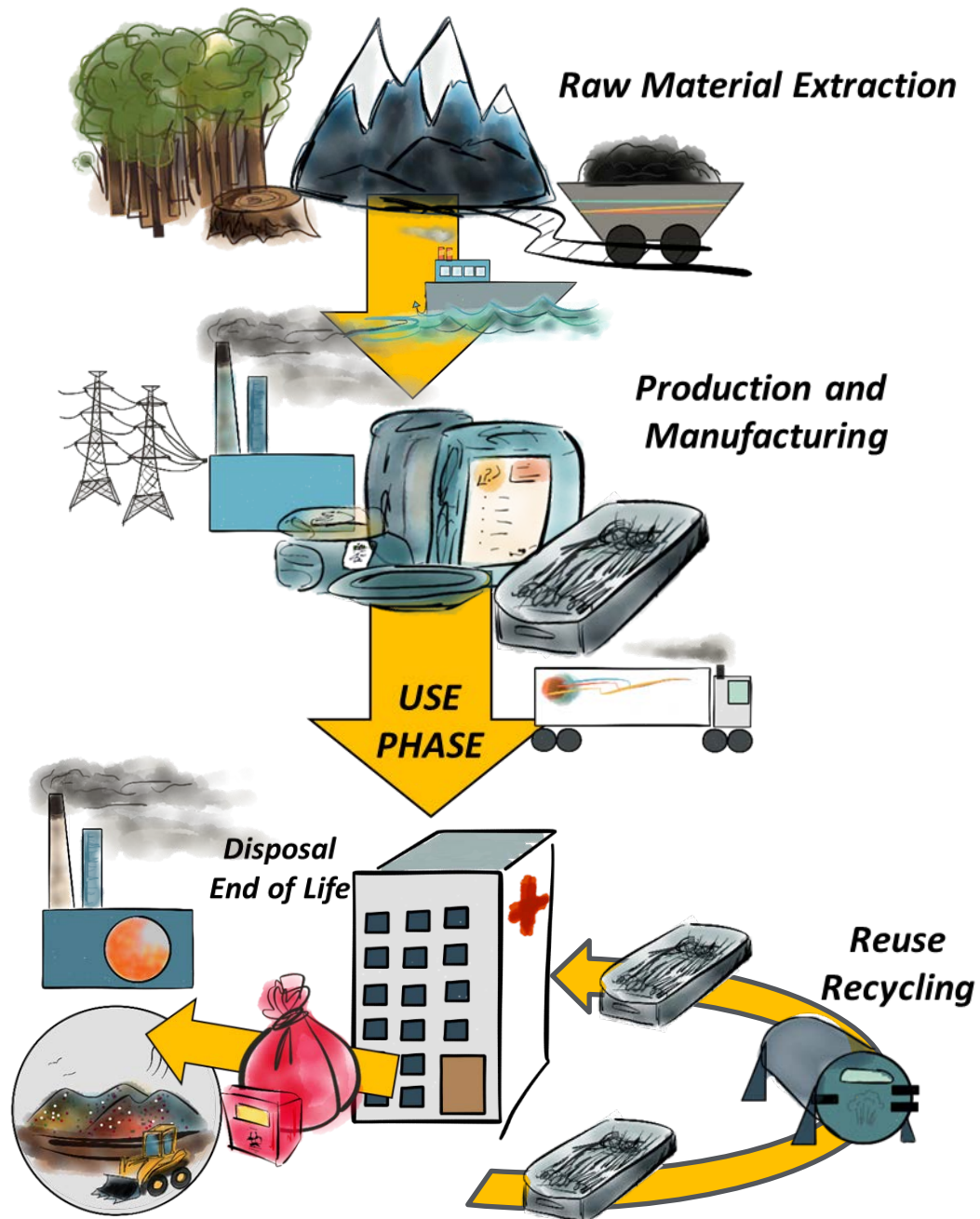
Policies and
Regulations

Electricity and
Capital Goods

Training and
Local Habits

We need data...

