ADItech – Formación online
December 10, 2024

WOMEN's BRAIN Foundation

Sex and gender biases in digital technologies and artificial intelligence

Davide Cirillo

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AI is everywhere

source: https://unsplash.com

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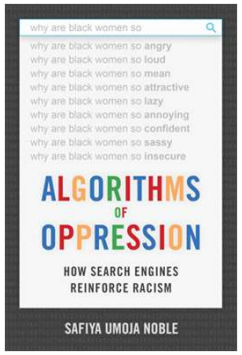
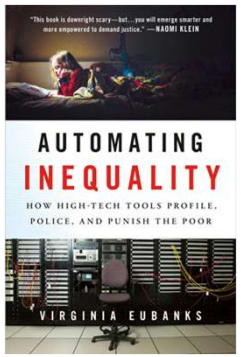
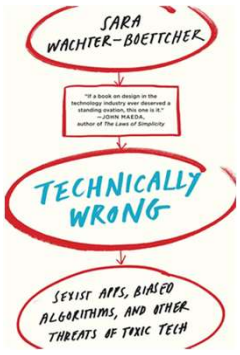
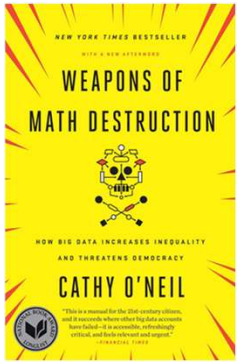
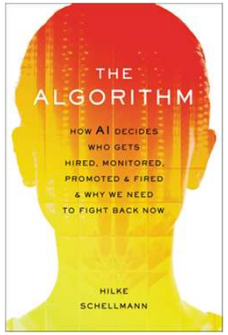
AI reflects our own biases

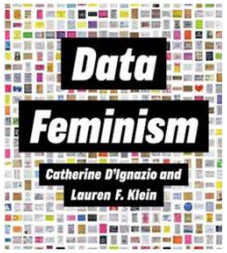


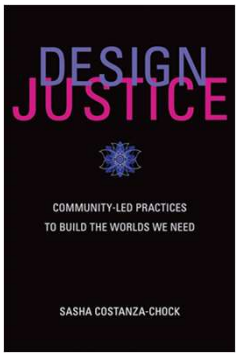


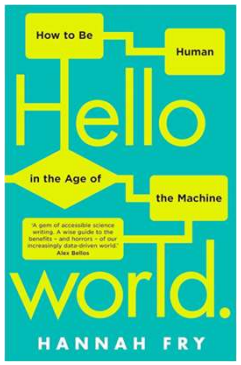


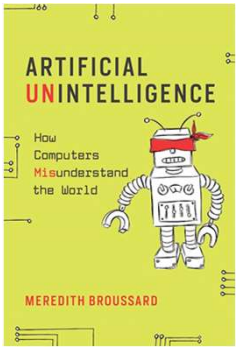


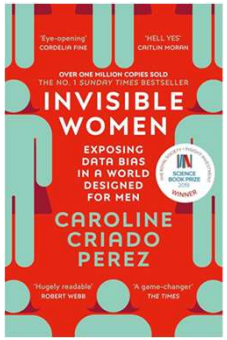


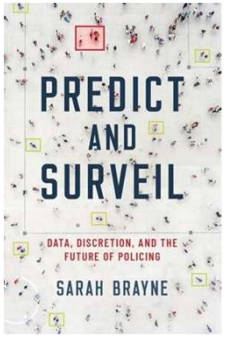


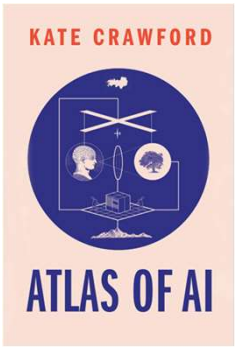


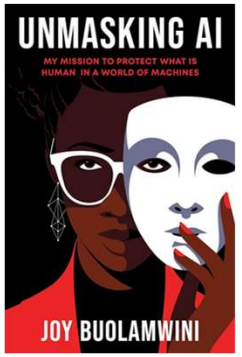


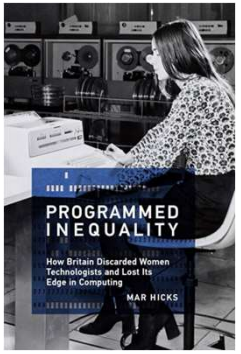












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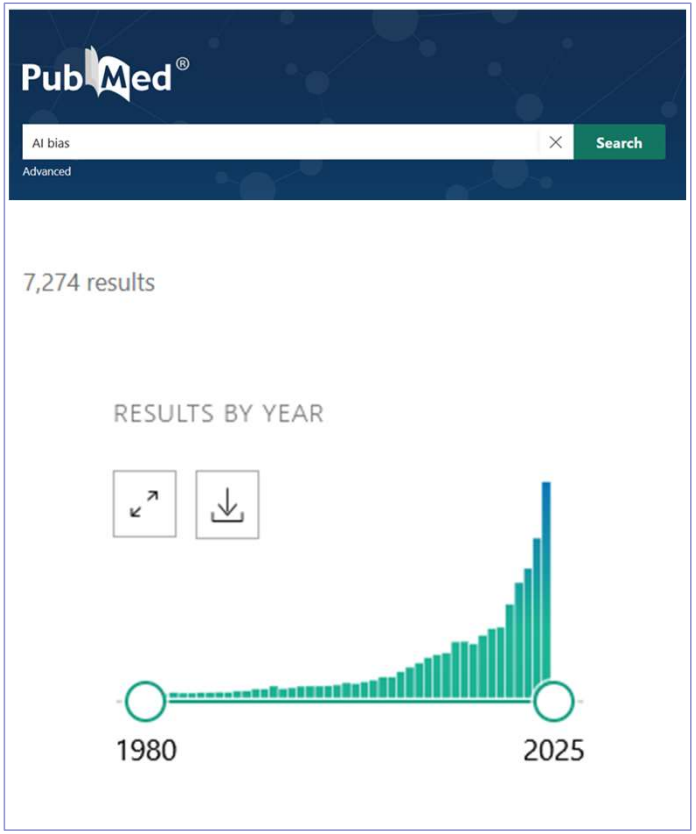
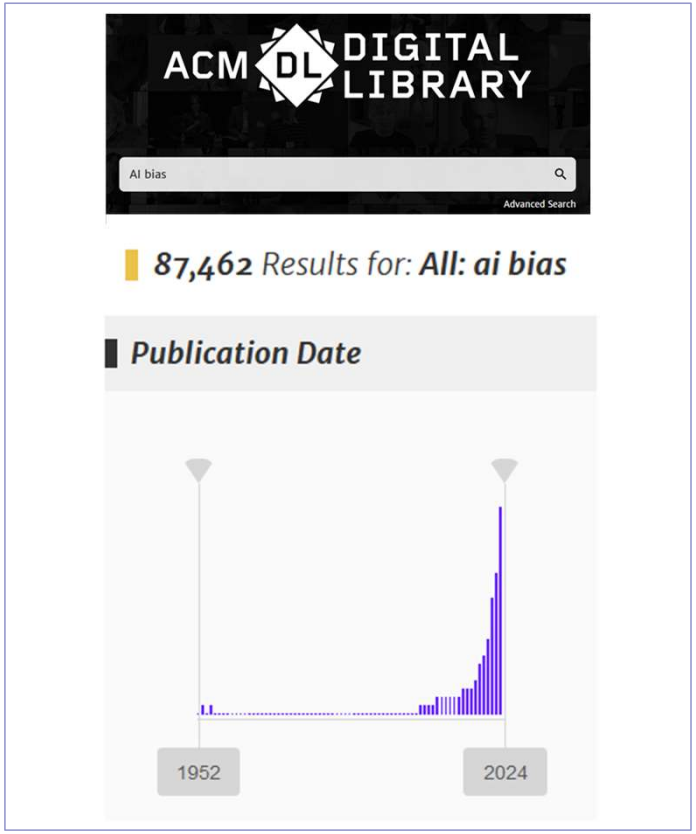
Life Sciences literature



