

Advancing global health equity: the role of human-centered engineering design approaches

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**What is health equity?
Why is it important in engineering design?**

**How do engineering designers contribute
to health equity?**

**What additional work is needed in
equitable engineering design?**

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Health differences

Consider the case of breast cancer...

In 2025, an estimated
316,950 female-bodied
people will be diagnosed with
breast cancer in the US

In 2025, an estimated
2,800 male-bodied
people will be diagnosed
with breast cancer in the US

This is a health *difference*. **But is it inequitable?**

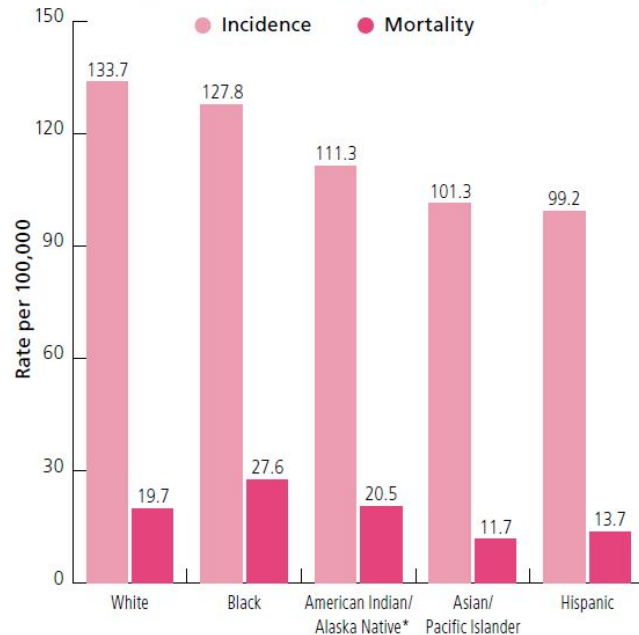
No. **The underlying reason for the difference is due to biologic factors** (including exposure to estrogen and progesterone)

Health disparities

Consider the case of breast cancer...

Black female-bodied people in the US have a **40% higher breast cancer mortality rate** than white female-bodied people in the US

Figure 3. Female Breast Cancer Incidence (2015-2019) and Death (2016-2020) Rates by Race/Ethnicity, US



Note: Rates are per 100,000 and age adjusted to the 2000 US standard population. Race is exclusive of Hispanic origin. *To reduce racial misclassification, incidence data are confined to PRCDA counties, while mortality data are for the entire US with adjustment factors for racial misclassification applied. (See Sources of Statistics, page 34).

Sources: Incidence – NAACCR, 2022. Mortality – National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention, 2022.

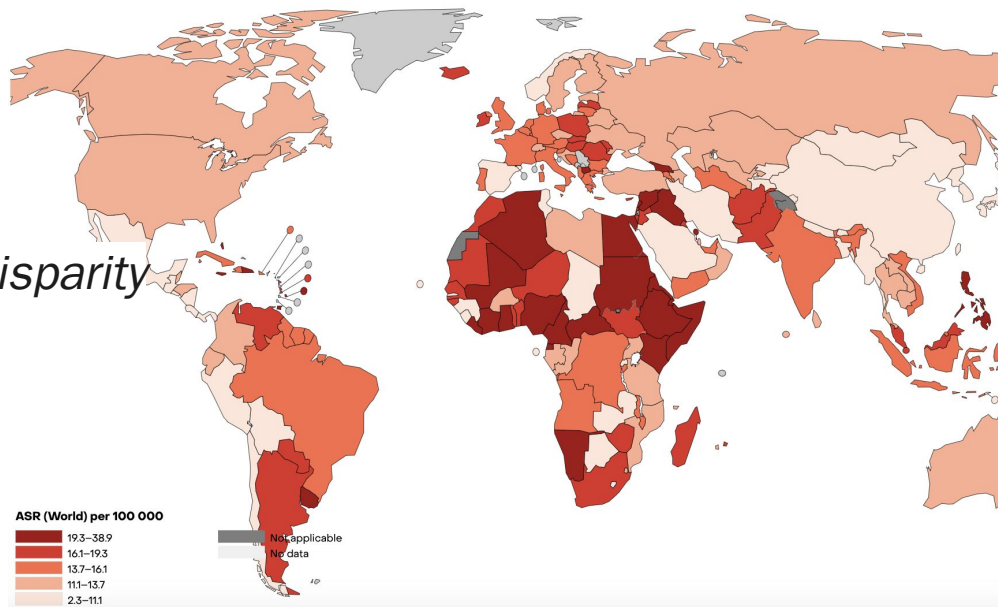
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Health disparities

Consider the case of breast cancer...

Age-standardized mortality rate of breast cancer in females per 100,000 (2022)

This is a health *disparity*



Health disparities

A health disparity is:

“a particular type of health difference that is **closely linked with social, economic, and/or environmental disadvantage**. Health disparities adversely affect groups of people who have **systematically experienced greater obstacles to health** based on their racial or ethnic group; religion; socioeconomic status; gender; age; mental health; cognitive, sensory, or physical disability; sexual orientation or gender identity; geographic location; or other **characteristics historically linked to discrimination or exclusion**.”

Healthy People 2030, a US initiative to set objectives to improve health and well-being this decade

Health equity

Linking health disparities and health equity:

“Health disparities are the metric we use to measure progress toward achieving health equity. A reduction in health disparities (in absolute and relative terms) is evidence that we are moving toward greater health equity.”

“Health equity means social justice in health (i.e., no one is denied the possibility to be healthy for belonging to a group that has historically been economically/socially disadvantaged).”

Health equity is a matter of social justice.
What's the role of engineering?

“Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness, and equity, and must be **dedicated to the protection of the public health, safety, and welfare.**”