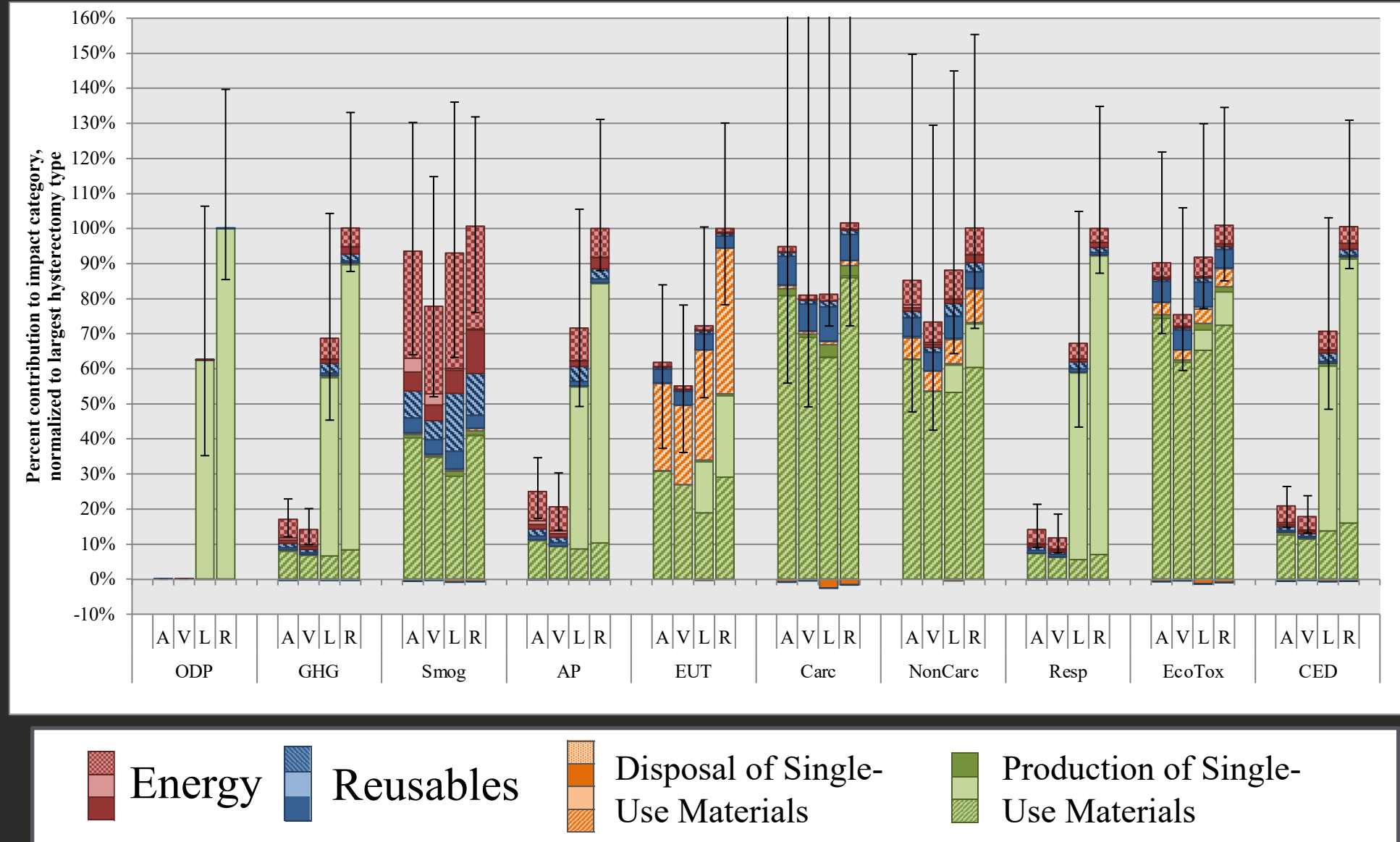




Life Cycle Assessment (LCA)

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Environmental Impacts of 4 Types of Hysterectomy



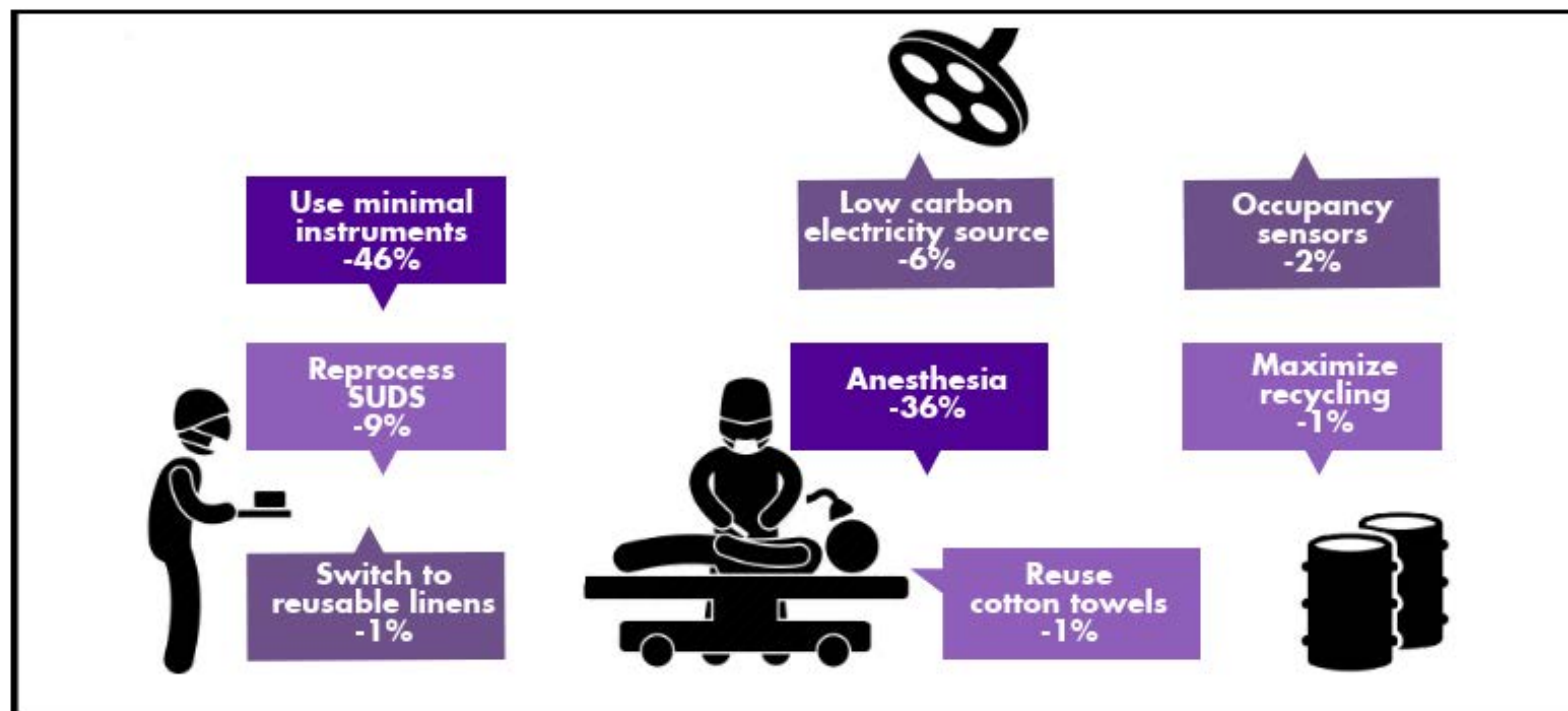
Research Informing Practice

Thiel, C. L., Woods, N. C., & Bilec, M. M. (2018). Strategies to Reduce Greenhouse Gas Emissions from Laparoscopic Surgery. American Journal of Public Health, 108(S2), S158-S164.
doi:10.2105/ajph.2018.304397

Strategies to Reduce Greenhouse Gas Emissions from Laparoscopic Surgeries

Thiel CL, Woods NC, Bilec MM

This study identifies and models the impact of sustainability interventions in the OR for laparoscopic hysterectomy.



If all US laparoscopic hysterectomies used these strategies, we'd reduce our footprint by 72 kilotons of CO₂-e.
That's like removing 15, 200 passenger vehicles from the road.

WHY OPHTHALMOLOGY?

1: Surgeries are Resource-Intensive (and Wasteful!)



Zygourakis, C. C., Yoon, S., Valencia, V., Boscardin, C., Moriates, C., Gonzales, R., & Lawton, M. T. (2016). Operating room waste: disposable supply utilization in neurosurgical procedures. *Journal of Neurosurgery*, 1-6.