Computer Sciences literature



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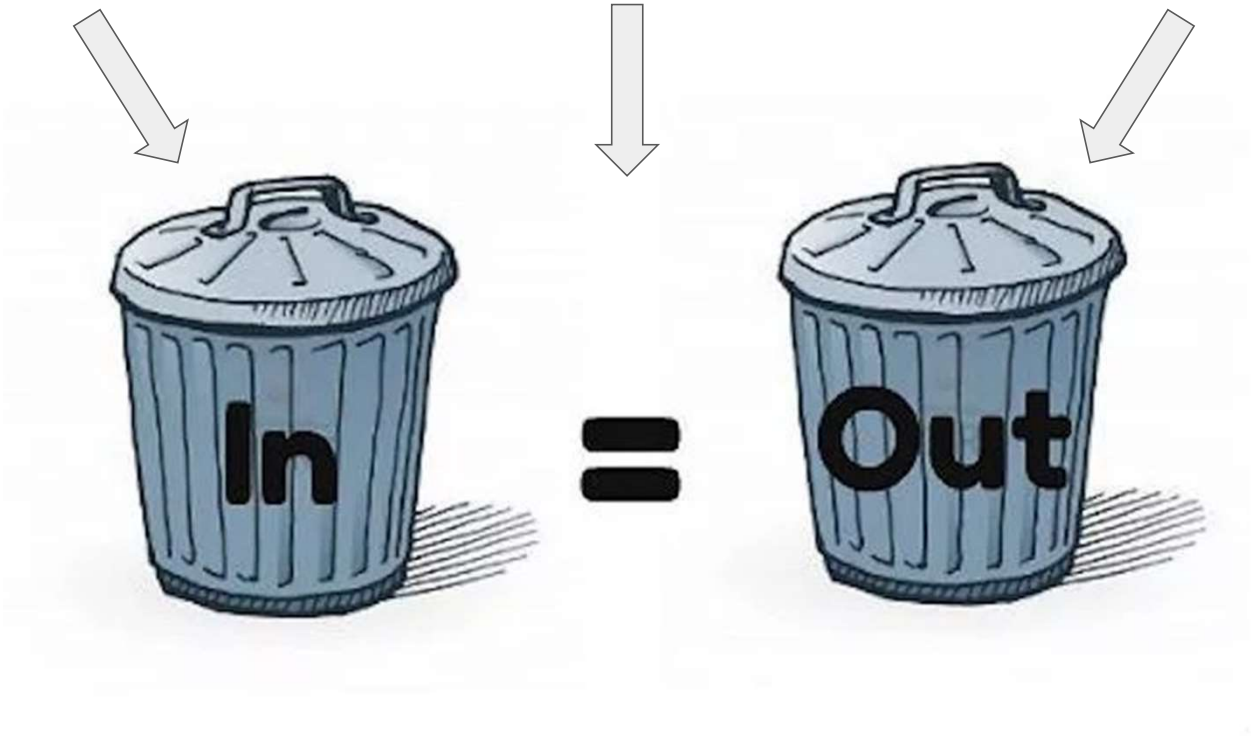
“Garbage in, garbage out”

How the data has been generated, collected, processed?

What is the model actually learning?

How will the output be used in the real-world?



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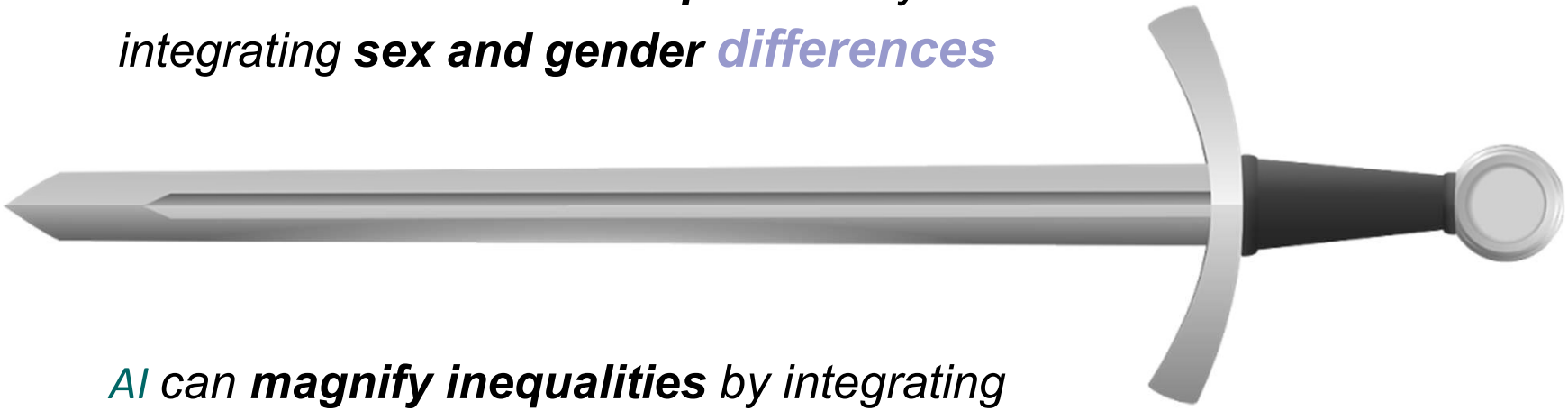
What is a bias?

A BIAS is a systematic error made by a **human** (cognitive bias) or a **machine** (algorithmic bias)

that leads to a **disadvantage** for an individual or a group of people identified by personal attributes (sex, gender, age, ethnicity, etc.)

AI act as a double-edge sword

*AI can **reduce inequalities** by integrating **sex and gender differences***



*AI can **magnify inequalities** by integrating **sex and gender biases***

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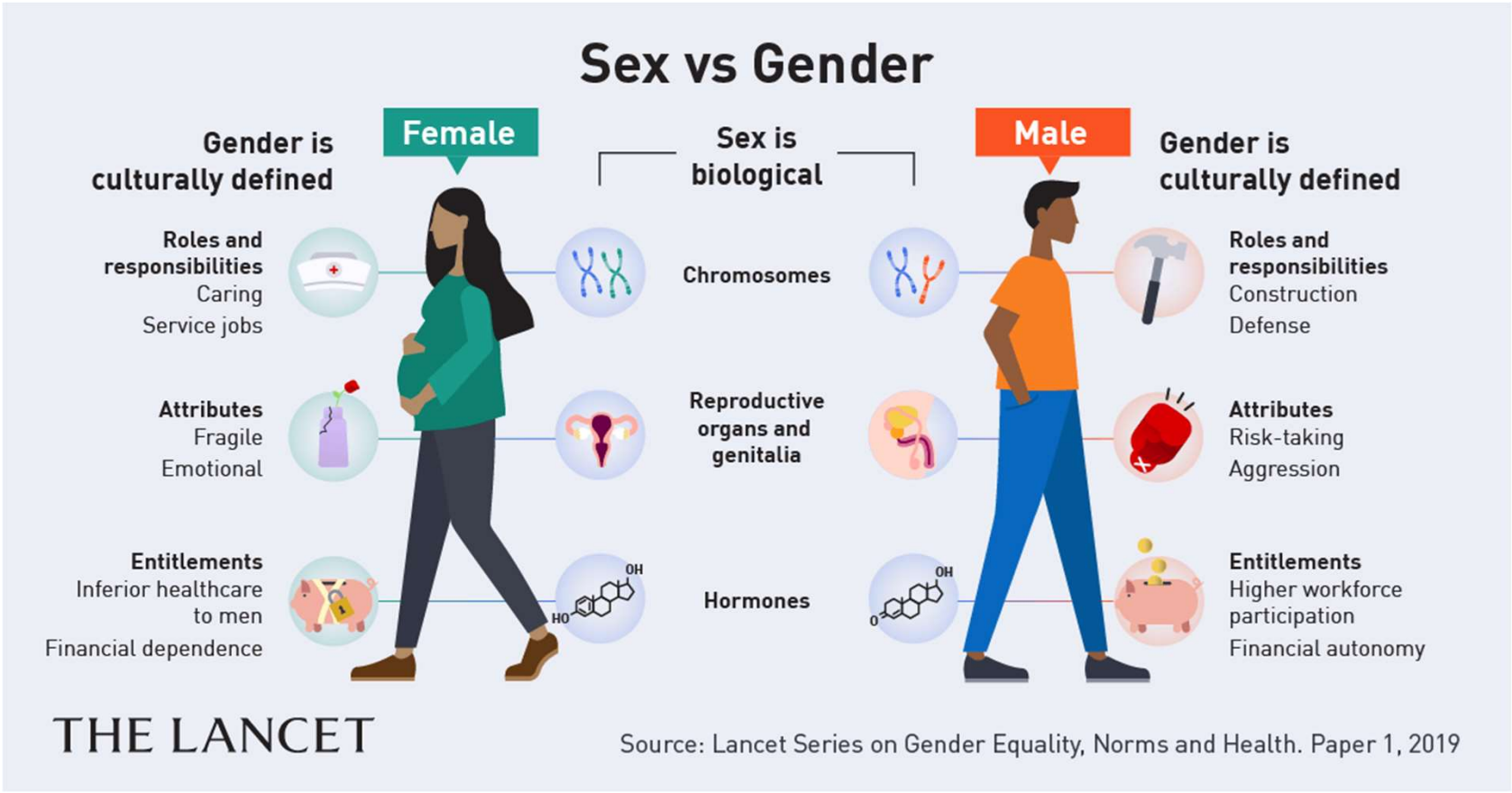