**Engineers can
and should
address
injustices,
including health
inequities**

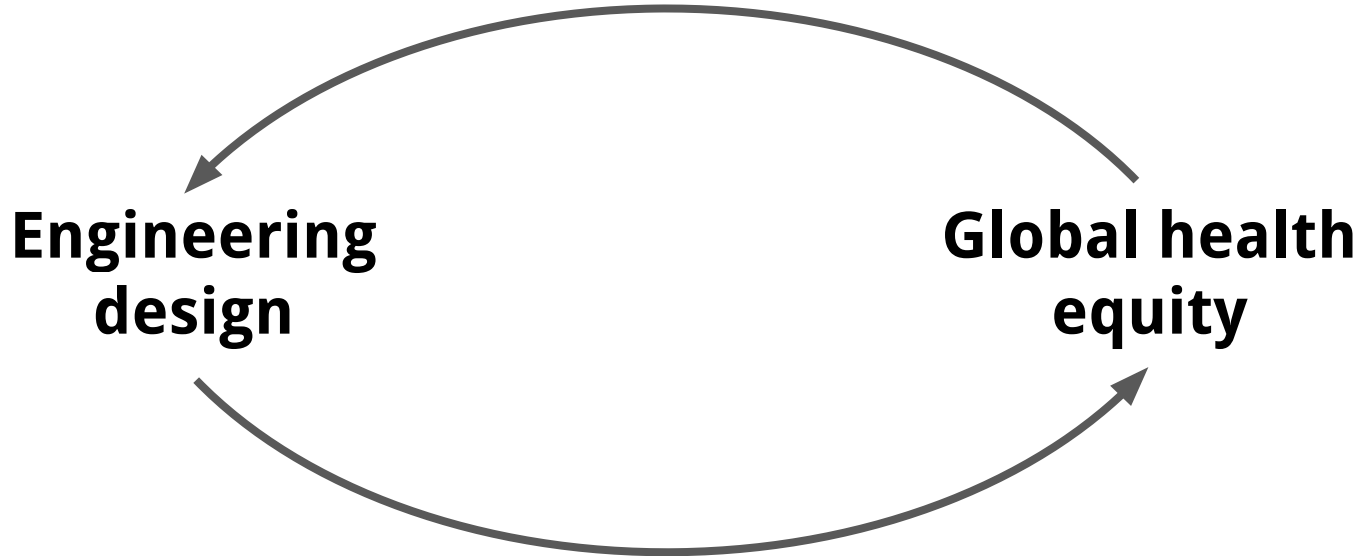


NATIONAL SOCIETY OF
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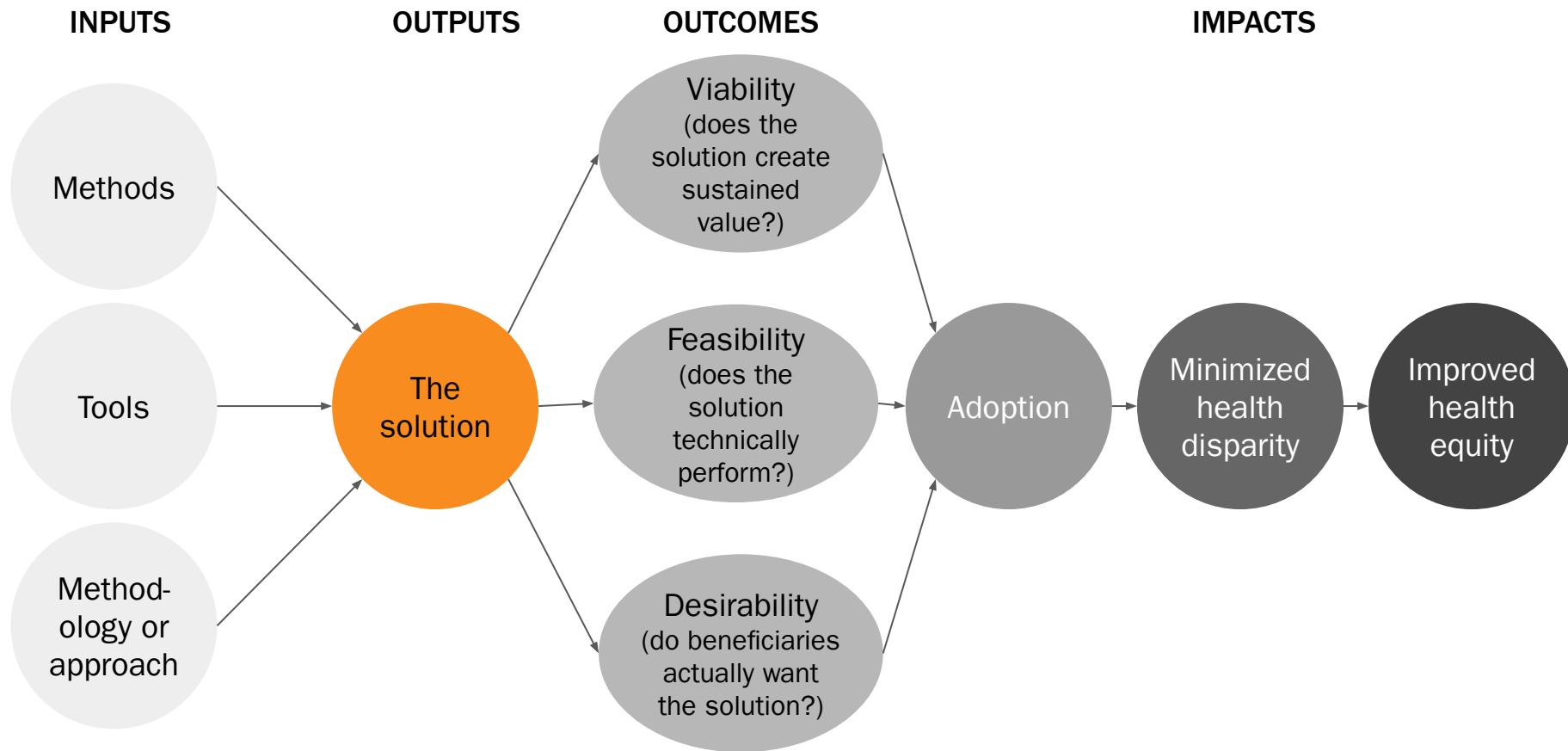
But how?

My work studies this question through the lens of **design**.

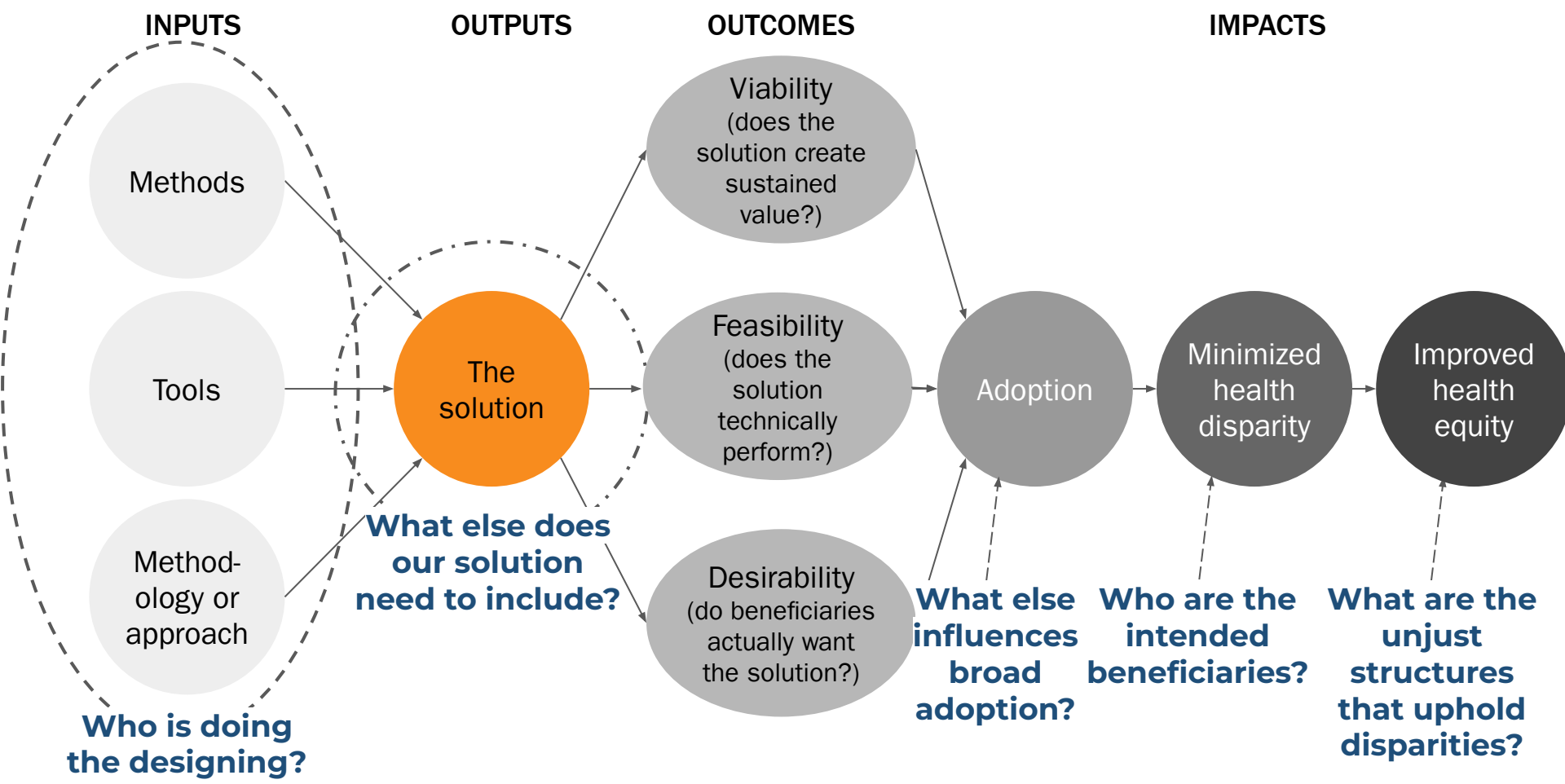
- (1) to **apply engineering design** to improve global health equity
- (2) to **advance the methods and tools** of equitable engineering design