Across 58 procedures (36 cranial, 22 spinal), the average cost of unused supplies was \$653 (range \$89-\$3640, median \$448, interquartile range \$230–\$810), or **13.1% of total surgical supply cost**. Accounting for the different case distribution in the 58 selected cases, the authors estimate approximately \$968 of OR waste per case, \$242,968 per month, and **\$2.9 million per year**, for their neurosurgical department.

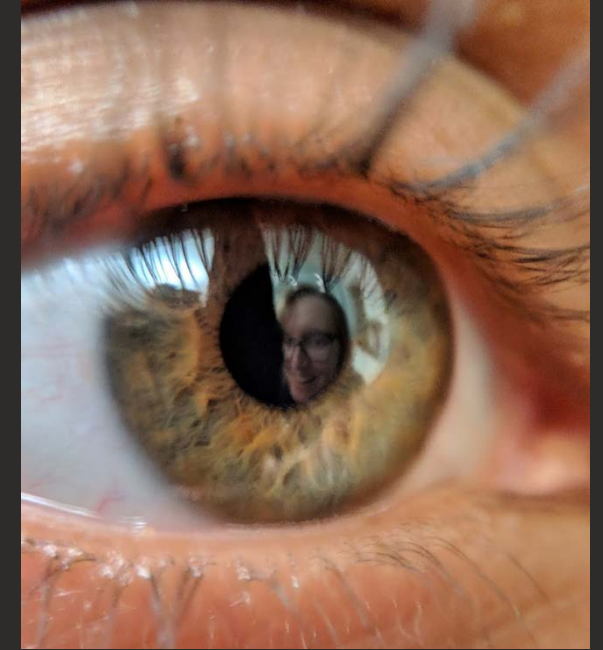
2. Ophthalmology is a BIG specialty

Cataract surgery:

- If you live long enough, you'll need cataract surgery
- One of the most-performed procedures world-wide
- US spends \$6.8 bil annually
- 12% of Medicare's budget (~\$3.4 bil) is spent on cataract surgeries

It's growing (or it needs to grow) globally

- Global population is aging
- There's more people in total
- WHO/IAPB are running the VISION 2020: The Right to Sight Initiative to increase global capacity and access to eye care services



**WHAT
DO WE KNOW?**

Carbon Footprint of Cataract Surgery (in the UK)

- A single phacoemulsification emits about 180kg CO₂-equivalents (this is about one week of “living” for the average Brit).
- Over 50% of these GHG emissions originates in procurement of supplies.
- Supplies are largely single-use disposables.

What does healthcare look like where it's done efficiently?

Eye (2013), 1–7

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www.nature.com/eye

Morris, D. S., T. Wright, J. E. A. Somner and A. Connor (2013). "The carbon footprint of cataract surgery." *Eye*(27): 495-501.

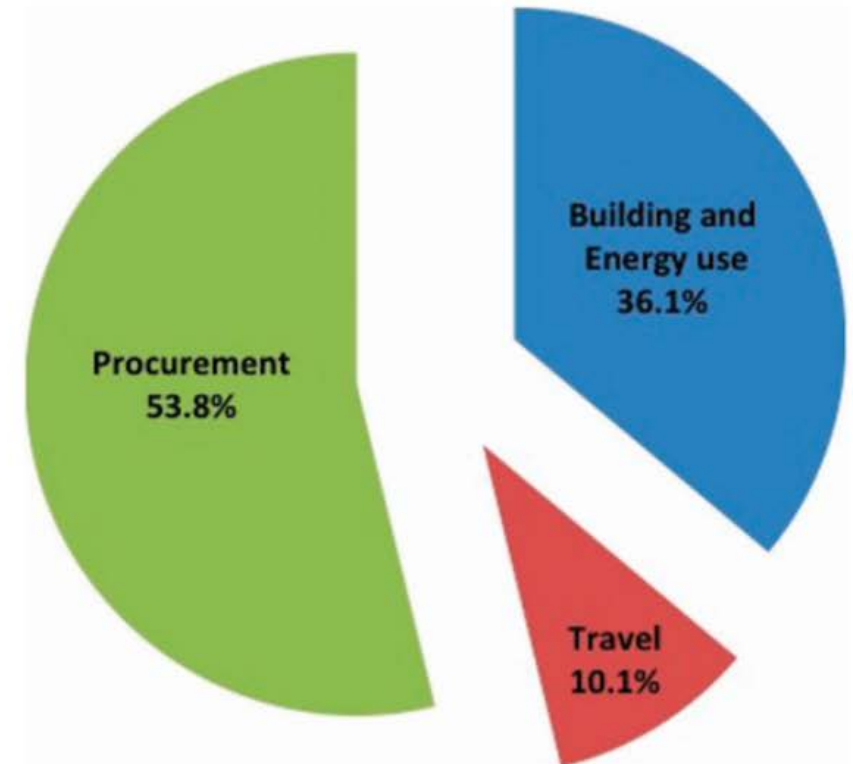
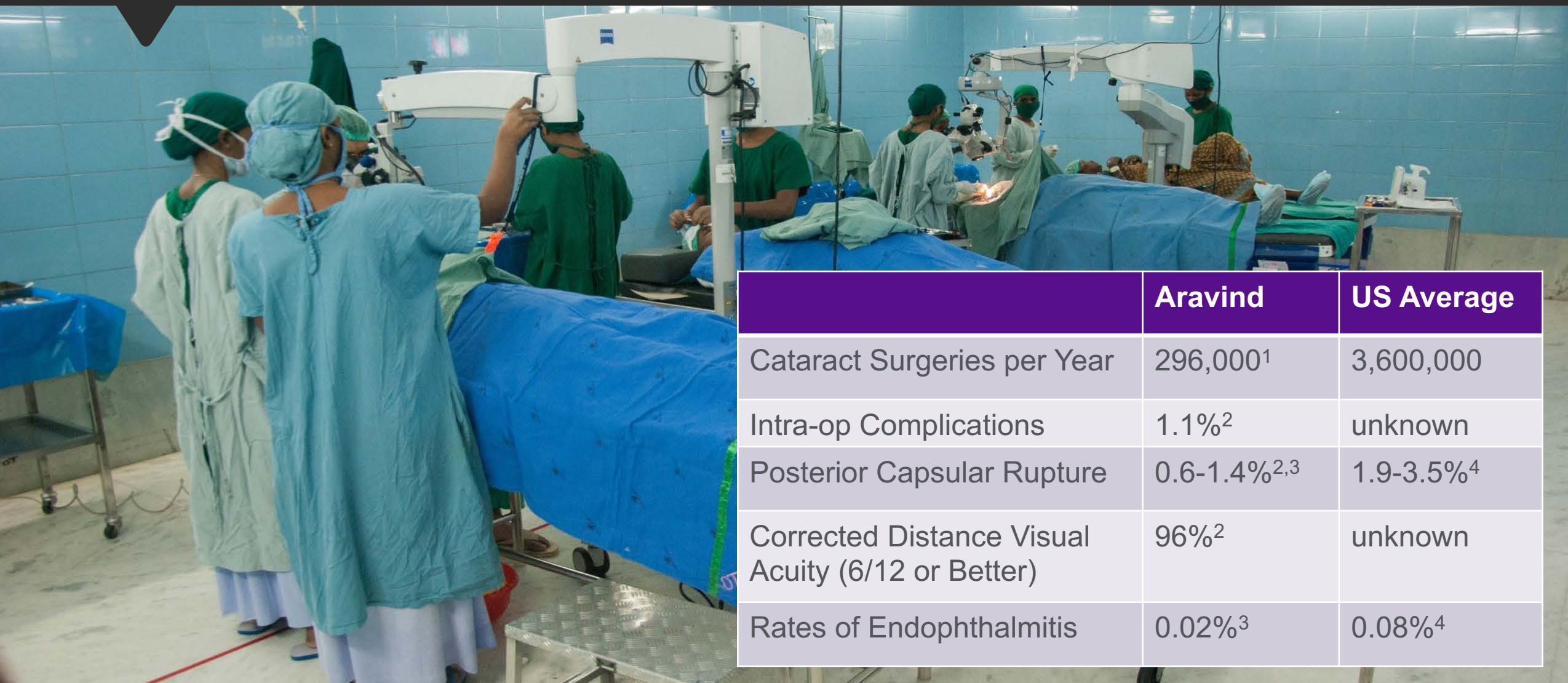


