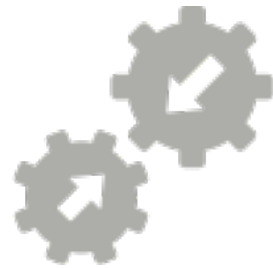


# Opportunity exists to reap social benefit in three strategic **engineering systems** focus areas



Multiscale  
Biomechanics



Mechanobiology

## **Engineering system:**

A constellation of technologies to maintain or restore the biomechanical form and function of our system testbeds



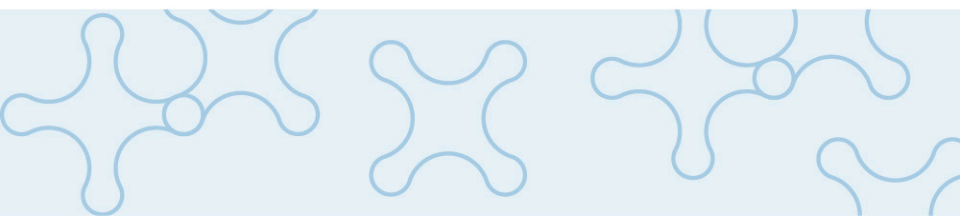
**Preterm birth**



**Pelvic floor disorders**



**Healthy aging**





# Preterm Birth Systems Testbed

Kristin Myers, Columbia University  
Michelle Oyen, Washington University in St. Louis

# Our Team Spans Disciplines & Schools



**Kristin Myers, CU**

Mechanical Engineering,  
Mechanics of Soft Tissues,  
Preterm Birth, Hydrated  
Biomaterials



**Christine O'Brien,  
WUSTL**

Radiology, Raman  
Spectroscopy, Maternal  
Hemorrhage, Wearable  
Devices



**Christine Hendon, CU**

Electrical Engineering,  
Imaging, Cardiac  
Electrophysiology



**Christine King, UCI**

Biomedical Engineering,  
Engineering Education,  
Health Systems



**Elisa Konofagou, CU**

Biomedical Engineering,  
Radiology, Ultrasound  
Imaging, Elasticity  
Imaging, Soft Tissue  
Biomechanics



**Arnold Advincula, CU**

OB/GYN, Gynecologic  
Health & Procedures



**Michelle Oyen, WUSTL**

Biomedical Engineering, Material  
Science, Mechanobiology of  
Implantation, Fetal Membrane  
Mechanics