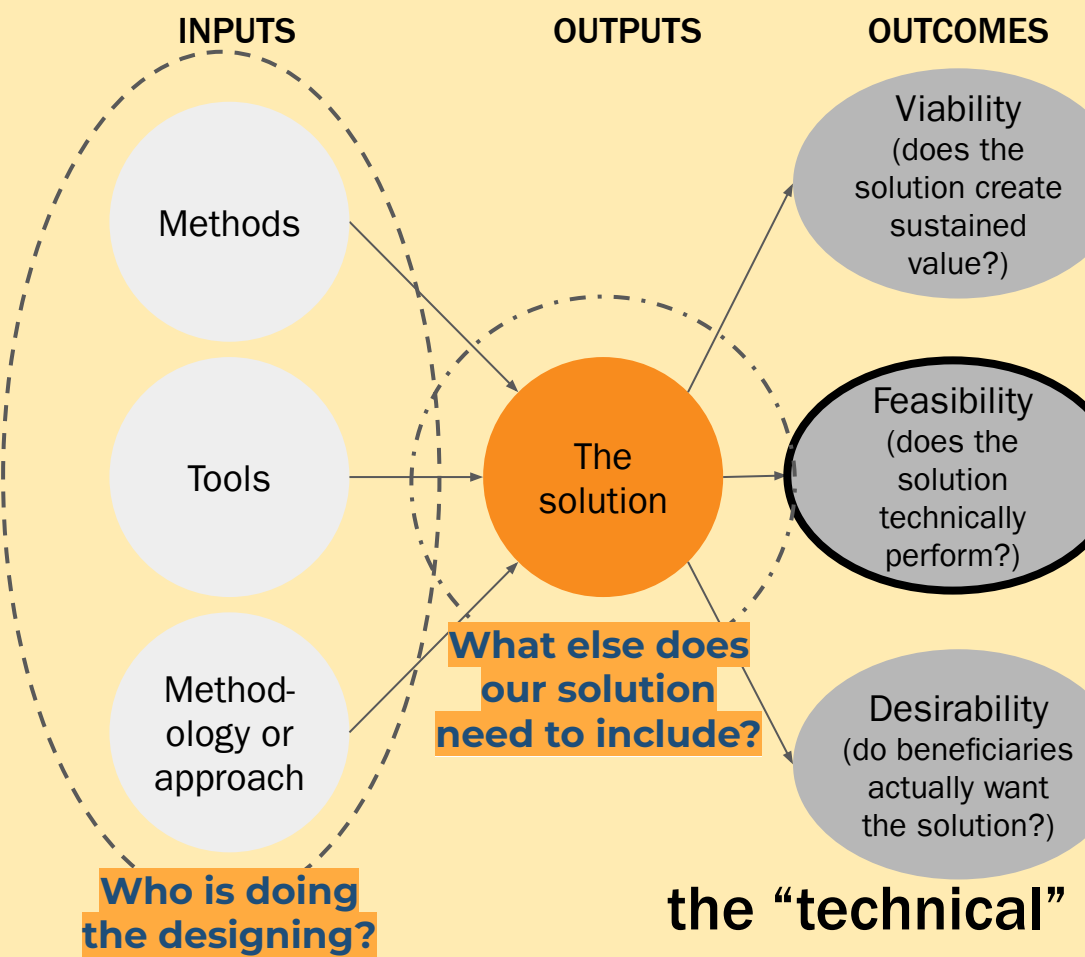
What do I mean by design?



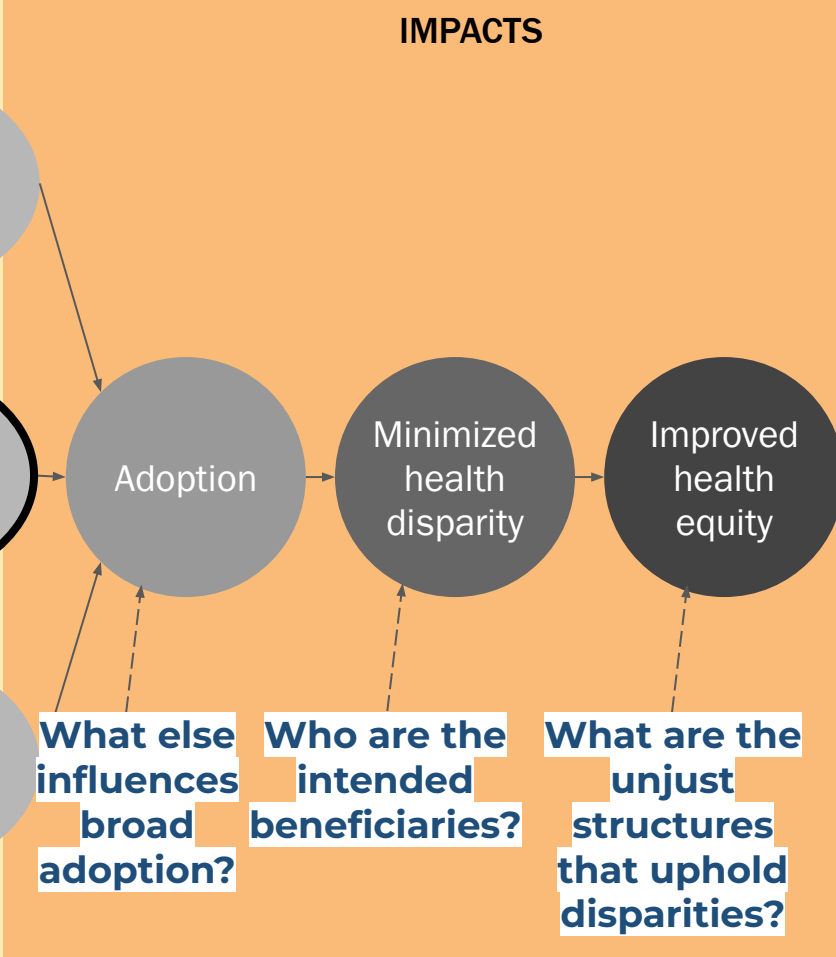
But what's missing?