Figure 2 The carbon footprint of a patient undergoing first eye cataract surgery divided into primary sectors of GHG emissions.

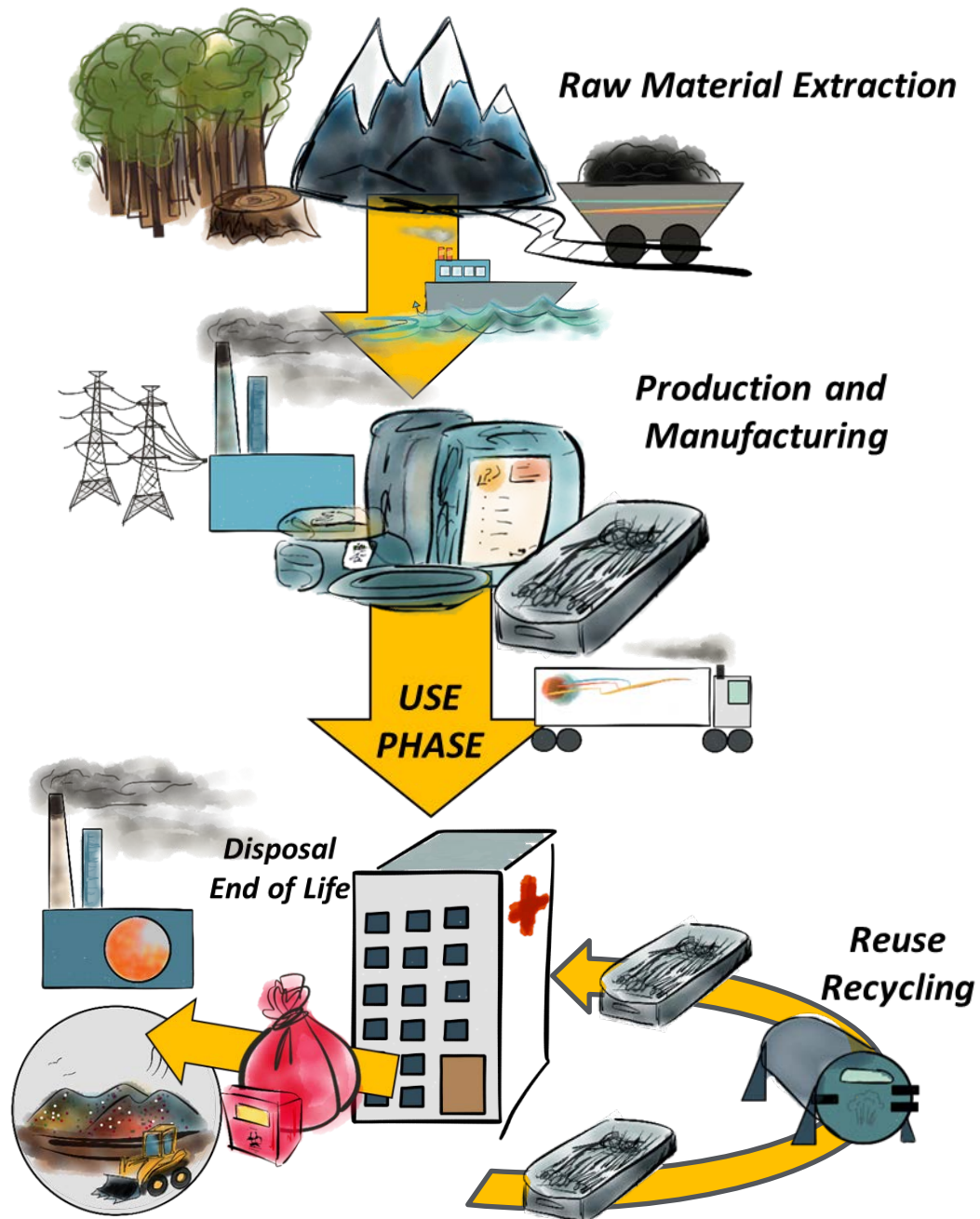
Venkatesh, R., S. W. van Landingham, A. M. Khodifad, A. Haripriya, C. L. Thiel, P. Ramulu and A. L. Robin (2016). "Carbon footprint and cost-effectiveness of cataract surgery." *Current Opinion in Ophthalmology* 27(1): 82-88.