**Itsik Pe'er, CU**

Computer Science,  
Computational Methods in  
Germline Human Genetics



**Joy-Sarah Vink, CU**

OB/GYN, Preterm Birth  
Prevention



**Yong Wang, WUSTL**

Biomedical Engineering  
OB/GYN, Preterm Birth  
Prevention



**Ronald Wapner, CU**

OB/GYN, Fetal Genetic  
Testing

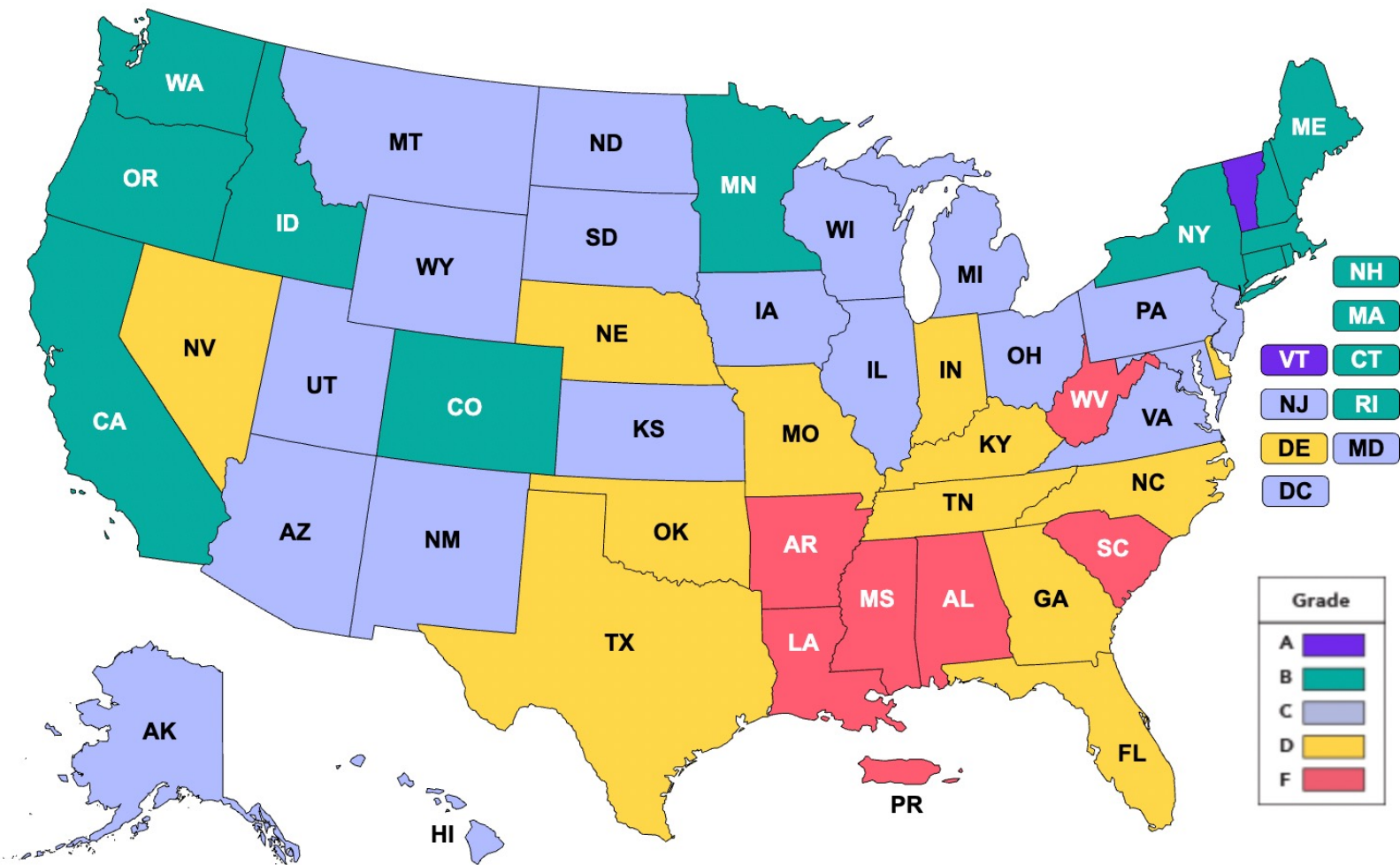


**Harry West, CU**

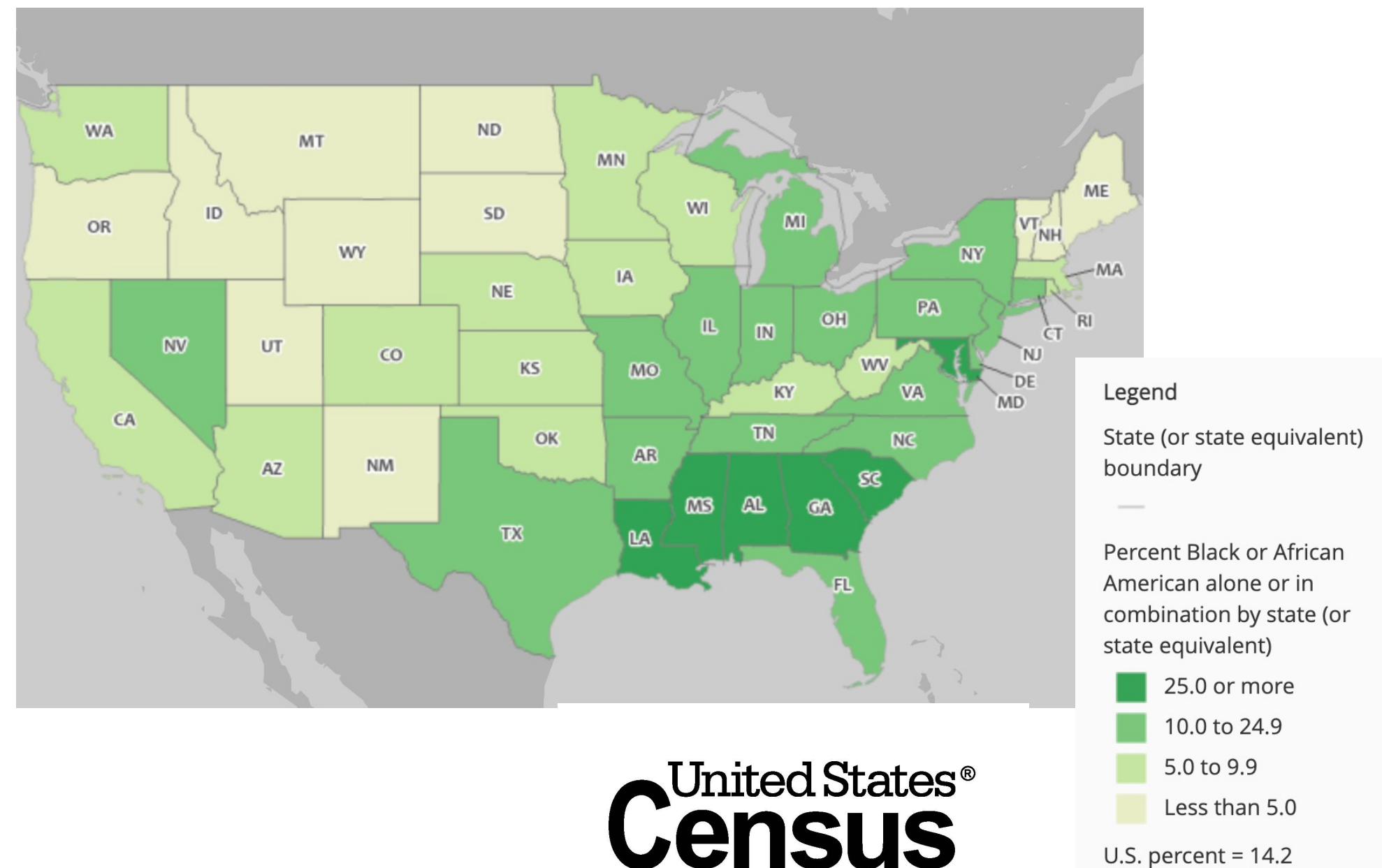
Mechanical Engineering,  
Industrial Engineering and  
Operations Research, Product  
Design Methodology, Service  
and Experience Design

# Preterm birth affects 10% of pregnancies and is geographically variable within the US

Preterm Birth Report Card 2021



Percent of Black or African American alone or in combination 2020



© 2012 March of Dimes Foundation

<https://www.marchofdimes.org/mission/reportcard.aspx>  
<https://www.census.gov/library/visualizations/2021/geo/demographicmapviewer.html>

United States®  
**Census**  
**2020**

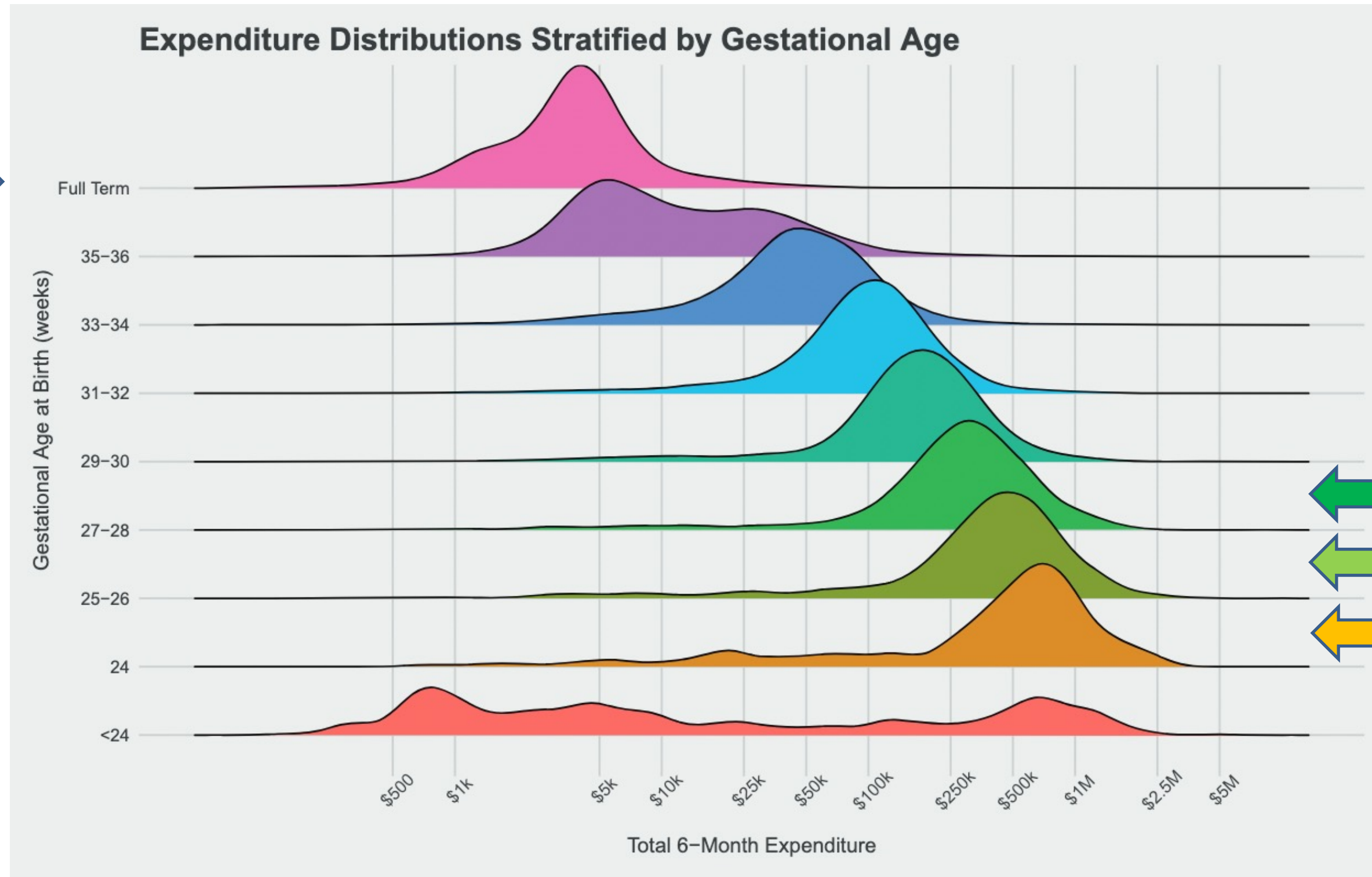
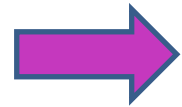
# IMWEL rises to the call of action from congress