Is this our responsibility?

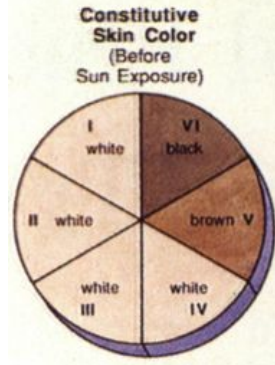


the "social" or "political"



Pulse oximeters are commonly calibrated with the **Fitzpatrick Scale**:

Fitzpatrick, 1988. "The Validity and Practicality of Sun-Reactive Skin Types I Through VI." Archives of Dermatology



Fenty Beauty has more shades!

<https://twitter.com/fentybeauty/status/1004065086153973761>



“Studies dating back to 2005 show pulse oximeters tend to overestimate the amount of oxygen a patient with darker skin may actually have in their blood. It’s simple physics: Melanin in skin absorbs some of the light the devices analyze to make their readings. The darker the skin, the more melanin there is and the less light passes through.

But for decades, this knowledge remained largely out of sight and was not acted on by manufacturers, who said the inaccuracies were minuscule and did not affect patient care.”

Pulse oximeters and their inaccuracies will get FDA scrutiny. What took so long? - <https://www.statnews.com/2022/11/01/pulse-oximeters-inaccuracies-fda-scrutiny/>

A Hundred Racist Designs - <https://medium.com/@otlhogilegordon/a-hundred-racist-designs-ff713cd5aa42>

Plaisime, 2023. “Invited Commentary: Undiagnosed and Undertreated—the Suffocating Consequences of the Use of Racially Biased Medical Devices During the COVID-19 Pandemic.” American Journal of Epidemiology

“Black patients had **nearly three times the frequency of occult hypoxemia** [overestimation of oxygen saturation] that was not detected by pulse oximetry as White patients.”

“Our results suggest that reliance on pulse oximetry to triage patients and adjust supplemental oxygen levels may place **Black patients at increased risk for hypoxemia.**”



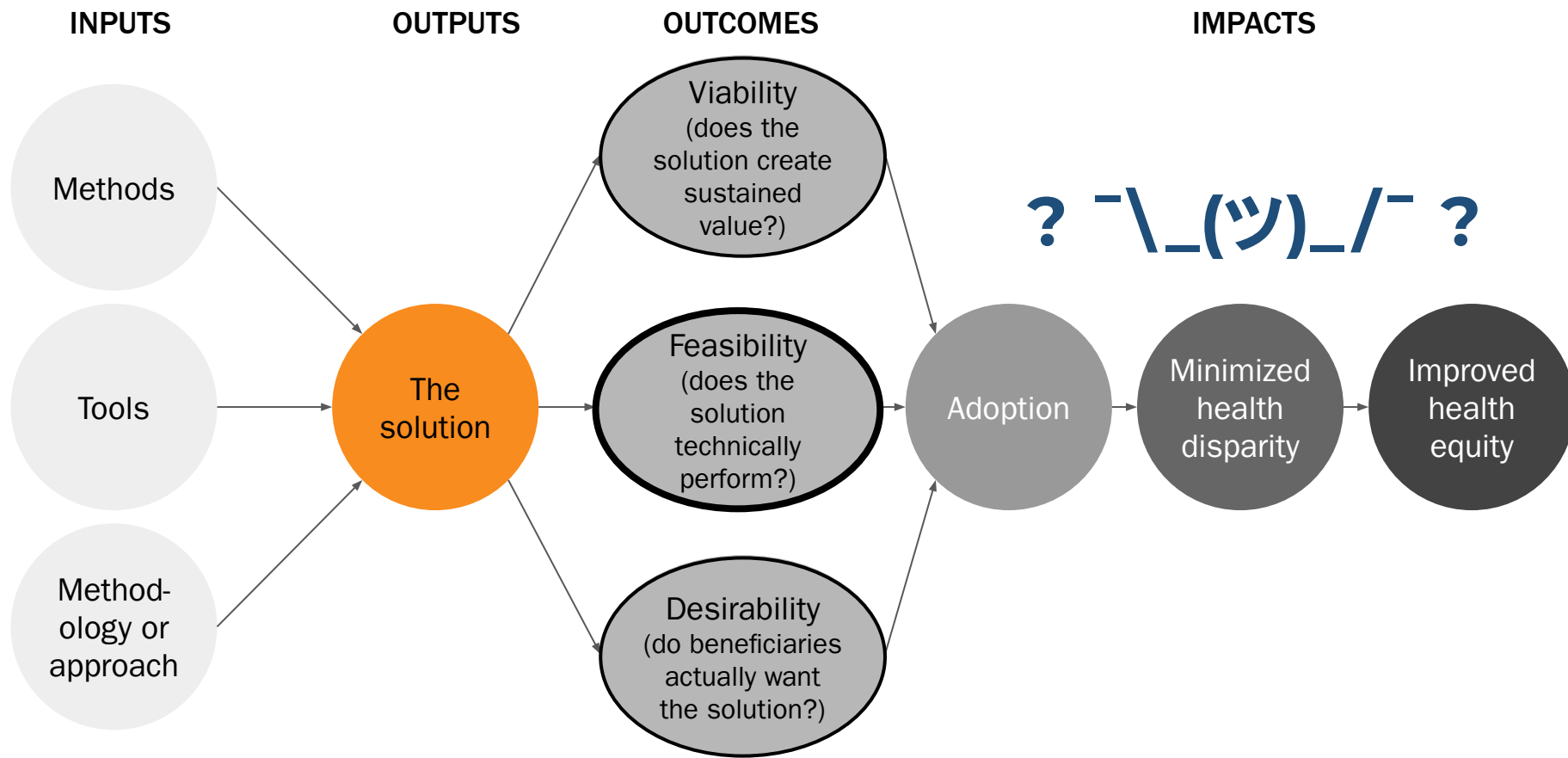
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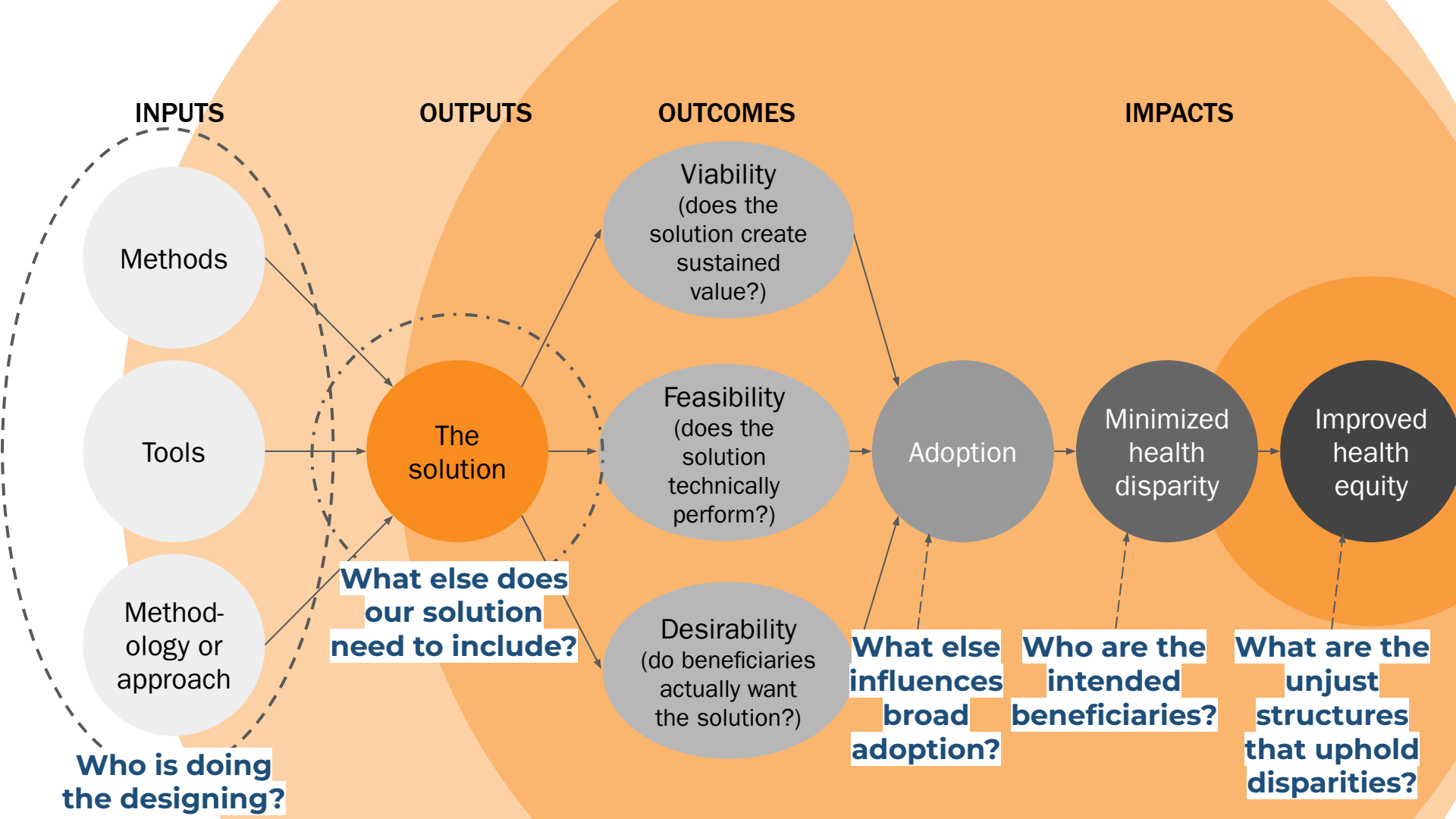
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Sjoding et al., 2021. “Racial Bias in Pulse Oximetry Measurement.” The New England Journal of Medicine