Aravind Eye Care System, Tamil Nadu India

1. Aravind Eye Care System Activity Report 2017-2018. https://www.aravind.org/content/downloads/AECS_Report_201718.pdf
2. Haripriya A, Chang DF, Reena M, Shekhar M. Complication rates of phacoemulsification and manual small-incision cataract surgery at Aravind Eye Hospital. *J Cataract Refract Surg* 2012;38(8):1360-9.
3. Haripriya, A., Chang, D. F., & Ravindran, R. D. (2017). Endophthalmitis Reduction with Intracameral Moxifloxacin Prophylaxis: Analysis of 600 000 Surgeries. *Ophthalmology*, 124(6), 768-775. doi: <https://doi.org/10.1016/j.ophtha.2017.01.026>
4. Stein, J. D. (2012). Serious adverse events after cataract surgery. *Current Opinion in Ophthalmology*, 23(3), 219-225. doi:10.1097/ICU.0b013e3283524068
5. Rangan VK, Thulasiraj RD. Making Sight Affordable (Innovations Case Narrative: The Aravind Eye Care System). *Innovations: Technology, Governance, Globalization* 2007;2(4):35-49. Rangan VK. The Aravind eye hospital, Madurai, India: in service for sight: *Harvard Business School*, 1993.
6. TED talk: https://www.ted.com/talks/thulasiraj_ravilla_how_low_cost_eye_care_can_be_world_class



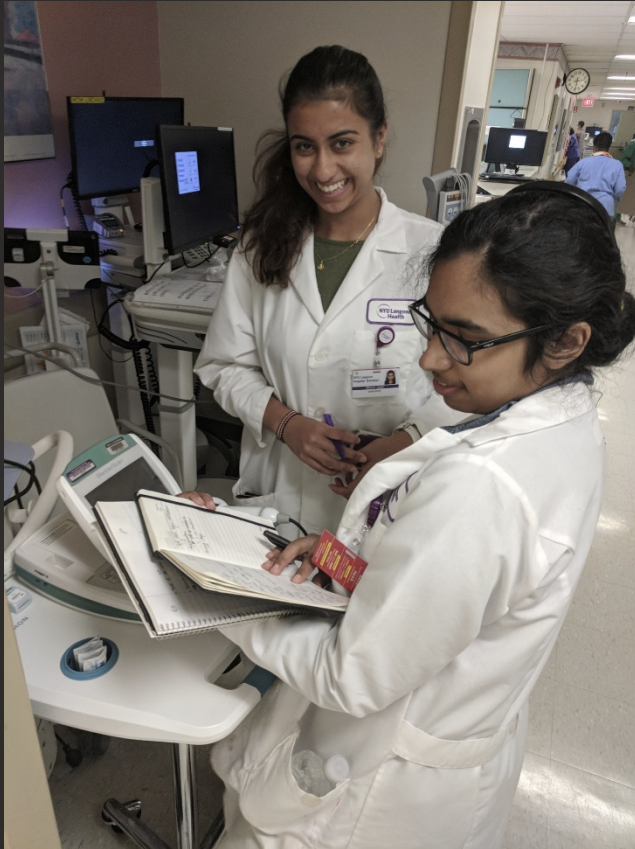
	Aravind	US Average
Cataract Surgeries per Year	296,000 ¹	3,600,000
Intra-op Complications	1.1% ²	unknown
Posterior Capsular Rupture	0.6-1.4% ^{2,3}	1.9-3.5% ⁴
Corrected Distance Visual Acuity (6/12 or Better)	96% ²	unknown
Rates of Endophthalmitis	0.02% ³	0.08% ⁴



Life Cycle Assessment (LCA)

Tool to quantify the environmental impacts of a product or process. Sums up emissions (to land, air, and water) at each stage in a product's life cycle.

Data Collection and Analysis



With any project,
we
typically
OBSERVE the
process
and **WEIGH** the
waste or
resource
consumption.