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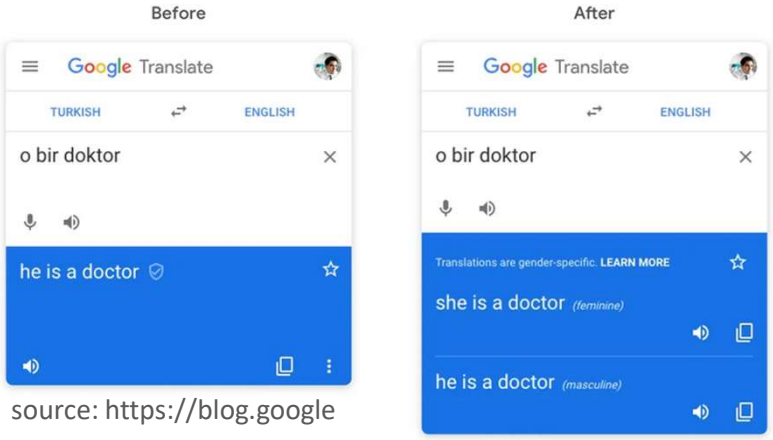
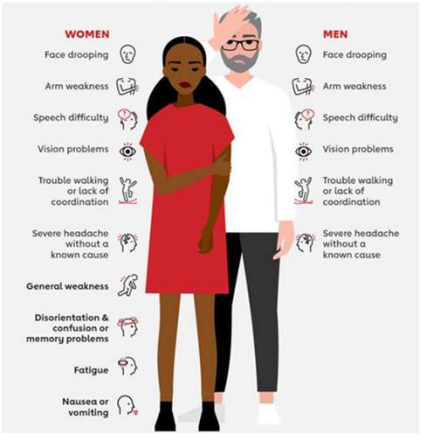
MACHINE TRANSLATION



source: https://blog.google

DISEASE DIAGNOSIS

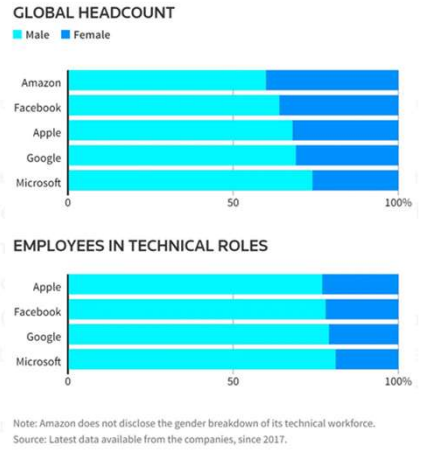


source: www.heart.org

IMAGE GENERATION

source: https://theconversation.com

CURRICULUM SELECTION



source: https://medium.datadriveninvestor.com

AUTOMOBILE ENGINEERING

source: www.ilmessaggero.it

ROBOTICS

source: https://www.racked.com

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The importance of intersectionality

Gender Classifier	Darker Male	Darker Female	Lighter Male	Lighter Female	Largest Gap
Microsoft	94.0%	79.2%	100%	98.3%	20.8%
FACE++	99.3%	65.5%	99.2%	94.0%	33.8%
IBM	88.0%	65.3%	99.7%	92.9%	34.4%

MIT Media Lab researcher
Joy Buolamwini

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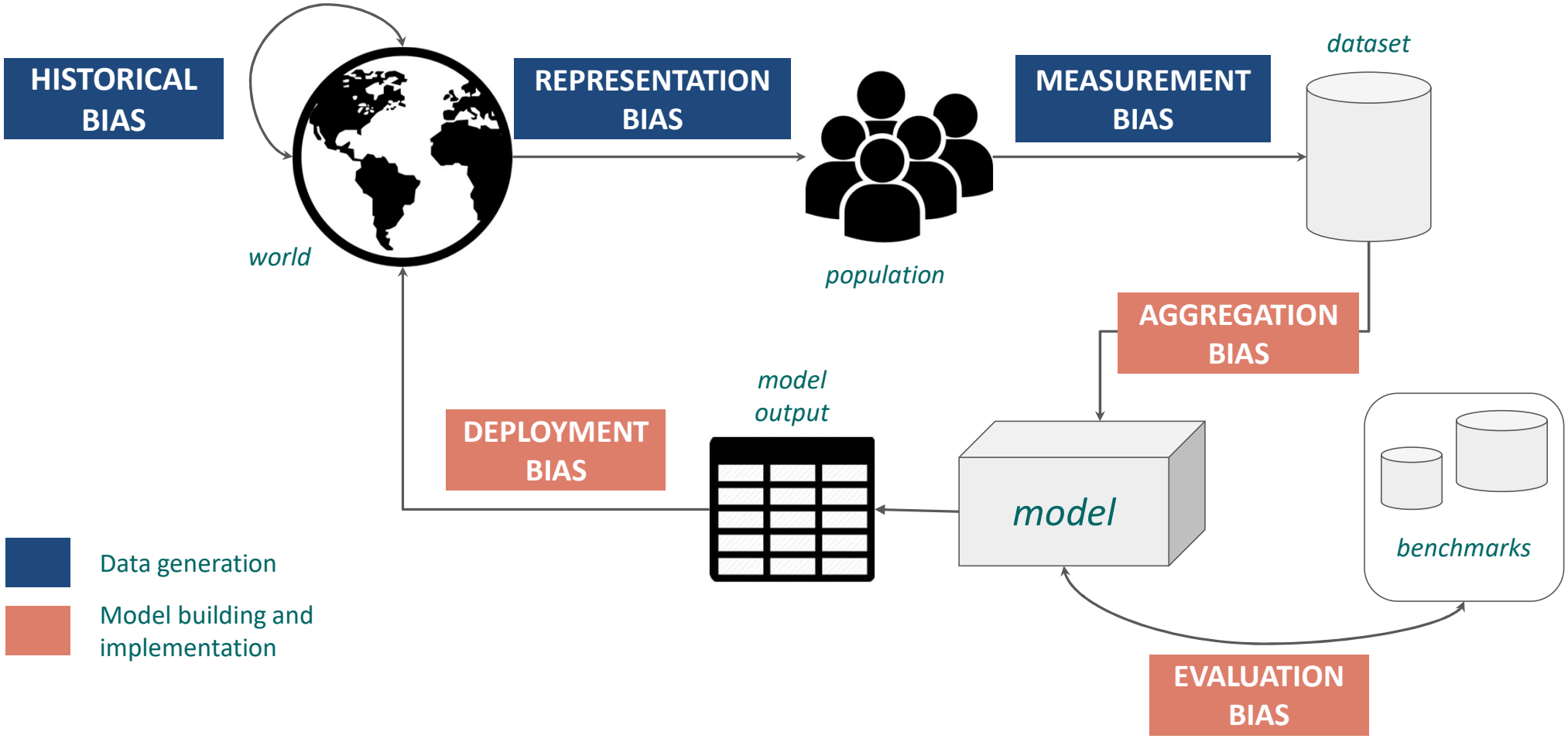

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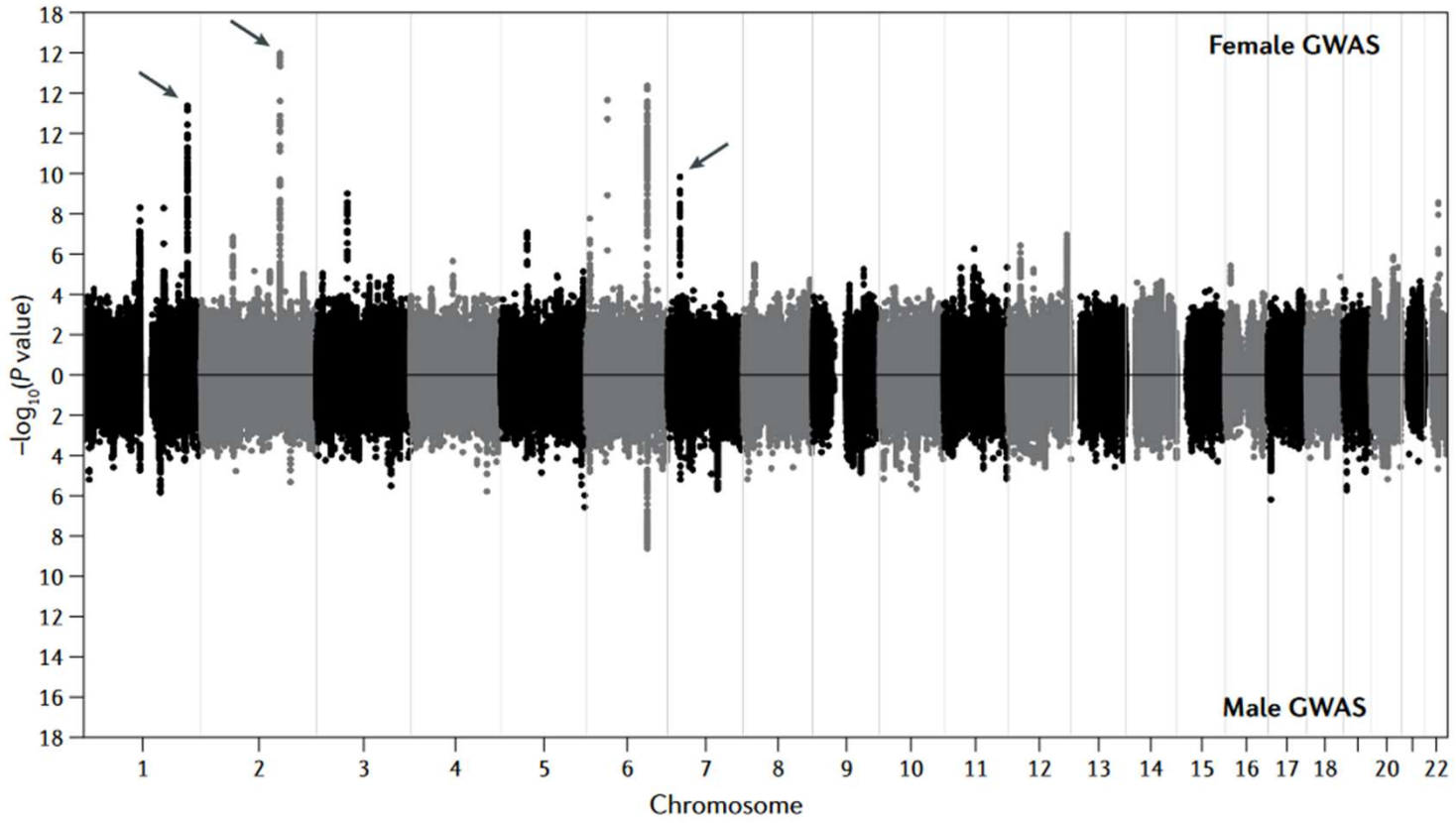
Representation bias in Genomics