**To create more equitable and just solutions,
we need more equitable and just design processes**

And we are not alone in this:

We need to include the participation of those with direct lived experience in health inequity, and those with expertise in social and political contexts.

**What is health equity?
Why is it important in engineering design?**

**How do engineering designers contribute
to health equity?**

**What additional work is needed in
equitable engineering design?**

Three broad categories of my research

Developing **training in design** for global health equity

Investigating **approaches, methods, and tools** in design for global health equity

Evaluating the **impact of design** in improving global health outcomes and inequities

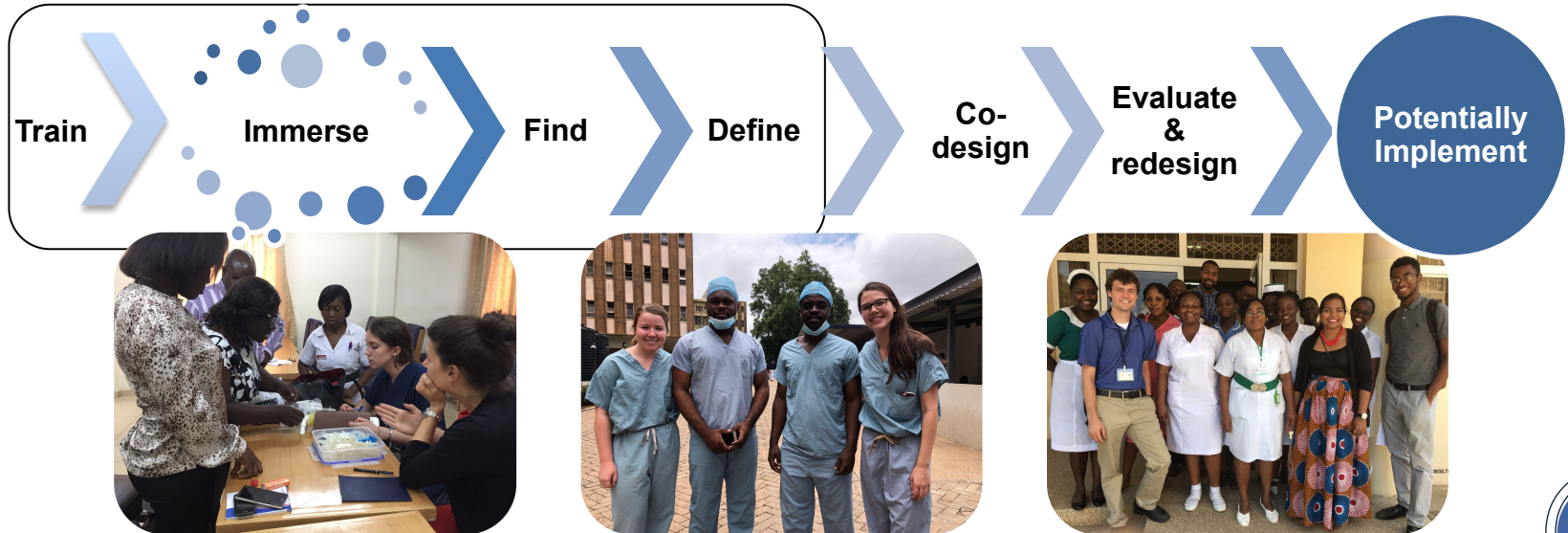
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health equity