Waste Generation in the OR

1 Cataract Removal, Phaco
(USA)

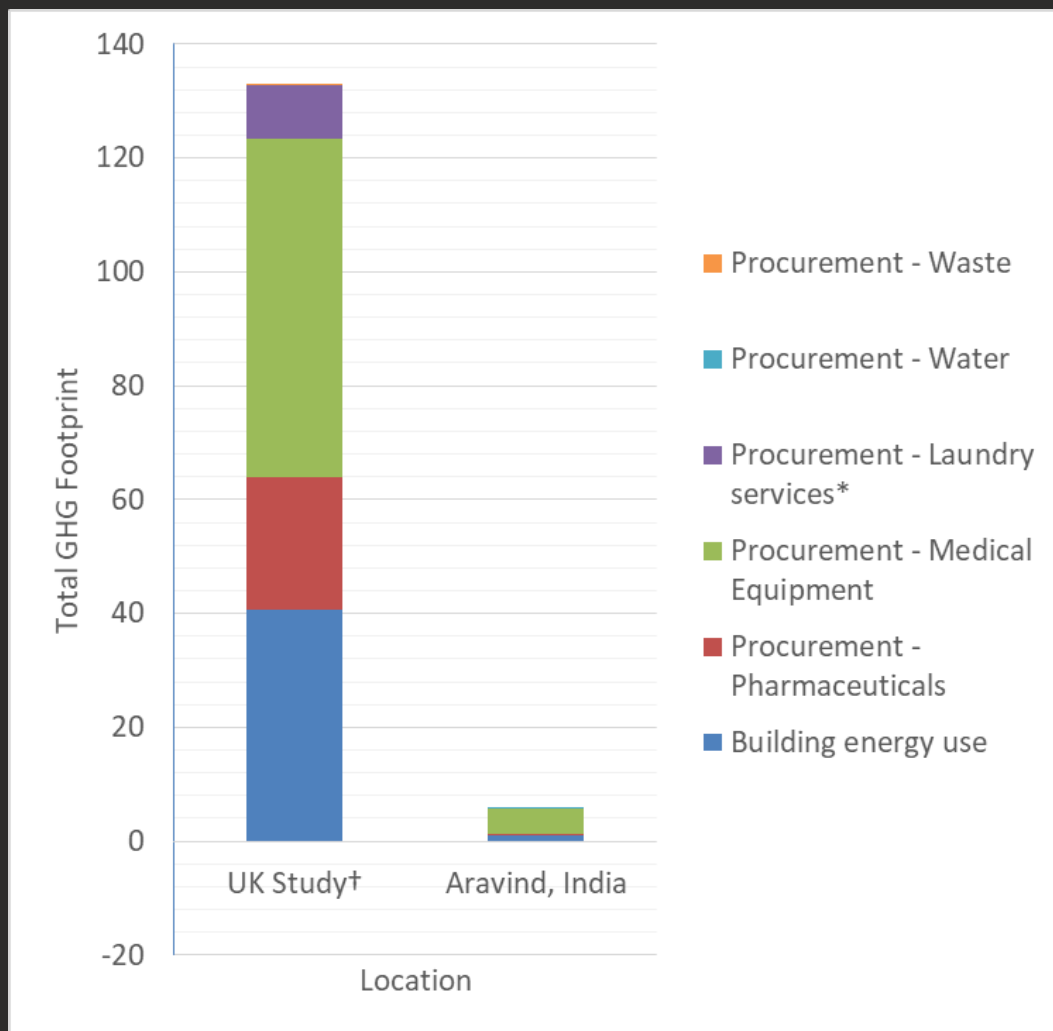
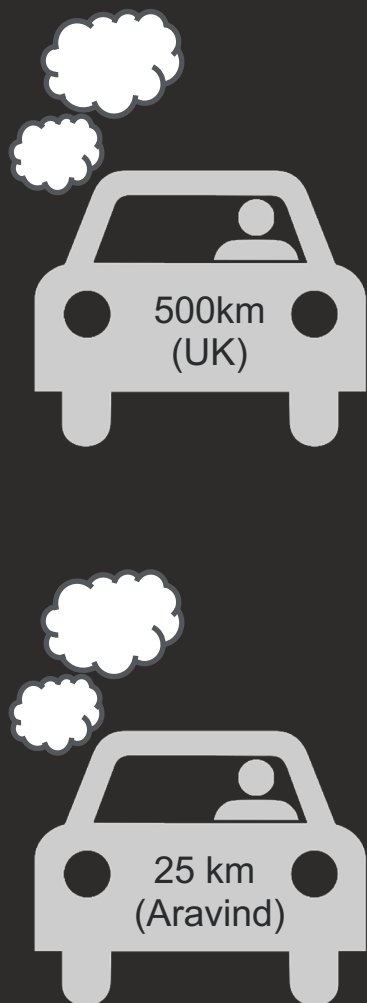


93 Cataract Removals, Phacos
(Aravind, India)



Awarded "best paper" at American Academy of Ophthalmology's (AAO) Annual Meeting. Chicago, IL. 2016

Carbon Footprint of Average Single Phacoemulsification at Aravind and the UK



Published in: Thiel, C., et. al (2017). Cataract surgery and environmental sustainability: Waste and lifecycle assessment of phacoemulsification at a private healthcare facility. *Journal of Cataract & Refractive Surgery*, 43(11), 1391-1398. doi: <https://doi.org/10.1016/j.jcrs.2017.08.017>

†Modified to match system boundaries, from Morris, D. S., T. Wright, J. E. A. Somner and A. Connor (2013). "The carbon footprint of cataract surgery." *Eye*(27): 495-501.