Khramtsova, E. A., Davis, L. K., & Stranger, B. E. (2018). *Nature Reviews Genetics.*

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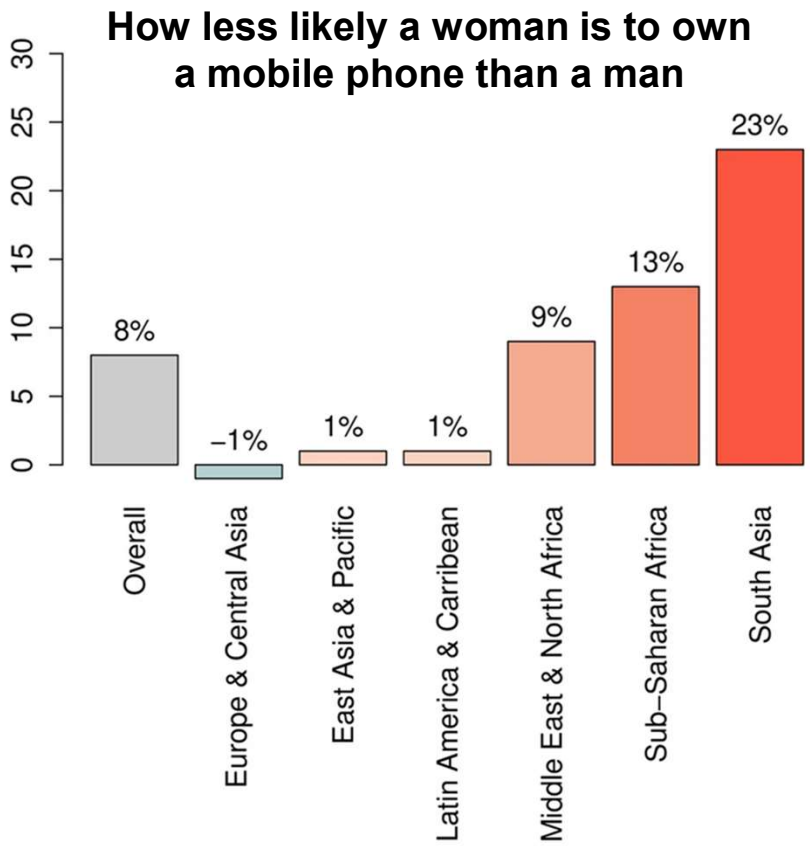
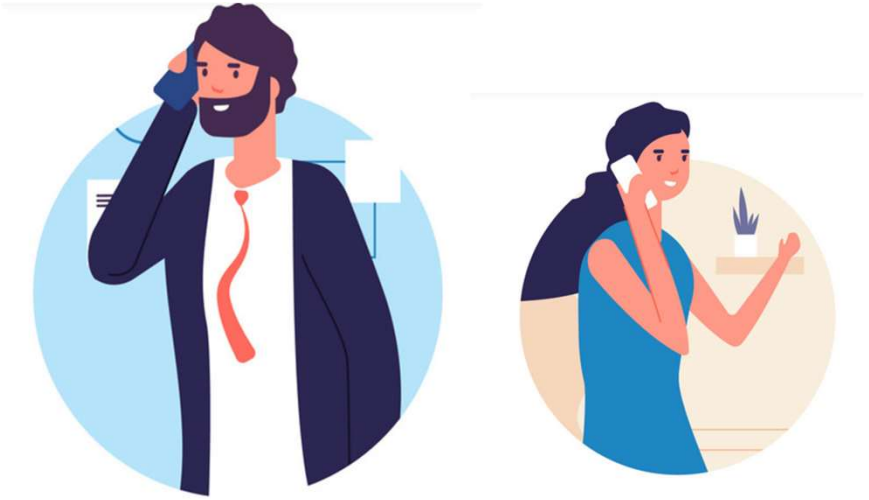
Deployment bias and the digital divide





GSMA “The Mobile Gender Gap Report 2020”

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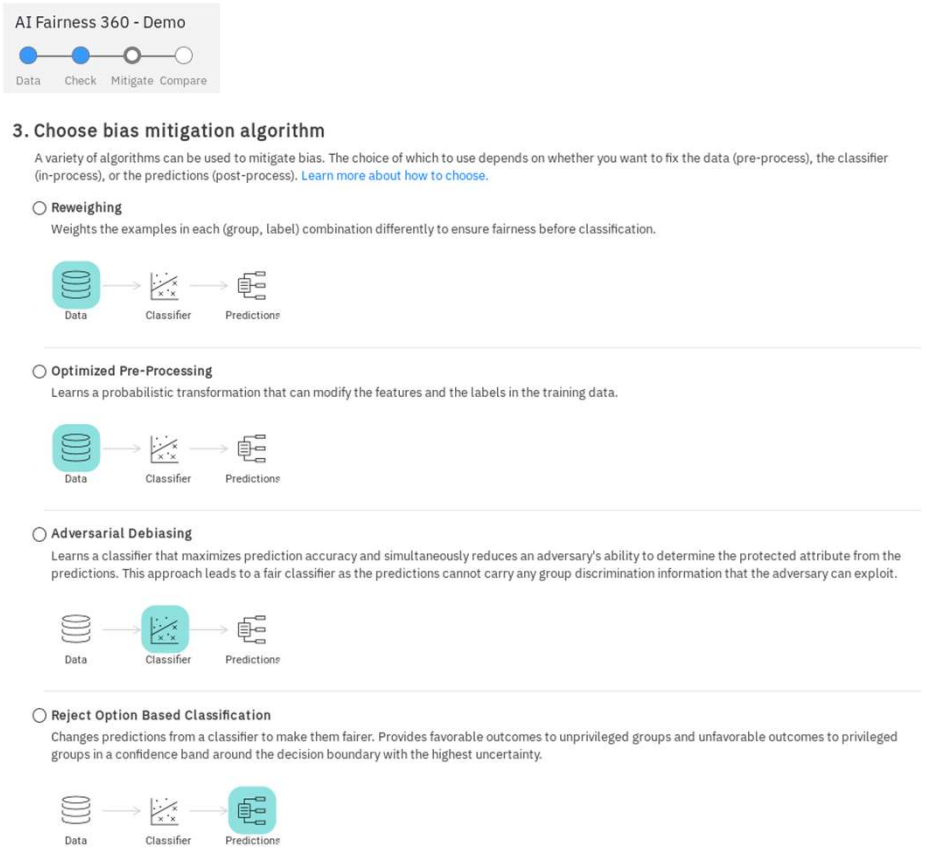
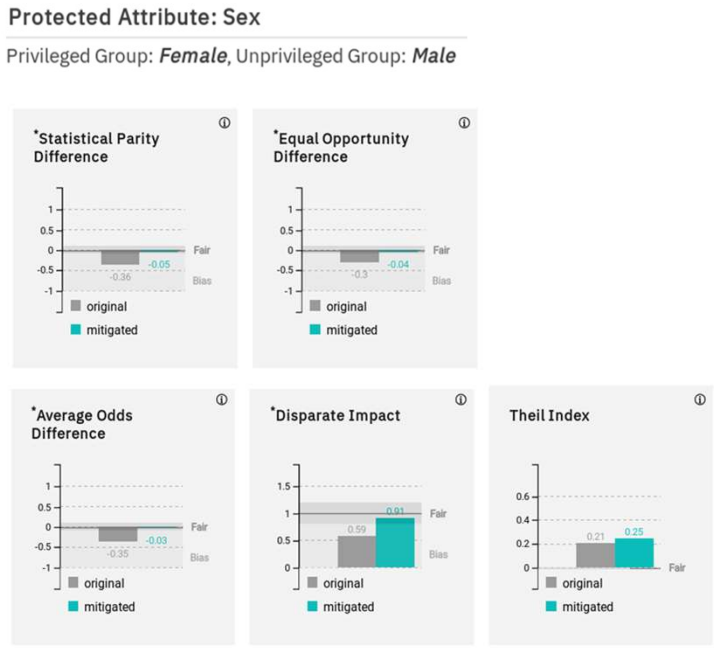
Open-source toolkit for bias detection and mitigation





https://aif360.mybluemix.net

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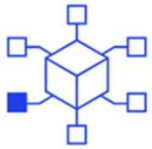
Six ways forward