Investigating
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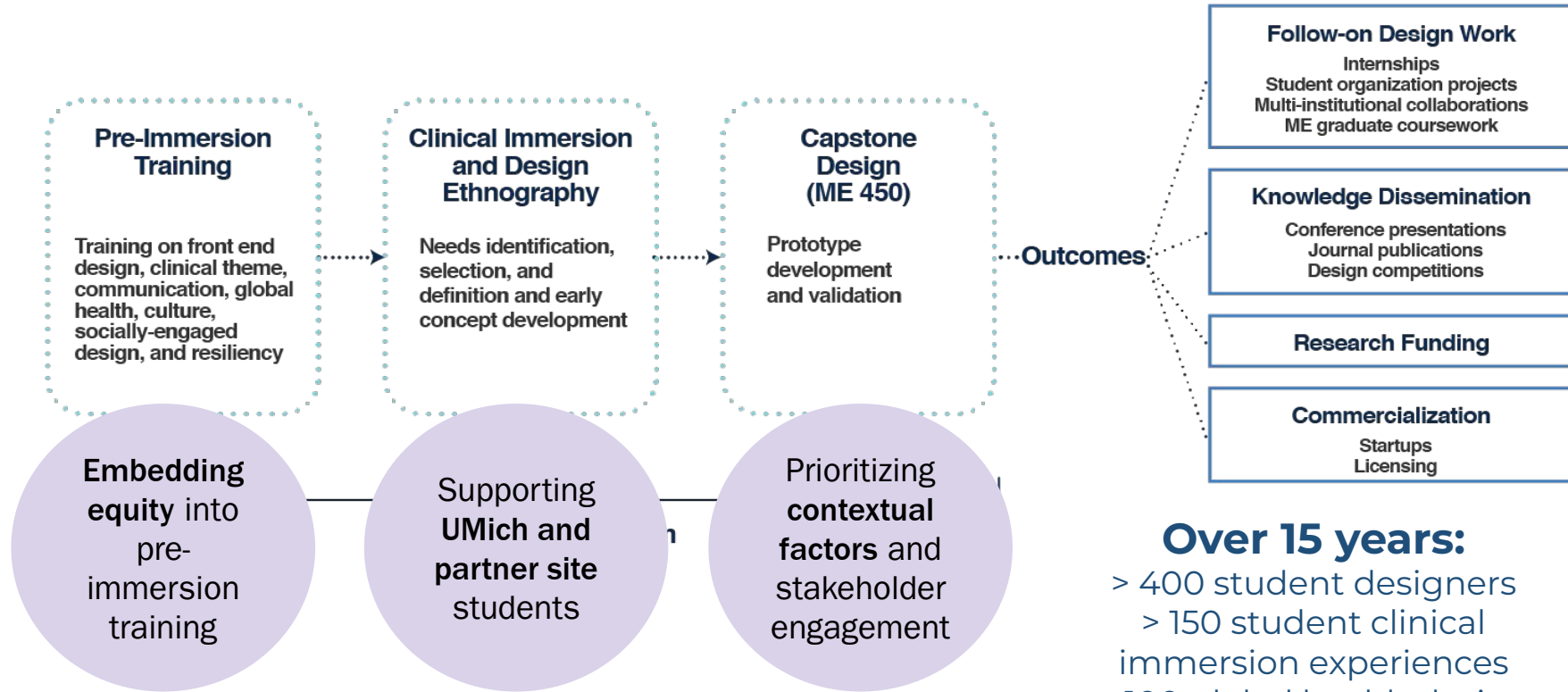
Evaluating the
impact of design in
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Global Health Design Initiative (GHDI)

Train a new generation of undergraduate engineering and design students to collaborate with stakeholders to **identify and define healthcare challenges**, and **develop potential healthcare solutions**



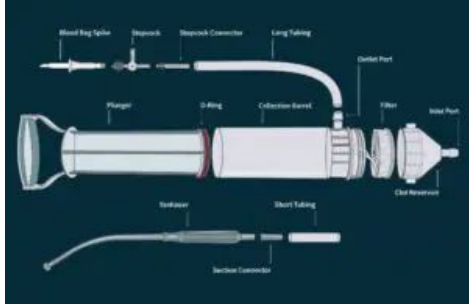
GHDI program model



Over 15 years:
> 400 student designers
> 150 student clinical immersion experiences
> 100 global health design projects

GHDl design project examples

Autologous Blood Salvage Device



- ✓ Startup Formation
- ✓ Commercialization

Postpartum Hemorrhage Device



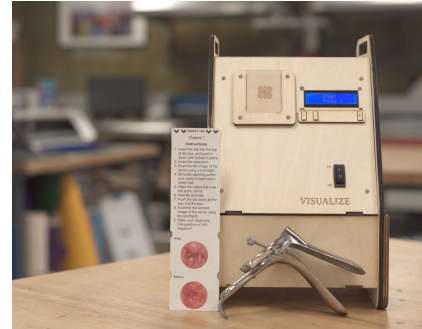
- ✓ Design Reports
- ✓ Student Conference Presentation

Assistive Device for Subdermal Contraceptive Implant Removal



- ✓ Follow-on Design Work (Students and Industry Professionals)
- ✓ Pre-clinical and Usability Testing

Cervical Cancer Screening Simulator



- ✓ Student Journal Publication
- ✓ Non-profit Incorporation
- ✓ Pursuing Pilot Testing

Developing **training
in design** for global
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Investigating
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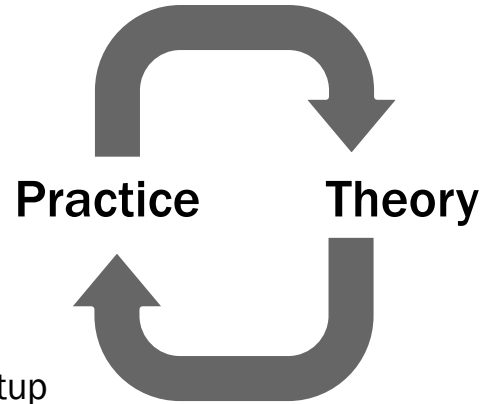
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Designing for access to cervical cancer screening

Two exploratory case studies



Technology-driven startup
aiming to standardize
low-cost cervical cancer
screening in India



Service-oriented
non-profit aiming to
deliver cervical cancer
screening to rural
Nicaragua

What is accessibility?