- The **Black Maternal Health Momnibus Act** of 2021
  - Twelve individual bills
  - Black Maternal Health Caucus
- The **Tech to Save Moms Act**
  - Promote the integration and development of telehealth and other digital tools
  - Reduce maternal mortality and severe maternal morbidity
  - Close racial and ethnic gaps in maternal health outcomes.

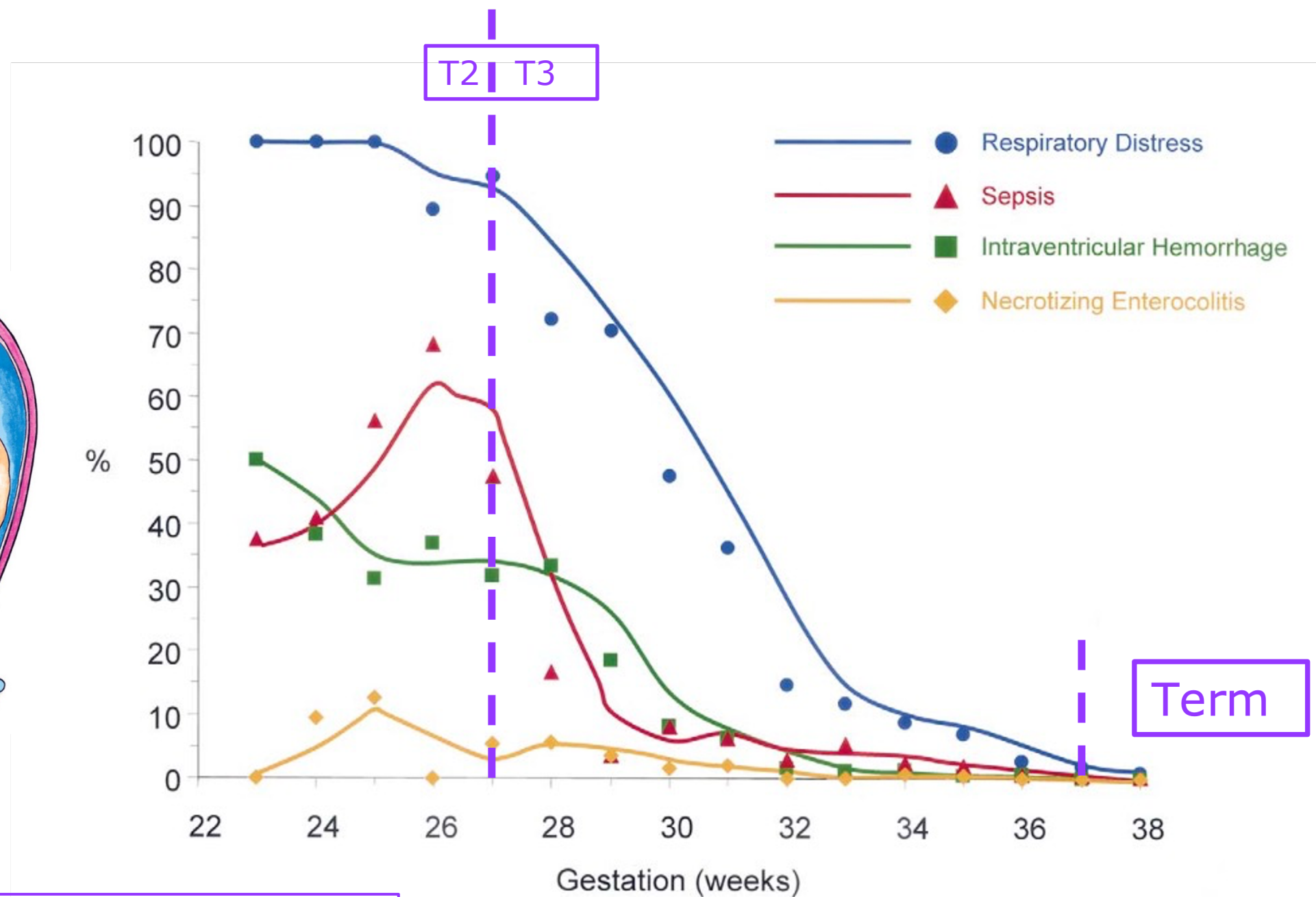
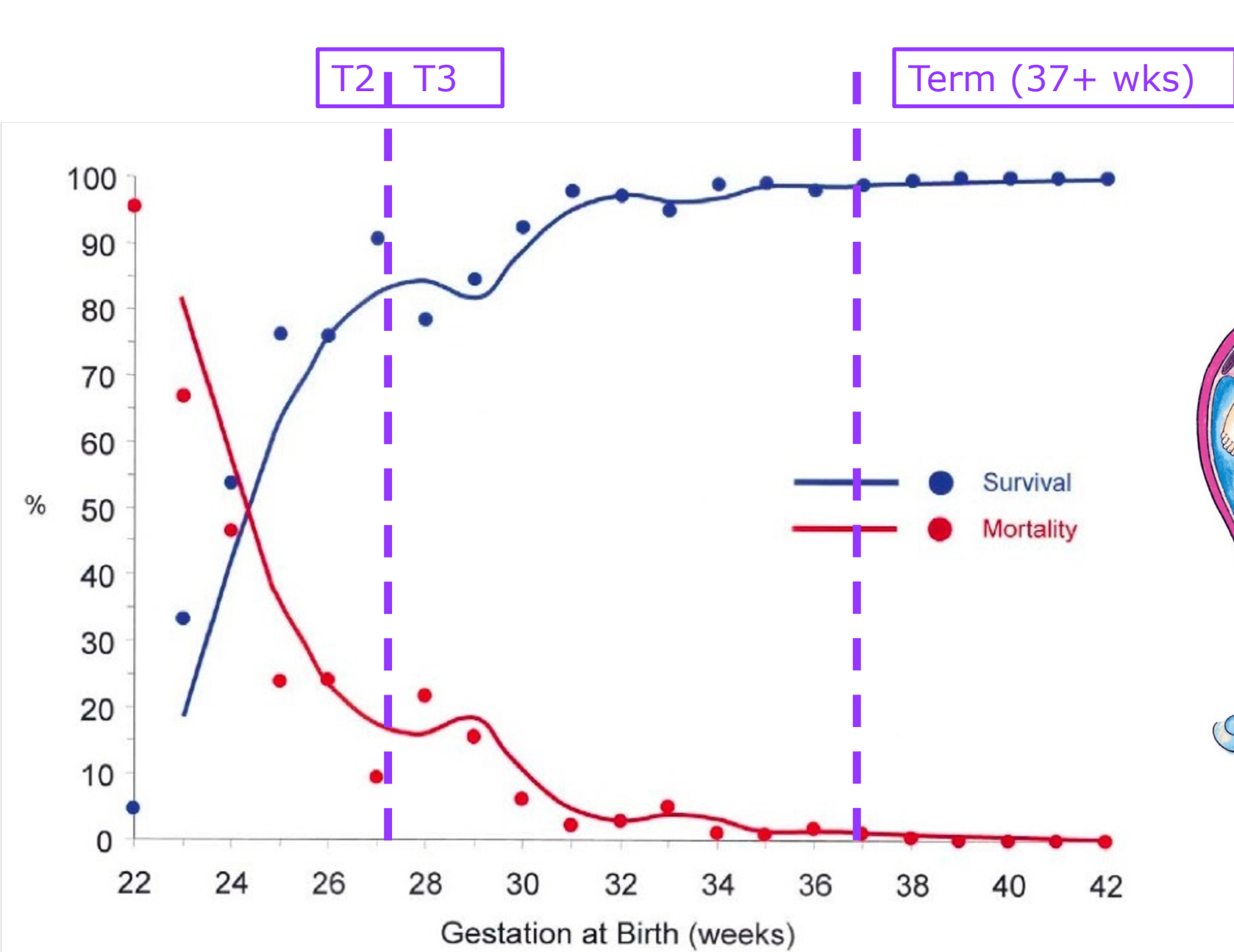
# Preterm birth costs skyrocket for second trimester