1



Be aware of contexts in which AI can help correct for bias and those in which there is high risk for AI to exacerbate bias

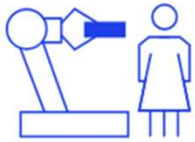
2

Establish processes and practices to test for and mitigate bias in AI systems

3

Engage in fact-based conversations about potential biases in human decisions

4



Fully explore how humans and machines can best work together

5

Invest more in bias research, make more data available for research (while respecting privacy), and adopt a multidisciplinary approach

6

Invest more in diversifying the AI field itself

source: https://www.mckinsey.com/featured-insights/artificial-intelligence/tackling-bias-in-artificial-intelligence-and-in-humans

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BSC and WBF unite to address Sex and Gender Bias in AI

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BSC and WBF unite to address Sex and Gender Bias in AI

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www.nature.com/npjdigitalmed

REVIEW ARTICLE OPEN

Check for updates

Sex and gender differences and biases in artificial intelligence for biomedicine and healthcare

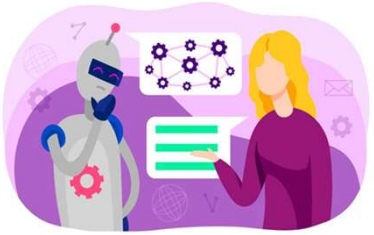
Davide Cirillo[1,10✉], Silvina Catuara-Solarz[2,3,10], Czuee Morey[3,4], Emre Guney[5], Laia Subirats[6,7], Simona Mellino[3], Annalisa Gigante[3], Alfonso Valencia[1,8], María José Rementeria[1], Antonella Santuccione Chadha[3] and Nikolaos Mavridis[3,9]

Precision Medicine implies a deep understanding of inter-individual differences in health and disease that are due to genetic and environmental factors. To acquire such understanding there is a need for the implementation of different types of technologies based on artificial intelligence (AI) that enable the identification of biomedically relevant patterns, facilitating progress towards individually tailored preventative and therapeutic interventions. Despite the significant scientific advances achieved so far, most of the currently used biomedical AI technologies do not account for bias detection. Furthermore, the design of the majority of algorithms ignore the sex and gender dimension and its contribution to health and disease differences among individuals. Failure in accounting for these differences will generate sub-optimal results and produce mistakes as well as discriminatory outcomes. In this review we examine the current sex and gender gaps in a subset of biomedical technologies used in relation to Precision Medicine. In addition, we provide recommendations to optimize their utilization to improve the global health and disease landscape and decrease inequalities.

npj Digital Medicine (2020)3:81 ; https://doi.org/10.1038/s41746-020-0288-5

Big Data Analytics

NLP



Robotics

Digital medicine

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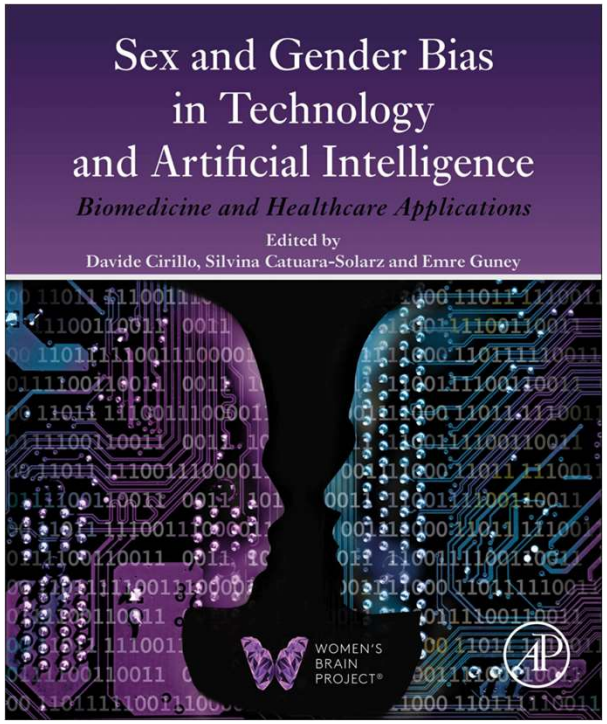
BSC and WBF unite to address Sex and Gender Bias in AI



ISBN: 9780128213926

ELSEVIER

"It's a must read for anyone working in this area; the materials presented here should be integrated into medical school curricula."

Londa Schiebinger
John L. Hinds Professor of History of Science, Stanford University
Founding director, Gendered Innovations in Science, Health & Medicine, Engineering, and Environment

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BSC and WBF unite to address Sex and Gender Bias in AI

EPMA Journal (2022) 13:299–313
https://doi.org/10.1007/s13167-022-00284-3

RESEARCH

Digital biomarkers and sex impacts in Alzheimer's disease management — potential utility for innovative 3P medicine approach

Robbert L. Harms[1] · Alberto Ferrari[2] · Irene B. Meier[3] · Julie Martinkova[2,4] · Enrico Santus[2,5] · Nicola Marino[2,6] · Davide Cirillo[2,7] · Simona Mellino[2] · Silvina Catuara Solarz[2] · Ioannis Tarnanas[1,8] · Cassandra Szoeke[2,9] · Jakub Hort[4,10] · Alfonso Valencia[7,11] · Maria Teresa Ferretti[2] · Azizi Seixas[12] · Antonella Santuccione Chadha[2]

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frontiers | Frontiers in Global Women's Health

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PUBLISHED 06 September 2023
DOI 10.3389/fgwh.2023.970312

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Raising awareness of sex and gender bias in artificial intelligence and health

Nataly Buslón[1]*, Atia Cortés[1], Silvina Catuara-Solarz[2], Davide Cirillo[1] and Maria José Rementeria[1]*

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Article | Open access | Published: 14 January 2021

Simulating SARS-CoV-2 epidemics by region-specific variables and modeling contact tracing app containment

Alberto Ferrari, Enrico Santus, Davide Cirillo, Miguel Ponce-de-Leon, Nicola Marino, Maria Teresa Ferretti, Antonella Santuccione Chadha, Nikolaos Mavridis & Alfonso Valencia

npj Digital Medicine **4**, Article number: 9 (2021) | Cite this article

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WEBSCI

Abortion and Miscarriage on Twitter: Sentiment and Polarity Analysis from a gendered perspective

Authors: Olivier Philippe, María Flores Rodero, Claire Yohalem Furtick, Laura Planas Simón, Maria Teresa Ferretti, Antonella Santuccione Chadha, Laia Subirats Maté, Davide Cirillo, María José Rementeria

(Less) Authors Info & Claims

WEBSCI '24: Proceedings of the 16th ACM Web Science Conference • May 2024 • Pages 311–319 • https://doi.org/10.1145/3614419.3644010

Artificial Intelligence–Aided Precision Medicine for COVID-19: Strategic Areas of Research and Development

Enrico Santus[1, 2]; Nicola Marino[2, 3]; Davide Cirillo[2, 4]; Emmanuele Chersoni[5]; Arnau Montagud[4]; Antonella Santuccione Chadha[2, 6]; Alfonso Valencia[4, 7]; Kevin Hughes[8]; Charlotta Lindvall[9, 10]

uthors | Cited by (22) | Tweetations (36) | Metrics

Abstract

Artificial intelligence (AI) technologies can play a key role in preventing, detecting, and monitoring epidemics. In this paper, we provide an overview of the recently published literature on the COVID-19 pandemic in four strategic areas: (1) triage, diagnosis, and risk prediction; (2) drug repurposing and development; (3) pharmacogenomics and vaccines; and (4) mining of the medical literature. We highlight how AI-powered health care can enable public health systems to efficiently handle future outbreaks and improve patient outcomes.