The degree of “fit” between patients and the healthcare system

Availability

High-quality services are available for all patients who need them

Physical Accessibility

Services are located near to patients

Accommodation

There known entry points for patients to use the services

Affordability

The services are affordable, considering income, liquidity, and insurance of patients

Acceptability

The services and the providers are socially acceptable to patients



Focus on Mujeres Móviles

Mujeres Móviles is a non-profit based in Nicaragua that aims to improve the health and wellbeing of women and girls across Nicaragua

Iteratively created and implemented a *mobile cervical cancer clinic*



Mujeres Móviles mobile cervical cancer clinic

Mobile clinic operations:

- Mobile clinic travels to rural communities to provide women with cervical cancer screening
- While women wait to be screened, MM nurses provide education on cervical cancer, screening, and sexual health (e.g., menstruation)
- Prior to screening, all women talk with a MM nurse one-on-one about their health concerns and history
- After all women have been screened, MM contracts with a lab specialist to ensure high quality and quick results
- When results are received for all women screened in a rural community, MM travels back to provide treatment to women with positive screening results

Mujeres Móviles mobile cervical cancer clinic



**Addresses
Physical
Accessibility**

**Addresses
Accommodation**

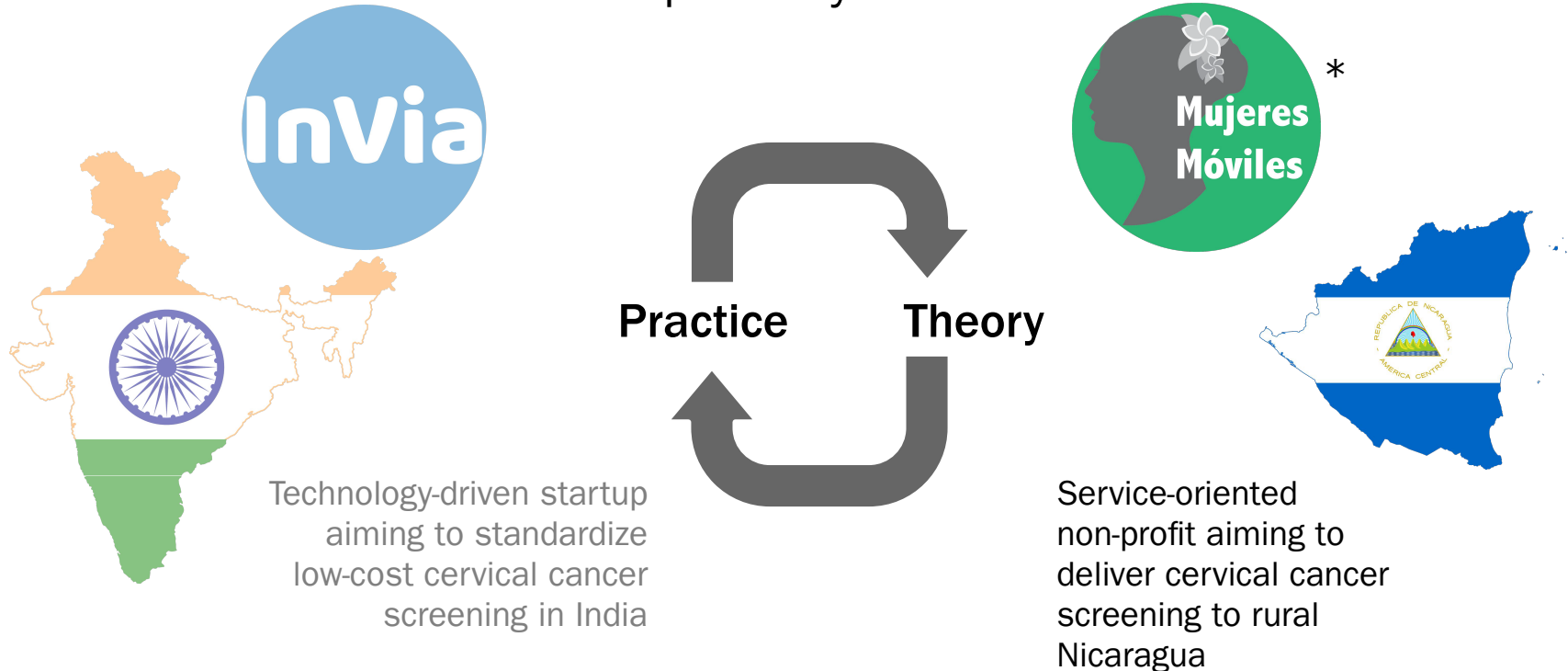
**Addresses
Acceptability**

**Addresses
Availability**

**Addresses
Affordability**

Designing for access to cervical cancer screening

Two exploratory case studies



“Designing for access”

Design is based upon explicit understanding of the **barriers to accessing existing solutions**

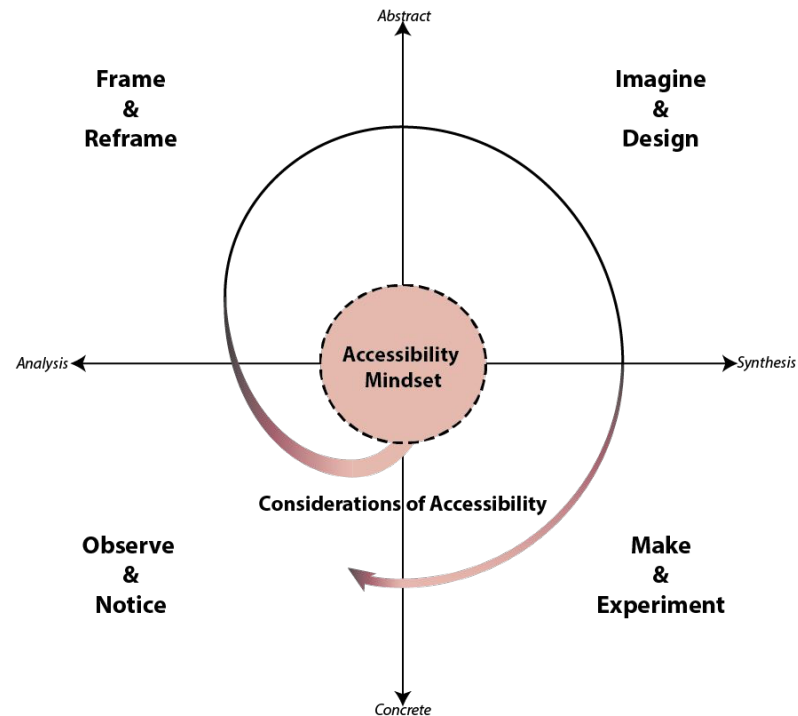
Stakeholders involved through the design process share their **perspectives on accessibility**

Design is refined by **evaluating** whether or not it sufficiently **addresses accessibility**

Research on **accessibility drives iterative** problem framing and development of new designs

Solution addresses the **multiple accessibility barriers** stakeholders face

Multi-disciplinary team members adopt a **mindset of accessibility**



Developing **training
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Designing for contraceptive access and autonomy

Aims to understand how DMPA-SC [subcutaneous Depo-Medroxyprogesterone Acetate] (Sayana Press) can be implemented to **support informed contraceptive choice, use, and autonomy from the perspective of women**

Four study countries: Kenya, Malawi, Nigeria, and Uganda

Specific objectives:

- 1) Explore which women are most likely to be interested in using DMPA-SC
- 2) **Identify and test interventions across a variety of settings, channels, and user groups to directly support the needs of women who can benefit from DMPA-SC**
- 3) Explore the relationship between DMPA-SC and contraceptive autonomy