Term birth insurance expenditures average \$5k



Preterm birth at 24-28 weeks GA Insurance expenditures average \$500k-\$1 million

# Preterm Birth increases both mortality and morbidity



27 weeks GA:

- ~20% mortality
- near 100% morbidity

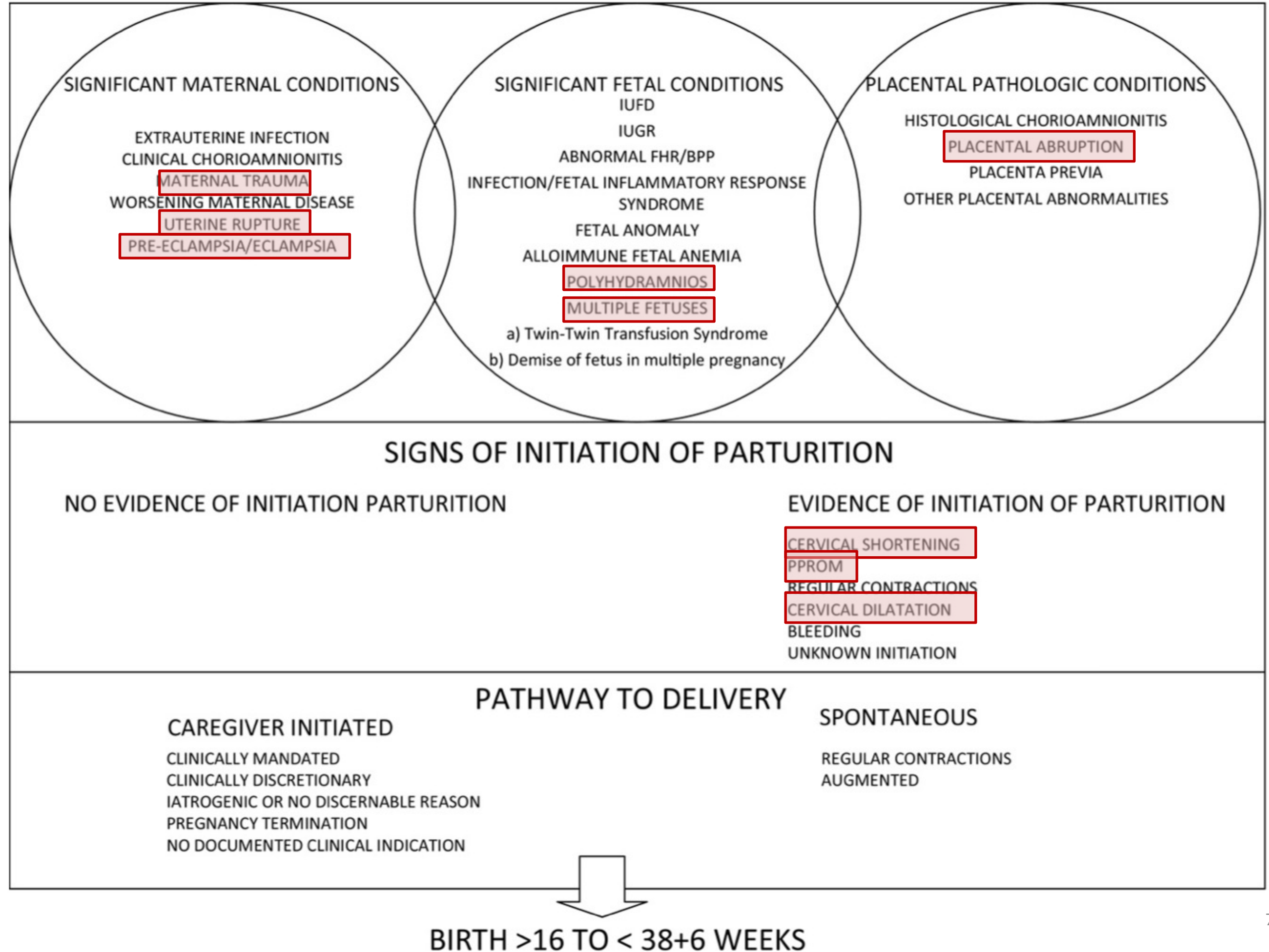
# Preterm Birth has multiple & overlapping etiologies