J Med Internet Res 2021;23(3):e22453

doi:10.2196/22453

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The way AHEAD

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Centro Nacional de Supercomputación

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Funded by the European Union

AHEAD

AI for Health: Evaluation of Applications & Datasets

MARIE SKŁODOWSKA-CURIE ACTIONS

Staff Exchanges (SE)

Coordinated by BSC
Kicking off in January 2025

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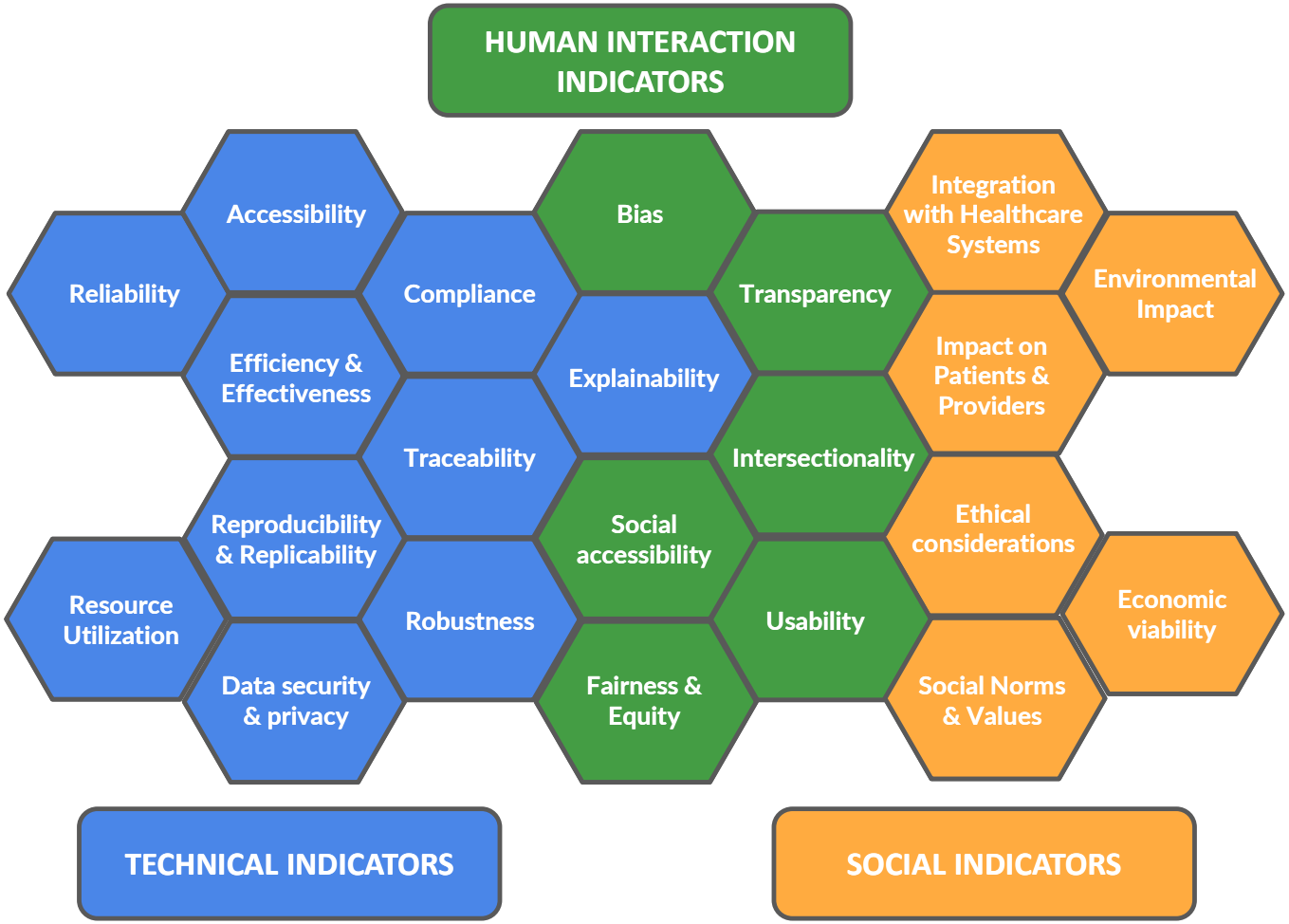
The way AHEAD



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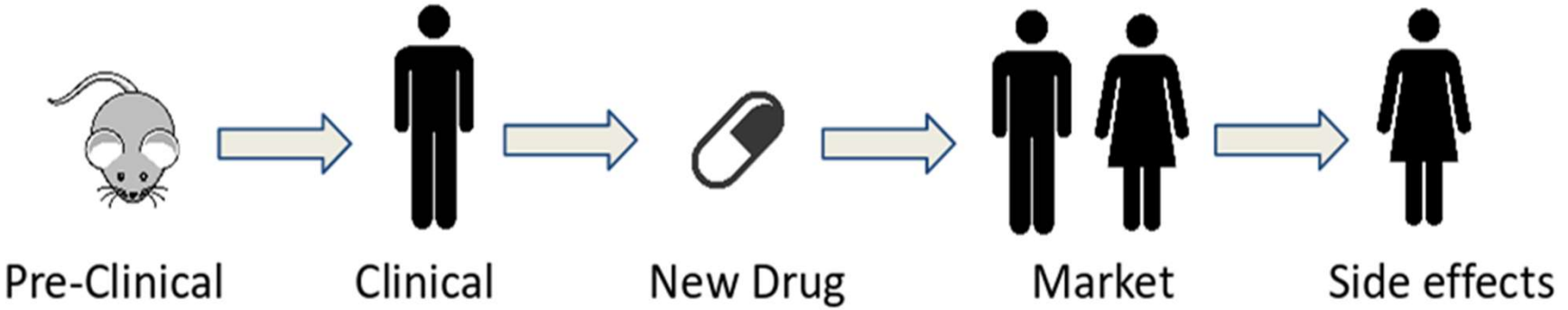
Data production and bias propagation



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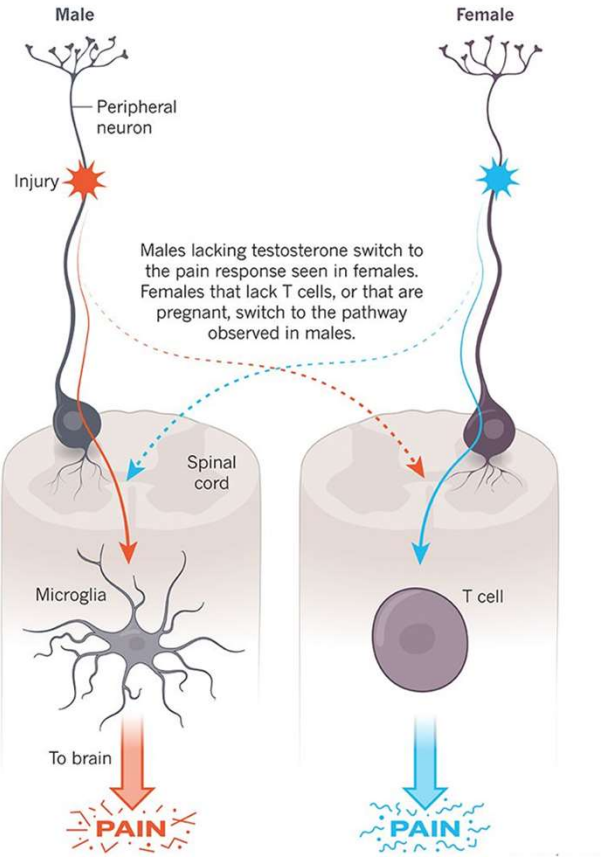
Example: Pain Mechanism



Sorge et al. *Nature Neuroscience* (2015)

- Different immune cells—microglia in males and T cells in females—mediate **mechanical pain hypersensitivity** in mice.
- Deletion of the gene Arg1 in microglia reduced mechanical pain hypersensitivity in females but not males, indicating a crucial role for ARG1+ microglia in female pain processing.
- These results reveal significant sex differences in immune mechanisms involved in pain processing, emphasizing the **need to include sex as a biological variable in pain studies**, with implications for understanding sex-specific chronic pain conditions.

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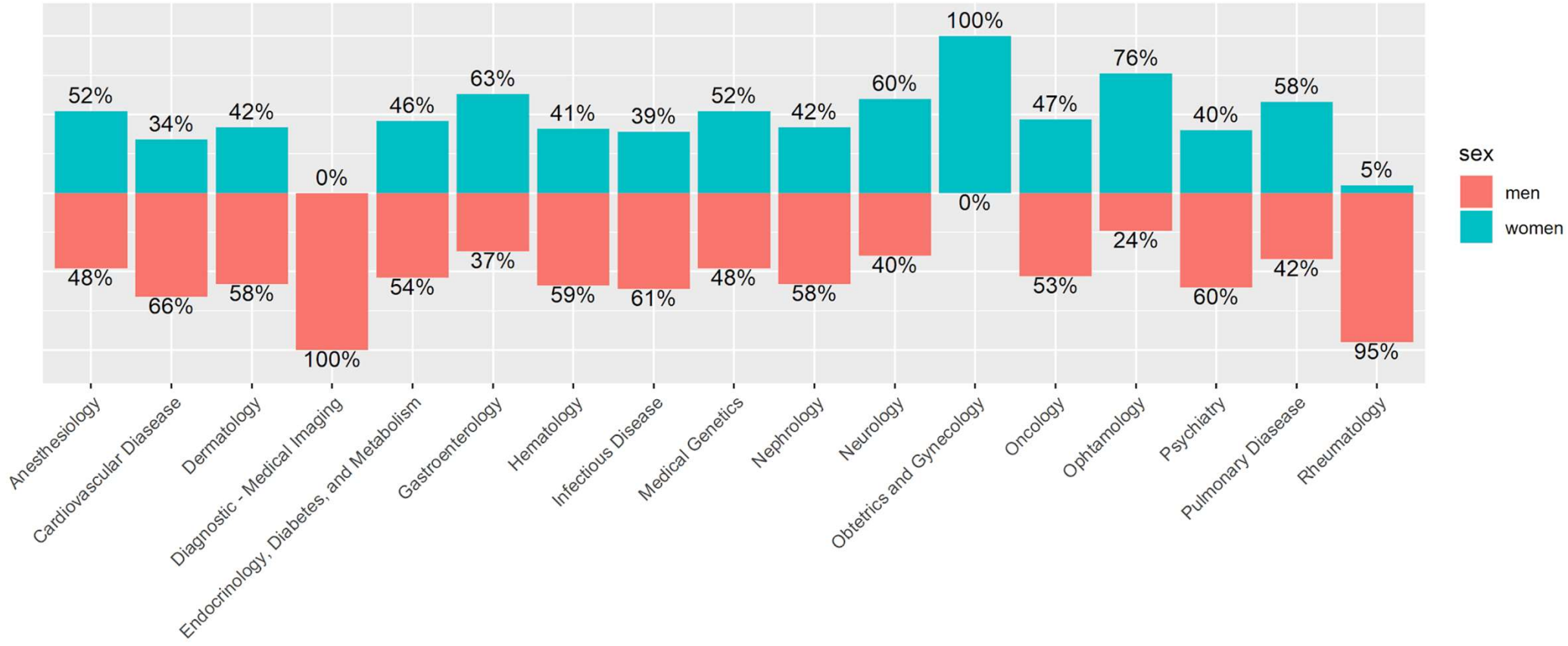
Clinical trials participation by therapeutic area