Implementing and evaluating a collaborative design process

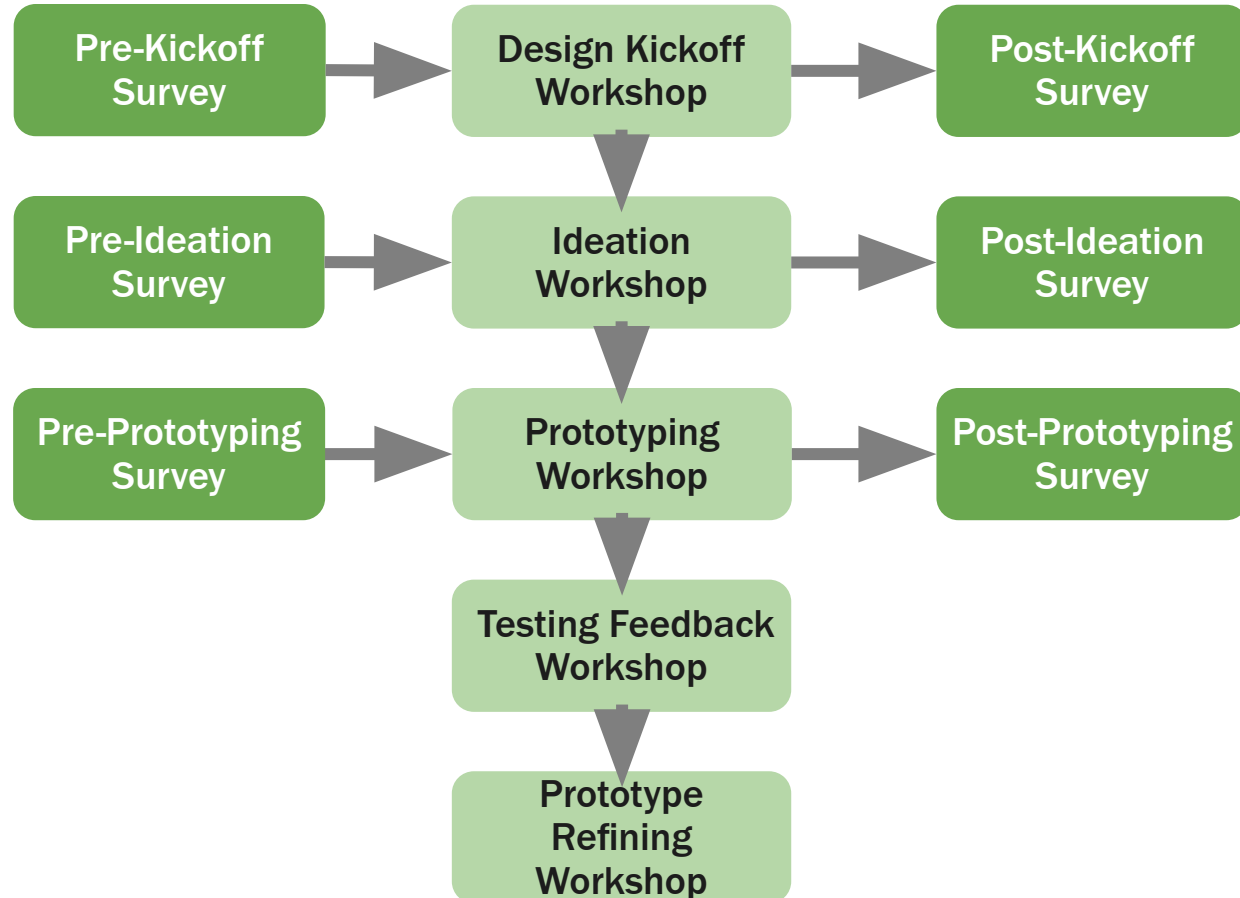
Collaborative Design Teams

(one in each site):

- US-based and study-site based researchers
- Implementation partners
- Contraceptive users
- Community leaders and other key stakeholders

Design Sites and Sectors:

- **Nairobi, Kenya:** e-commerce
- **Mulanje and Ntchisi, Malawi:** community health workers
- **Mayuge and Oyam, Uganda:** peer social networks



Implementing and evaluating a collaborative design process: participants' experiences

Participants' knowledge increased across workshops regarding what human-centered design is, why it's important, and what are the best practices for each phase

- Knowledge gained aligned with stated learning goals and expectations

Main challenges faced:
time constraints, frustrations with ideation, and technical difficulties

Areas of enjoyment: **opportunity for teamwork** (across different team members) and **interactive activities**

Suggested areas for improvement: **increase time for the workshops, broaden participation** (e.g., men), **provide note-taking materials**, and **use local languages more**

Improvement of process evaluation: explore **what motivates participants to participate**, explore **how participants perceive the value of their contributions**, incorporate **observations and in-depth interviews**, reduce **amount of survey questions**

Currently being implemented in a study **evaluating the collaborative design process** employed to develop contraceptive counseling and follow-up solutions in Ethiopia and Kenya



**What is health equity?
Why is it important in biomedical design?**

**How do biomedical designers contribute
to health equity?**

**What additional work is needed in
equitable biomedical design?**

Additional research needed in these focus areas

Developing **training
in design** for global
health equity

Investigating
**approaches,
methods, and tools** in
design for global
health equity

Evaluating the
impact of design in
improving global
health outcomes and
inequities

Additional research needed

Developing training
in design for global
health equity

Embedding **considerations of justice and equity** in engineering and design training

Evaluating the **impact of how those considerations translate to student learning outcomes** and engagement with justice and equity

Broadening design training to larger groups of co-designers and evaluating learning outcomes

Additional research needed

Investigating
approaches,
methods, and tools in
design for global
health equity

Further studies of **design justice**: how practitioners and academic researchers operationalize “justice” in their design work

Further studies of how designers working in health equity **embed and operationalize participation** in their design work

Additional research needed

Evaluating the **impact of design** in improving global health outcomes and inequities

Continued **implementation of equity- and justice-informed design approaches in health equity applications**; studying the health outcomes and impacts of designed solutions

Refining evaluation strategies to measure equity and justice in both design processes and design outcomes

Conclusion



**Systems of oppression,
inequality, and inequity
are by design**

**Therefore, they can be
redesigned**



www.creativereactionlab.com

Acknowledgements

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Kelsey Holt, ScD, MA
Sita Syal, PhD
Shanna Daly, PhD

Mujeres Móviles
InVia

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Kenya Medical Research Institute
Malawi University of Science and Technology
Makerere School of Public Health
Akena+ Associates
St. Paul's Hospital Millennium Medical College
The many participants who engaged in a series of collaborative design workshops

GHDI Partner Institutions

Korle Bu Teaching Hospital
Komfo Anokye Teaching Hospital
University of Ghana
Kwame Nkrumah University of Science and Technology

Gates Foundation



**Michael and Phyllis
Korybalski**

**The Papadopoulos
Family Foundation**

**The Joseph B. and Florence V.
Cejka Foundation**

Thank you!

**What is health equity?
Why is it important in engineering design?**

**How do engineering designers contribute
to health equity?**

**What additional work is needed in
equitable engineering design?**

Health equity is social justice in health.

Engineering design can either contribute to justice or exacerbate injustice in health.

To contribute to health equity, **engineering design must examine equity and justice in design processes and outcomes**

Health inequities are complex and deeply rooted.

Additional research, practice, and activism is needed to work towards a horizon of social justice in health.

Thank you!

Questions? Comments? Critiques?

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