Aravind's Strategies for Efficient Surgical Delivery

1. Physical layout



Aravind's Strategies for Efficient Surgical Delivery

1. Physical layout
2. Task shifting



Aravind's Strategies for Efficient Surgical Delivery

1. Physical layout
2. Task shifting
3. Standardization
 - Pathway steps
 - Instrumentation
 - Surgical approach



Aravind's Strategies for Efficient Surgical Delivery

1. Physical layout
2. Task shifting
3. Standardization
4. Reduce waste, maximize reuse

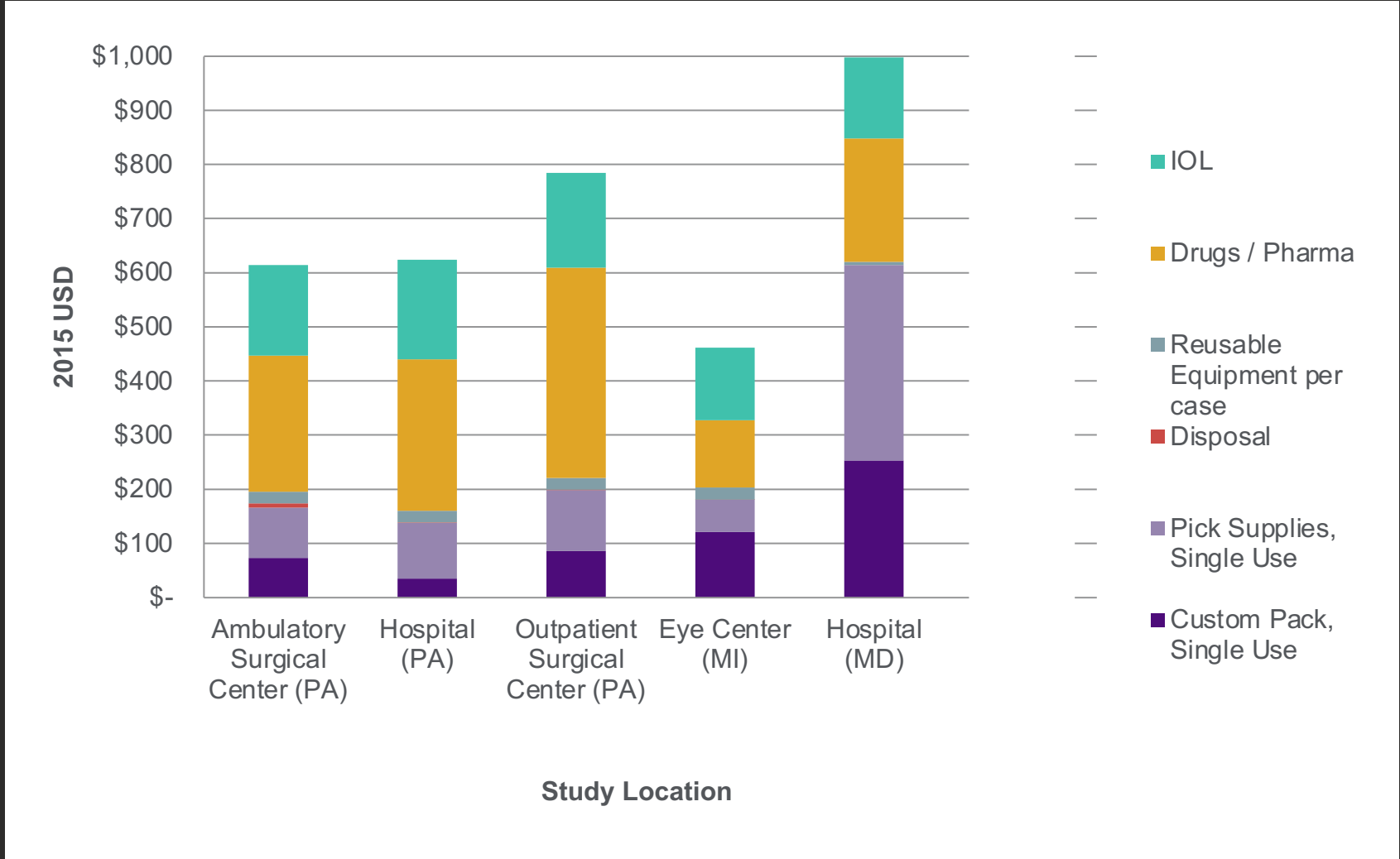


Aravind's Strategies for Efficient Surgical Delivery

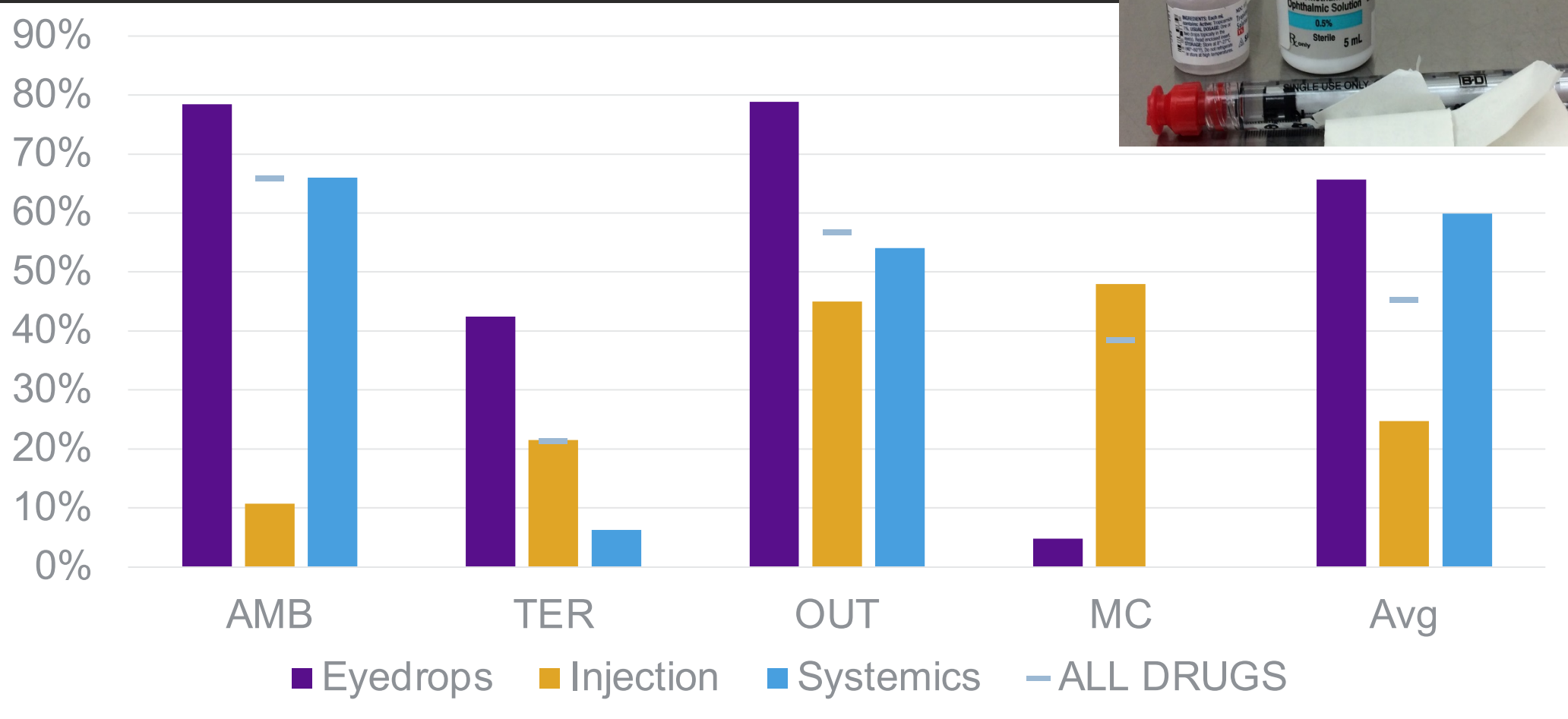
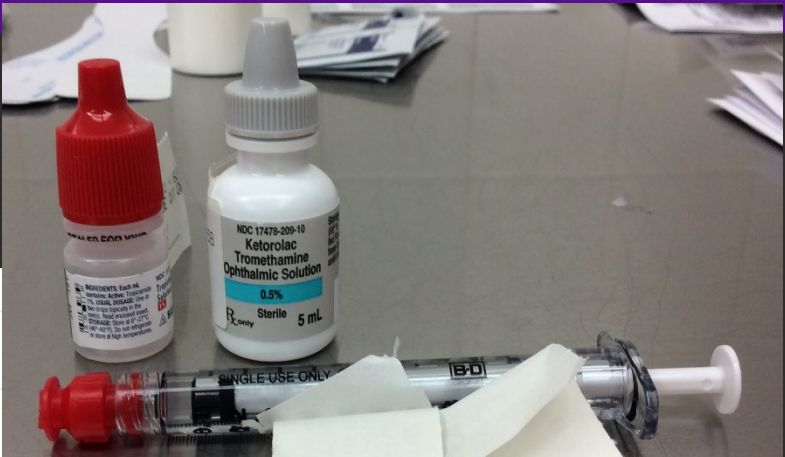
1. Physical layout
2. Task shifting
3. Standardization
4. Reduce waste, maximize reuse
5. Maintain safety



Prices (USD) for Supplies in Average Phaco, by Facility



Waste of Cataract Surgical Drugs



Tauber, et al. 2019. JAMA Ophthalmology Quantification of the Cost and Potential Environmental Effects of Unused Pharmaceutical Products in Cataract Surgery
<https://doi.org/10.1001/jamaophthalmol.2019.2901>

The Costs of Pharmaceutical Waste



Financial Costs

- Minimum: **\$36,900 wasted per year.**
- At 2 sites **over \$190,000 in drugs** per year.
- (When surgery is \$3,600 per eye, this waste **could theoretically have covered an additional 53 surgeries** at each of the latter two locations.)