## Preterm birth with an apparent mechanical factor:

- Maternal
- Fetal
- Placental
- Birth-Related

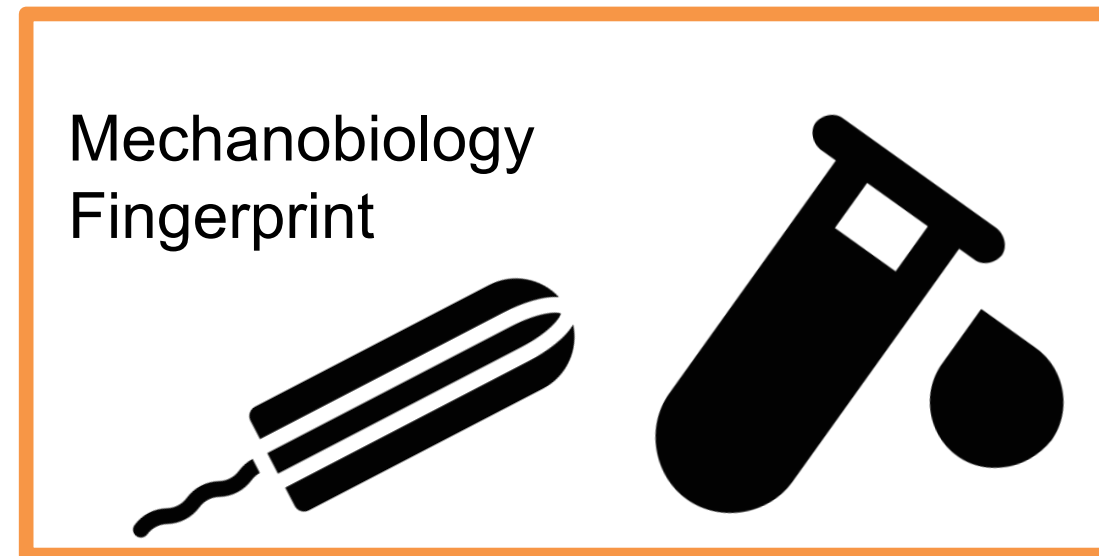
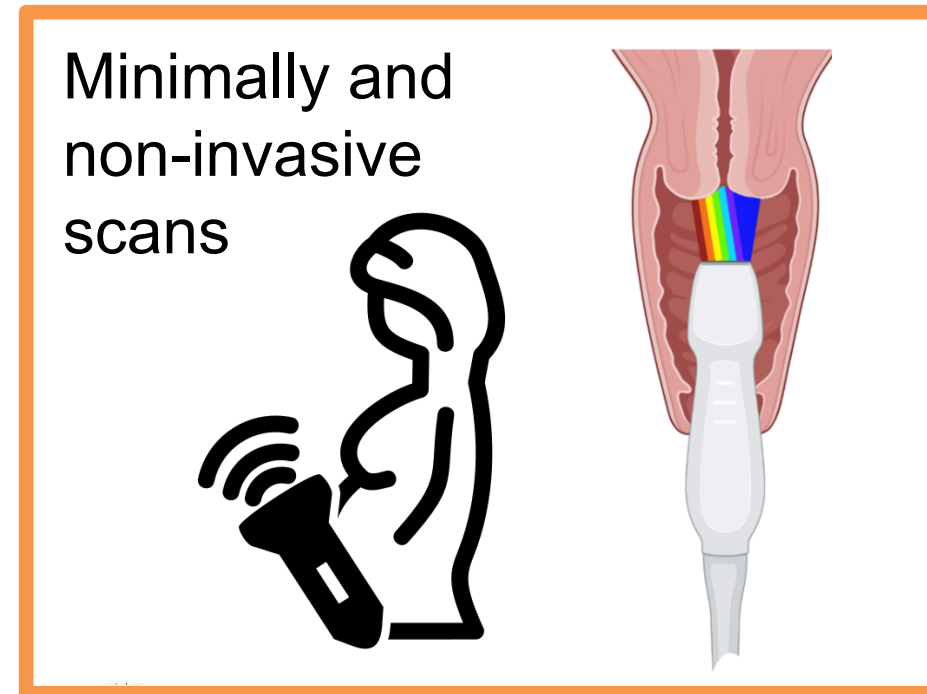
Obstet Gynecol. 2014 Jun;123(6):1201-1206

**FIGURE**  
Phenotypic components of the preterm birth syndrome

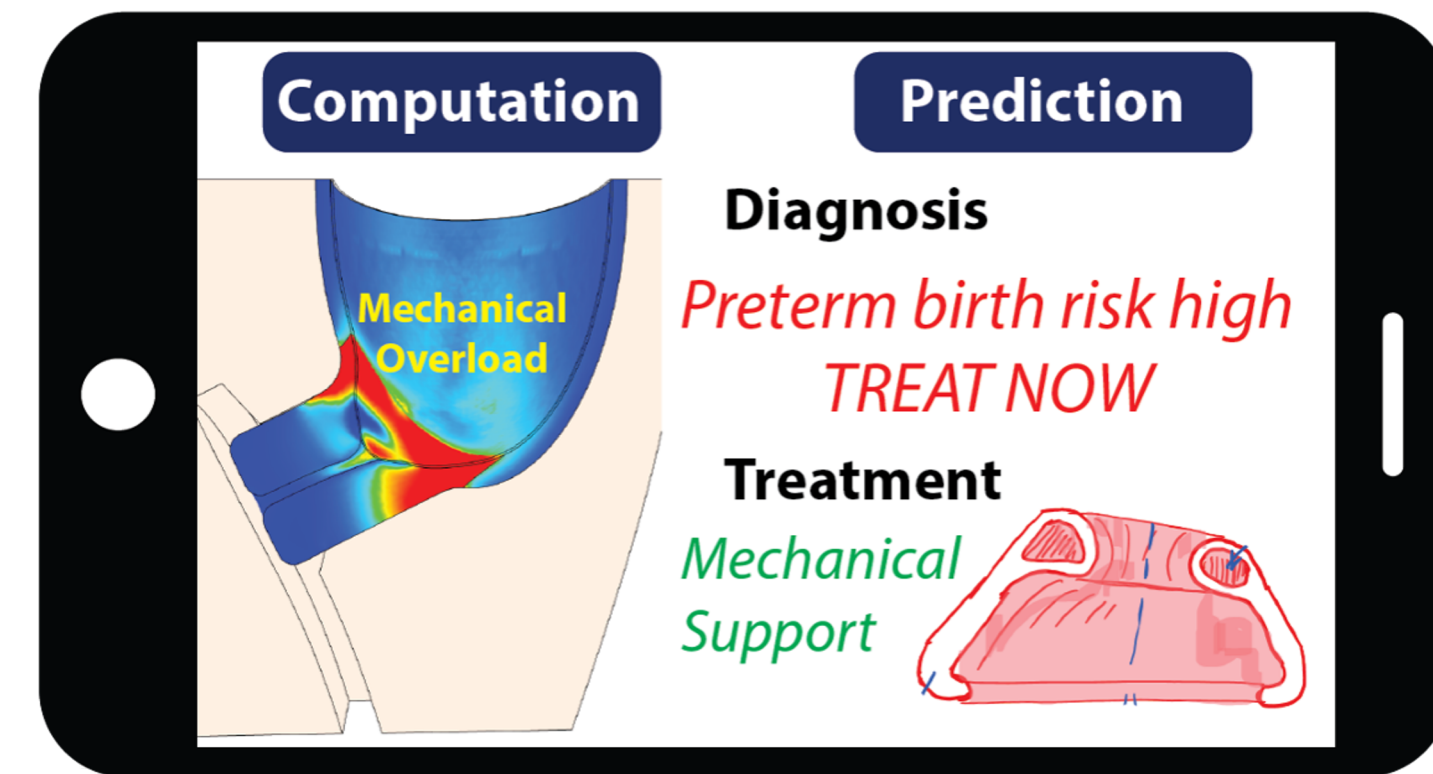


# A preterm birth risk assessment tool to alert action can be built with a mechanics-based approach

- Given:**  
patient-specific metrics
- Evaluate:**  
tissue loading and remodeling
- Identify:**  
clinical biomarkers
- Investigate:**  
personalized clinical solutions
- Improve:**  
maternal and fetal health