Trials for New Molecular Entities (NMEs) approved in 2015–2016

source: FDA & Office of Women's Health (OWH)



Adapted from Ayuso. *Cont Clin Trials* (2019)

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Table 3. Prescription drugs withdrawn from the US market (1997–2000).

Drug	Type of drug	Patient population	Primary health risk
Prescription drugs with evidence of greater health risks in women			
Pondimin®	Appetite suppressant	Women	Valvular heart disease
Redux®	Appetite suppressant	Women	Valvular heart disease
Rezulin®	Diabetic	Women	Liver failure
Lotronex®	Gastrointestinal	Women	Ischemic colitis
Seldane®	Antihistamine	Women and men	Torsades de Pointes
Posicor®	Cardiovascular	Women and men	Lowered heart rate in elderly women and adverse interactions with 26 other drugs
Hismanal®	Antihistamine	Women and men	Torsades de Pointes
Propulsid®	Gastrointestinal	Women and men	Torsades de Pointes
Prescription drugs without evidence of greater health risks in women			
Raxar®	Antibiotic	Women and men	Torsades de Pointes
Duract®	Analgesic and anesthetic	Women and men	Liver failure

Parekh et al. *Expert Rev. Clin. Pharmacol.* (2011)

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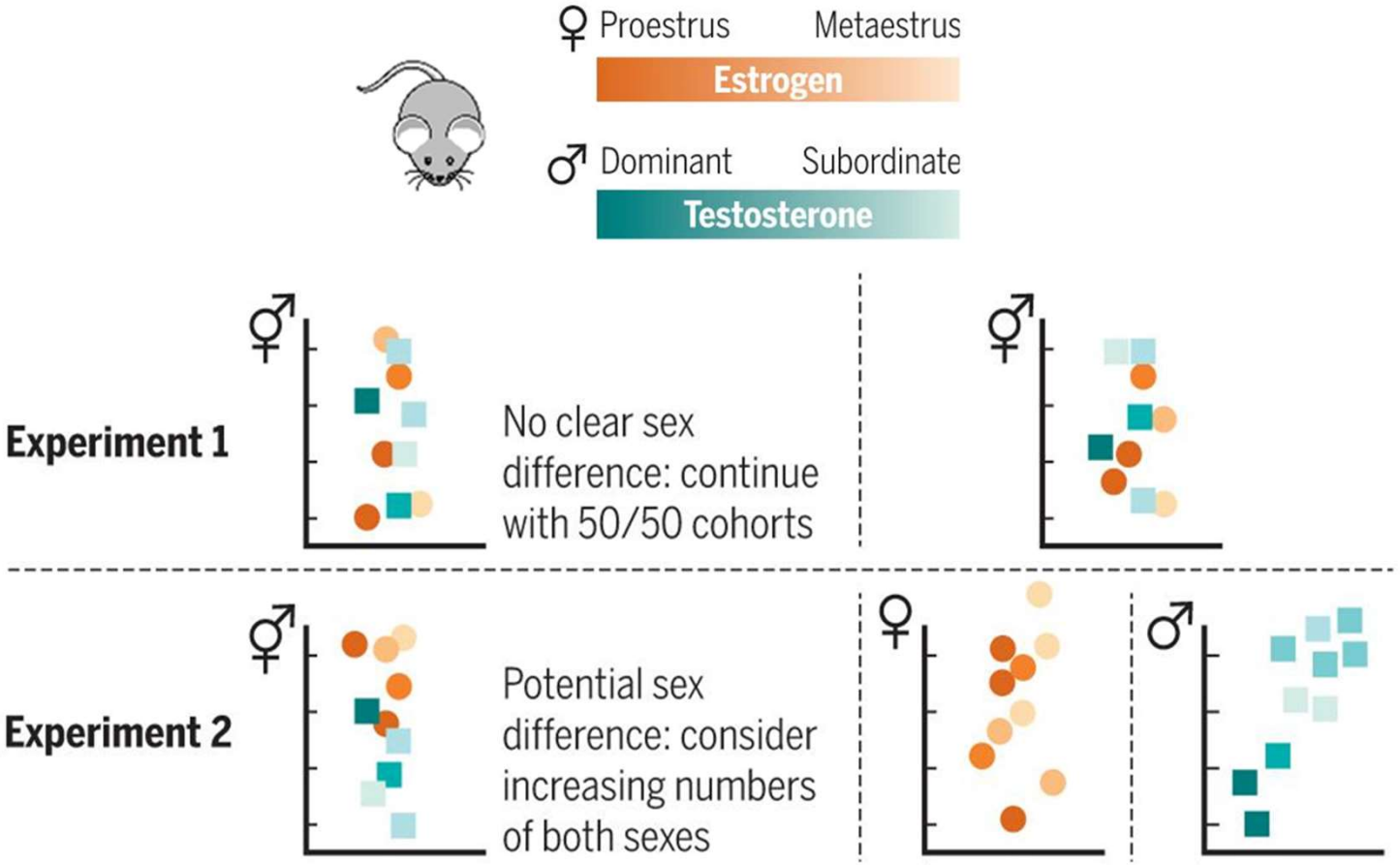
General recommendations for experimental design



Shansky. *Science* (2019)

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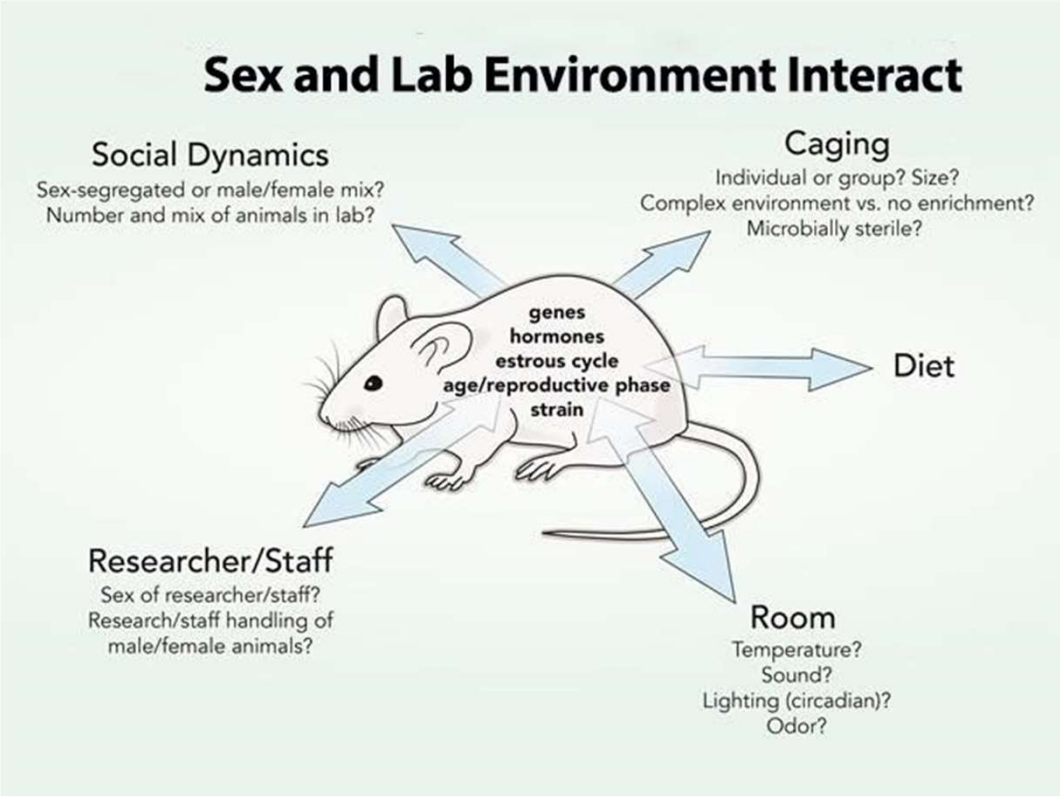
Interaction between sex, gender and environmental conditions