Environmental Costs

- Using 2011 U.S. cataract surgery prevalence estimates, drug wastage contributes an unnecessary **23,000 to 105,000 metric tons CO₂ emissions** per site.
- (This is equivalent to driving a car **from Anchorage, Alaska to Miami, Florida between 4,600 and 51,400 times every year.**)

Tauber, et al. 2019. JAMA Ophthalmology Quantification of the Cost and Potential Environmental Effects of Unused Pharmaceutical Products in Cataract Surgery
<https://doi.org/10.1001/jamaophthalmol.2019.2901>

Major Conclusion:

Low-Resource settings may be a GREAT place to look for more efficient resource use!

RCS Bulletin: Steyn A, Cassels-Brown A, Chang D, Faal H, Vedanthan R, Venkatesh R, et al. **Frugal innovation for global surgery: leveraging lessons from low- and middle-income countries to optimise resource use and promote value-based care.** The Bulletin of the Royal College of Surgeons of England. 2020;102(5):198-200.



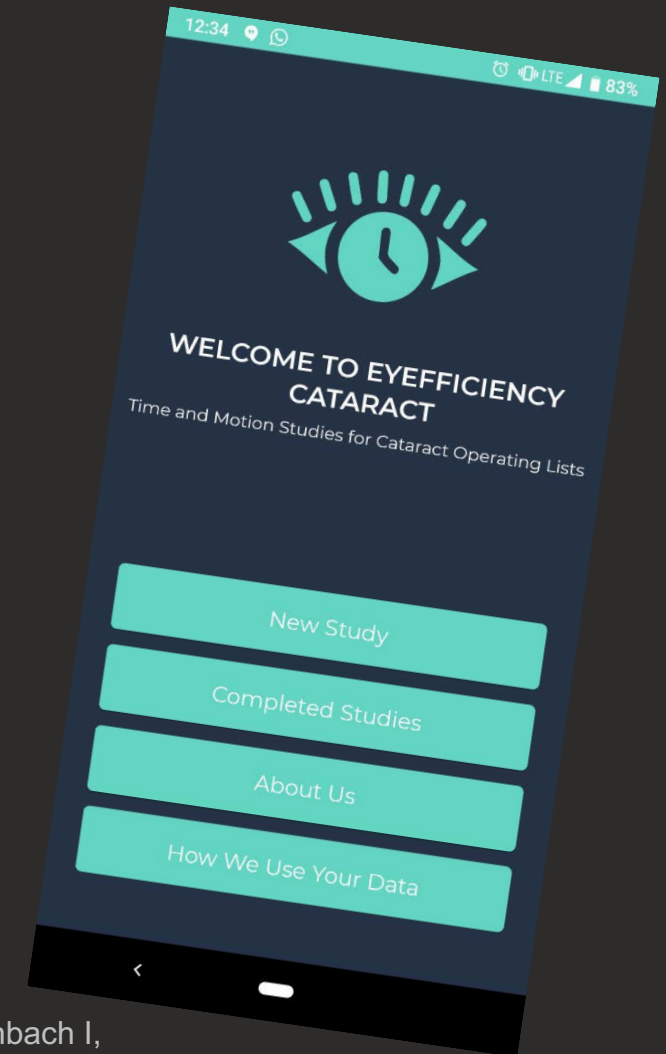
HOW IS OPHTHALMOLOGY ENGAGING IN SUSTAINABILITY?

Global Engagement

Eyefficiency Global Cataract Surgical Services Auditing Tool

- Tool measures Productivity, Cost, Carbon Emissions, and Waste Generation of Cataract Surgical Services (any site globally)
- Can anonymously compare sites
 - Develop best practices guidance
 - Develop regional strategies to optimize performance
- Finished pilot testing, intending to launch at IAPB (Int'l Agency for Prevention of Blindness) General Assembly (delayed due to COVID-19)
- <https://eyefficiency.org/>

Thiel CL, Cassels-Brown A, Goel H, Stancliffe R, Steinbach I, Thomas P, et al. Utilizing off-the-shelf LCA methods to develop a 'triple bottom line' auditing tool for global cataract surgical services. Resources, Conservation and Recycling. 2020;158:104805.



Global Engagement

Climate Action Work Group at the IAPB

- Sustainability guidance for ophthalmologists and eye care facilities worldwide
- <https://www.iapb.org/about-iapb/iapb-work-groups/climate-action/>

Sustainability Work Group at the Royal College of Ophthalmologists

- <https://www.rcophth.ac.uk/professional-resources/sustainability/>



**WHAT
ARE WE DOING ABOUT IT
(IN THE USA)?**

TAKE IT AWAY DAVID!



Thank You!

Funding & support for this work provided by:

- National Science Foundation (Research Development Workshop: Environmental Sustainability and Clinical Care & an Integrative Graduate Education and Research Traineeship, IGERT)
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- Standard Charter Bank, International Agency for Prevention of Blindness, IAPB; and our partners at the Centre for Sustainable Healthcare



Thank you!

Research Partners:

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- Andy Cassels-Brown, Peter Thomas, Jorge Vendries, Inge Steinbach, Rachel Stancliffe, Hena Goel (Eyeefficiency) & Members of the IAPB Climate Action work group
- Thulasiraj Ravilla, R. Venkatesh, Vengadesan (Aravind)
- David Chang and the OICS Task Force
- Students: Dhruvi Joshi, Punima Prasad, Jagan Subramanian, Abdur “Mani” Rehman, David Kleyn, Jenna Tauber, Anthony Chua, Cordelia Kwon, Pallavi Sreedhar

Questions?

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www.clinicallysustainable.org (website)