Patient + Caregiver Partnership



# Example: A preterm birth risk assessment tool to alert action can be built with a mechanics-based approach

**Given:**  
patient-specific metrics

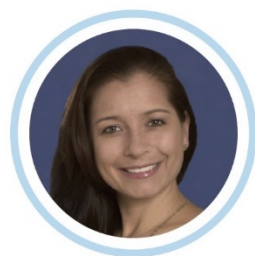
**Evaluate:**  
tissue loading

**Identify:**  
clinical biomarkers

Engineering, medicine, &  
industry partnership



Kristin Myers,  
CU




Joy Vink,  
CU

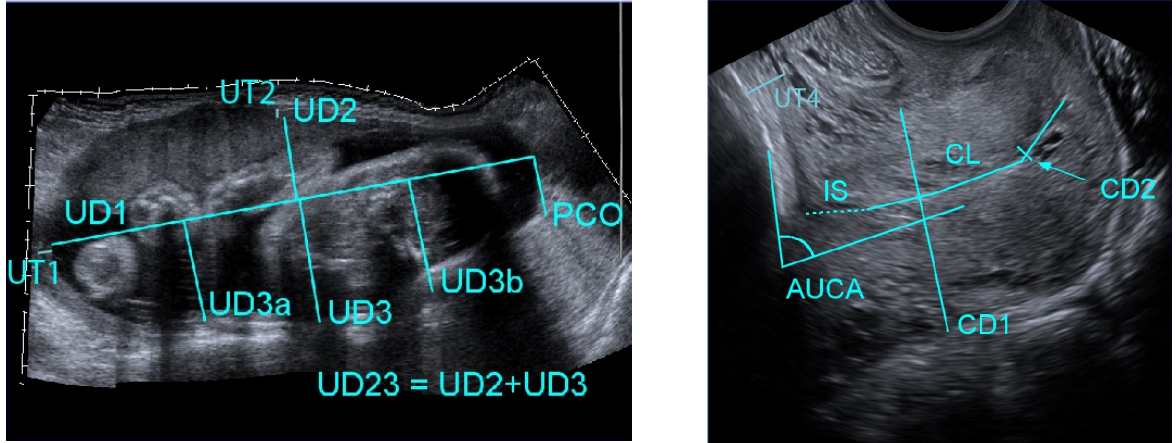


Sabrina Badir,  
Pregnolia AG

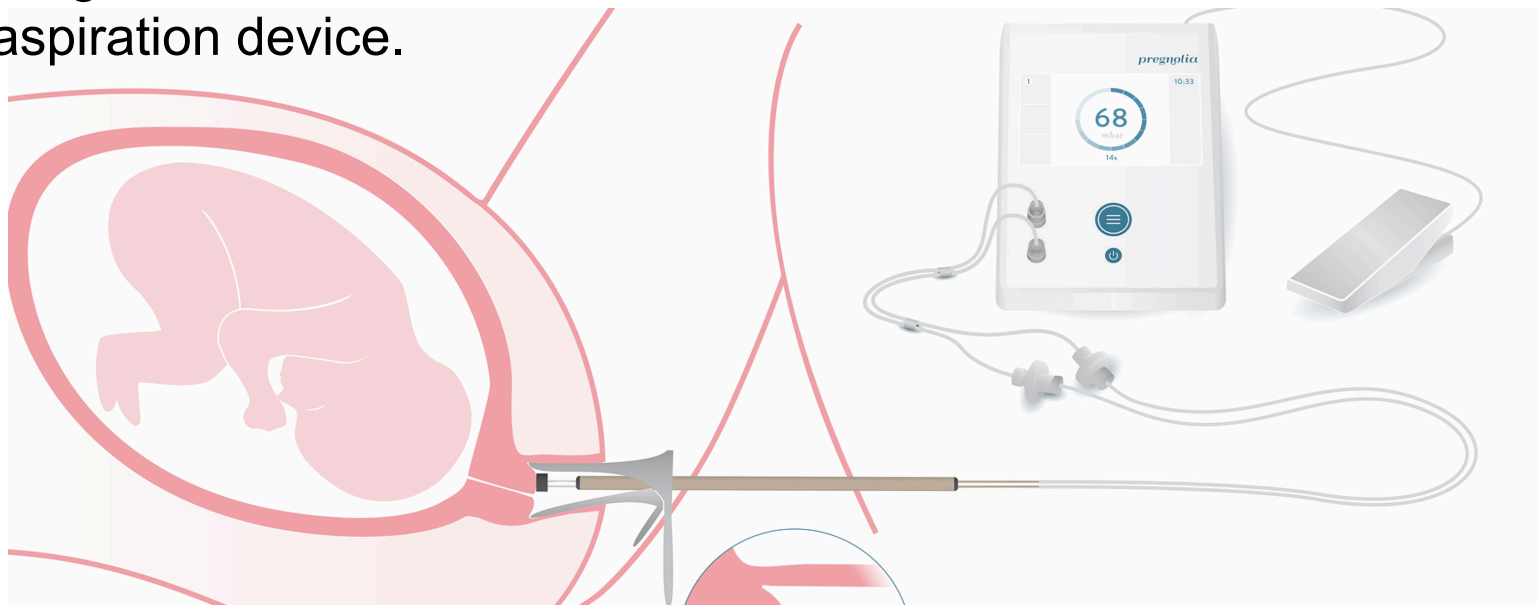
Minimally and non-invasive scans

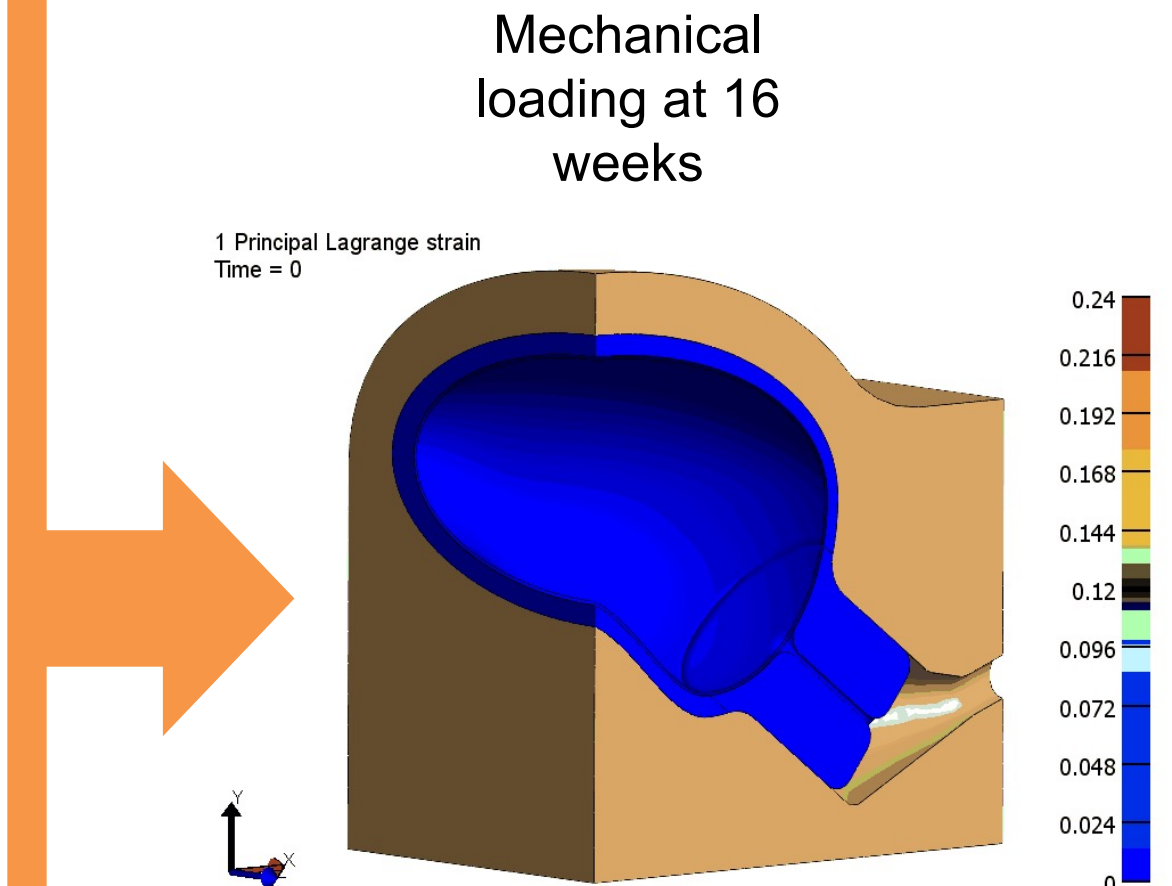


Ultrasonic maternal anatomy scan

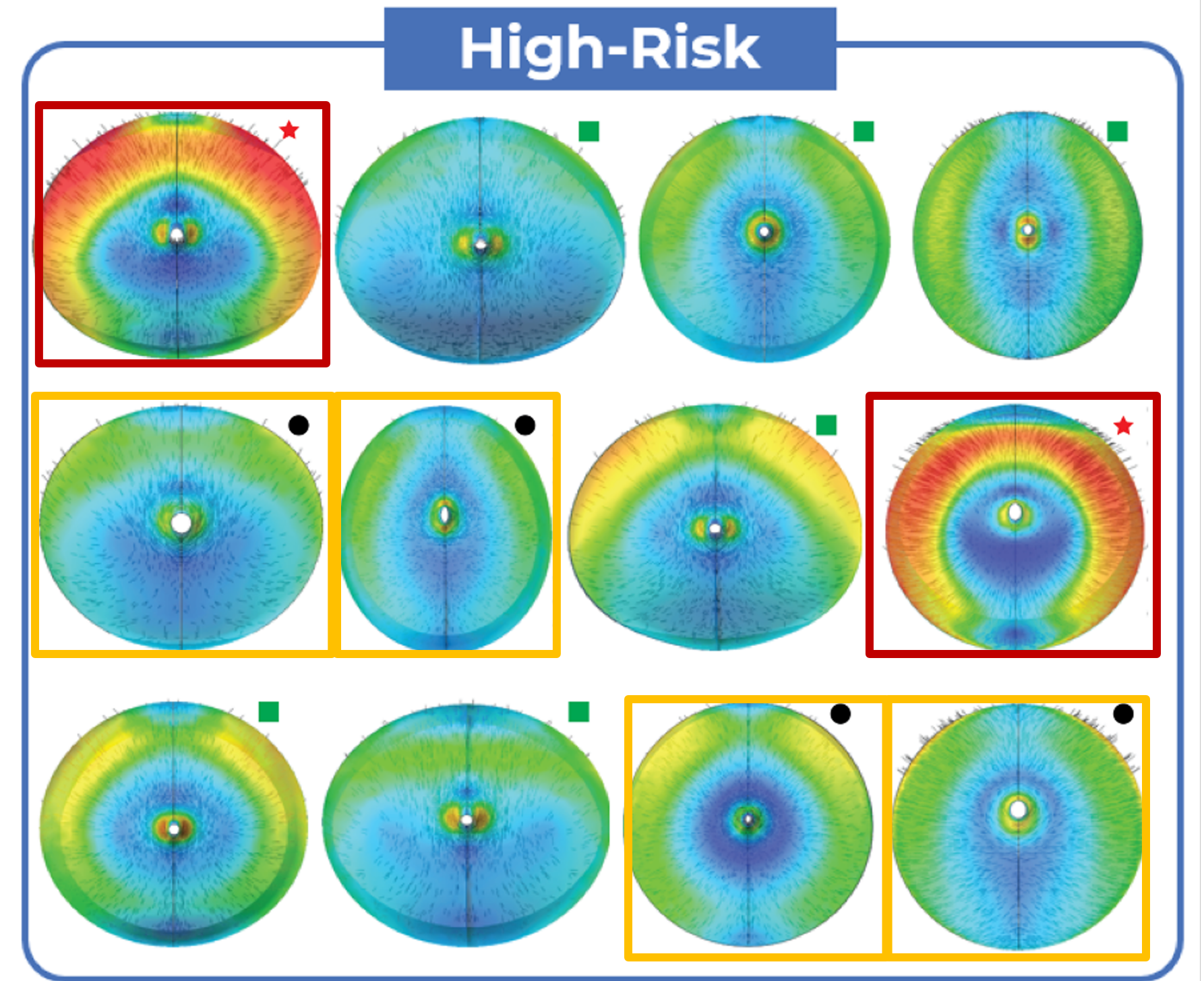
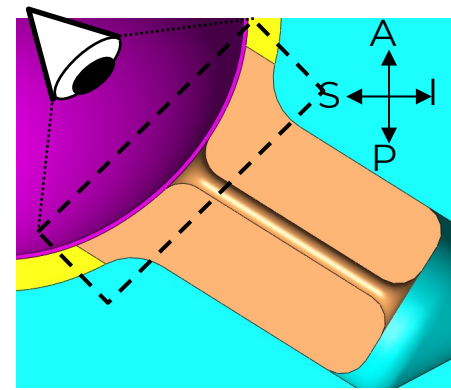
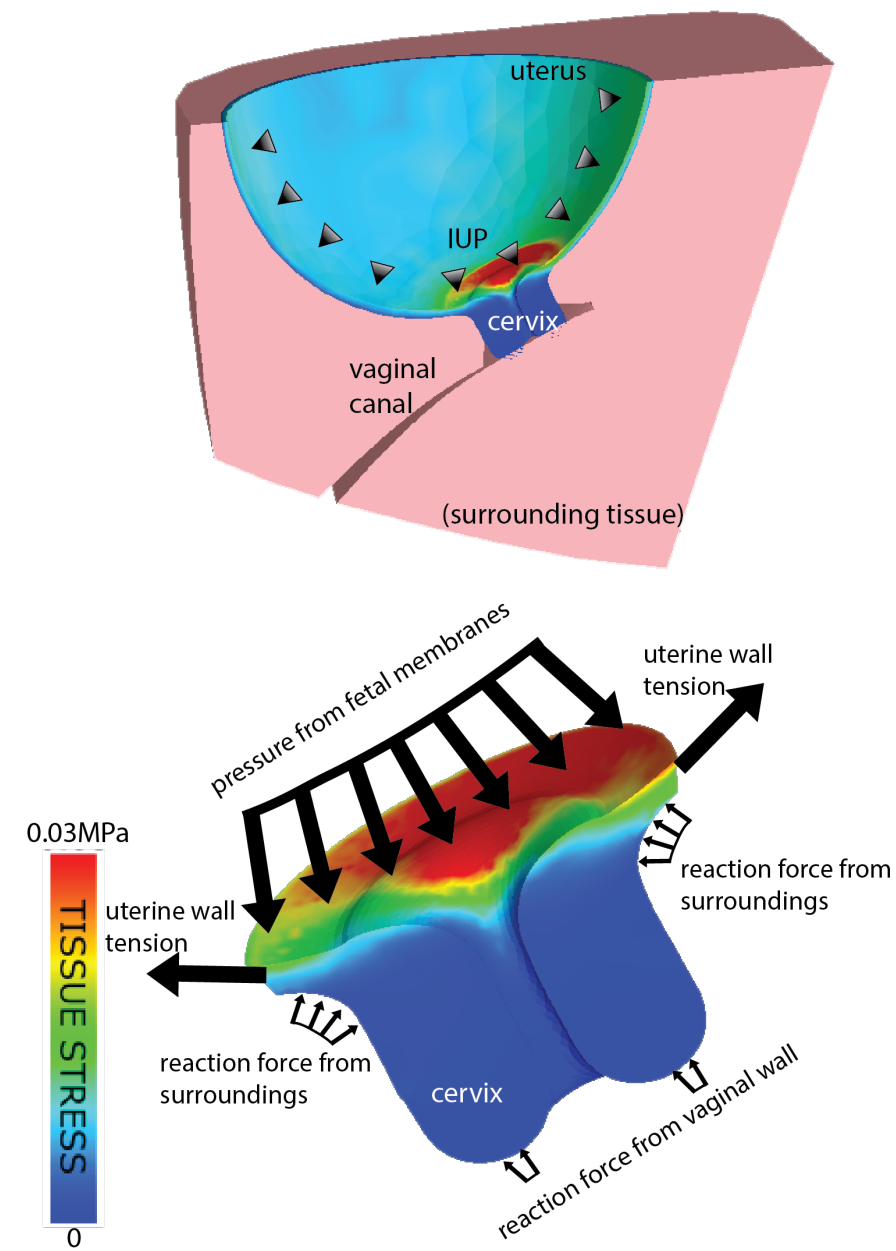