- **Experimenters** can be a confounding variable in rodent research where stress is an important factor.
- Environmental processes, such as caging practices or differential handling, may affect females and males differently.
- **Researchers should not identify an effect as dependent on sex (or a biological trait) when, in fact, it is dependent on an environmental condition.**

http://genderedinnovations.stanford.edu/case-studies/

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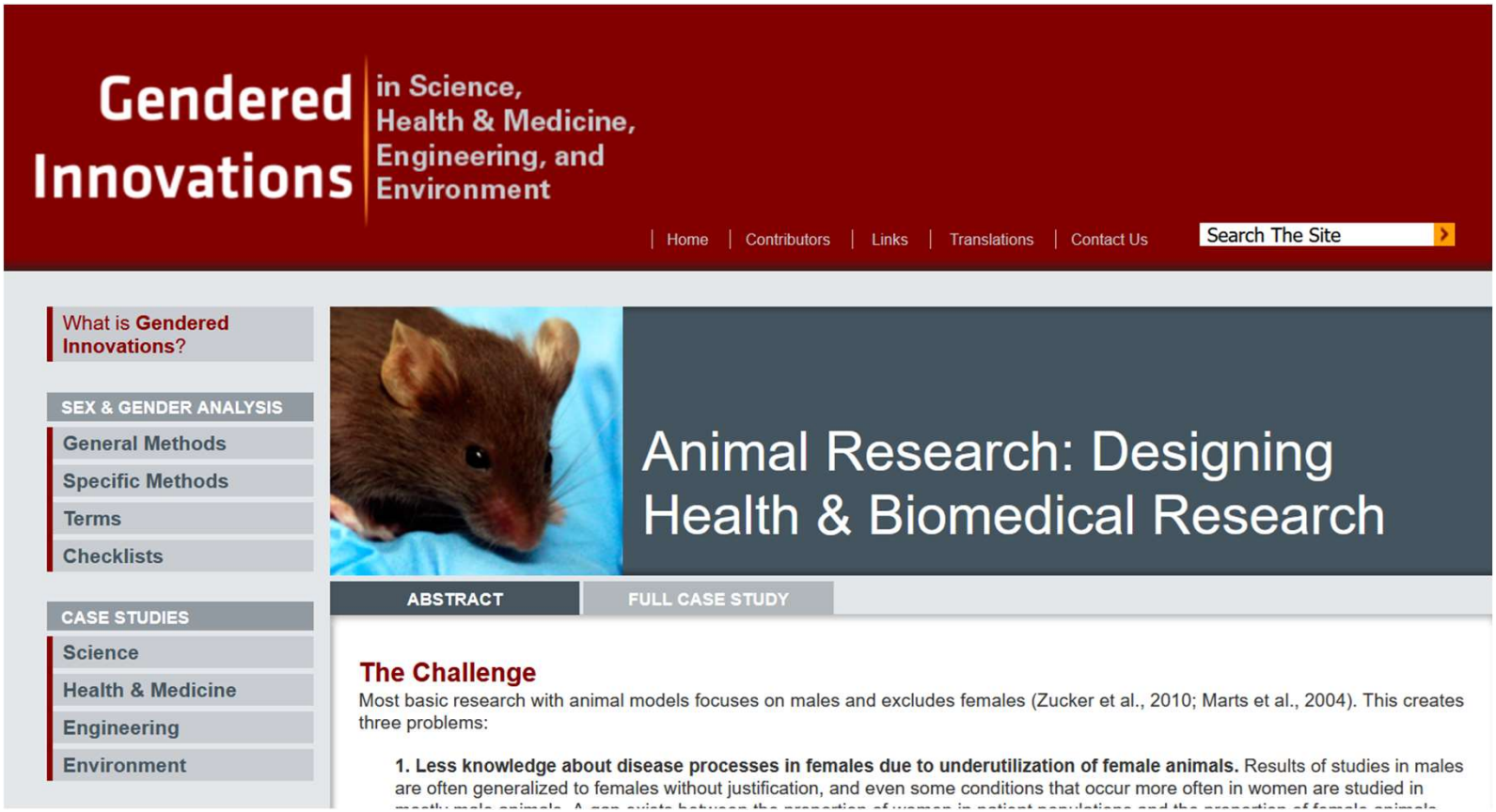
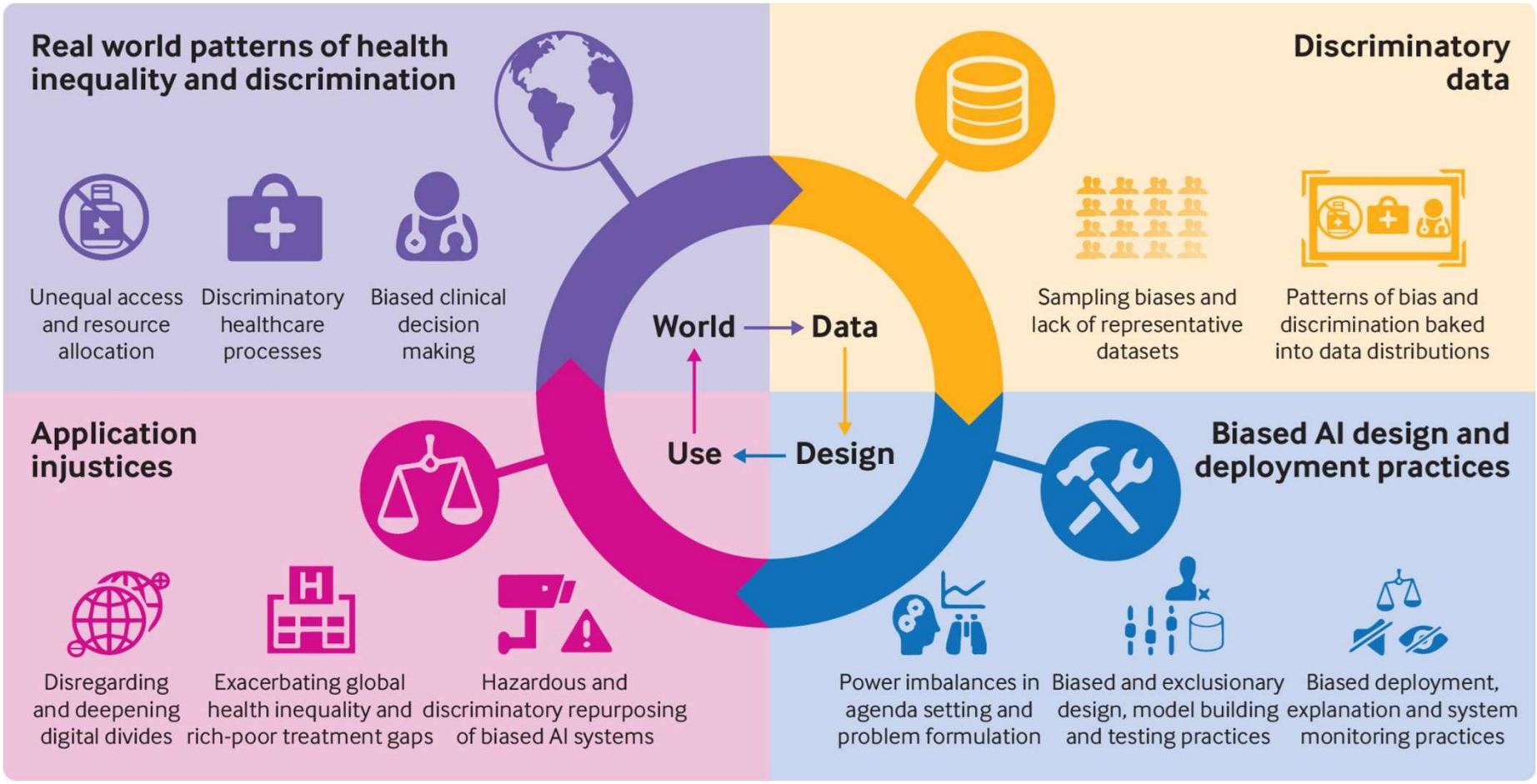
The case studies of Gendered Innovations



http://genderedinnovations.stanford.edu/case-studies/



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Main takeaways

- **Artificial Intelligence** is pervasive in our society, increasingly so in the health domain
- A **bias** is a systematic error that leads to a disadvantage for an individual or a group of people.
- **Sex and gender bias** in is particularly prominent in AI applications for health and it can emerge at all stages of the AI life cycle.
- **Solutions** to combat AI bias include
    - Implement processes to identify and reduce bias in AI systems with tools, strategies, and transparency.
    - Support AI bias research, enable privacy-respecting data access, and apply a multidisciplinary approach.
    - Promote diversity in AI to better address and prevent bias.

WOMEN's BRAIN Foundation

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Centro Nacional de Supercomputación

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Thank you!

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