Pregnolia cervical aspiration device.





# Example: Patient-specific cervical stiffness and load pattern predicts preterm birth better than clinical gold standard



Anatomy and material stiffness

+

Cervical loading simulation

=

Improved risk assessment

# A preterm birth risk assessment tool to alert action can be built with a mechanics-based approach

**Given:**  
patient-specific metrics

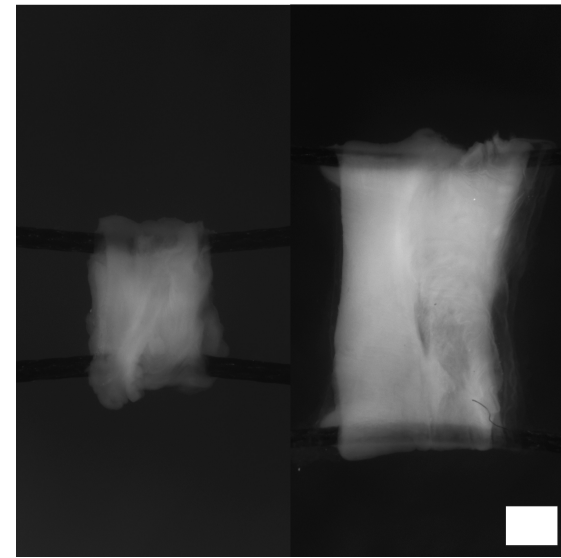
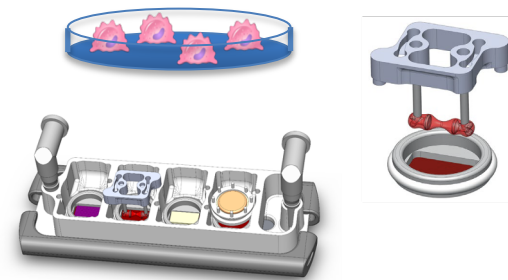
**Evaluate:**  
tissue loading and remodeling

**Identify:**  
clinical biomarkers

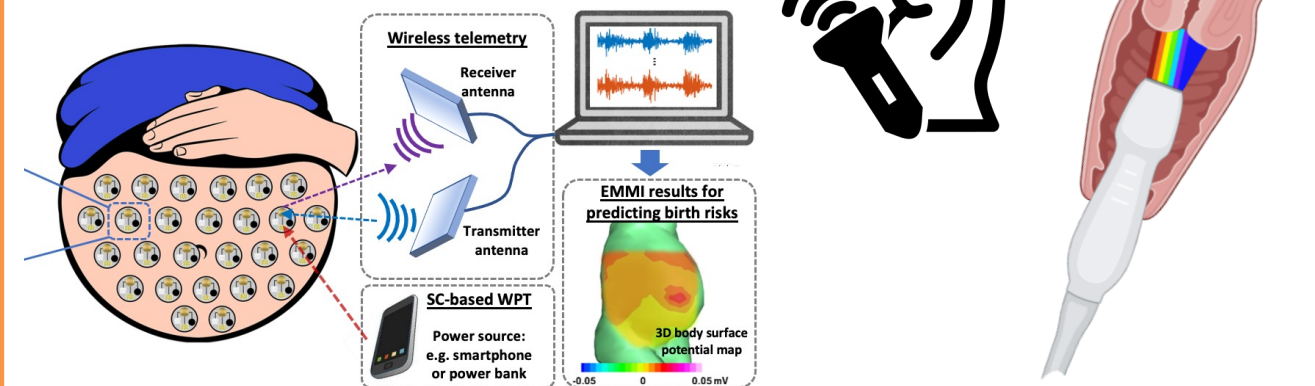
**Investigate:**  
personalized clinical solutions

**Improve:**  
maternal and fetal health

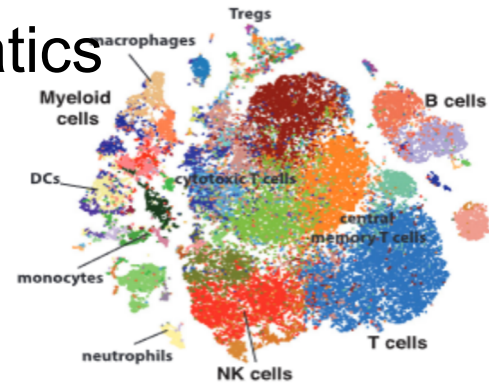
Biomechanics +  
Mechanobiology +  
Mechano-organs



Clinically  
Deployable Tools

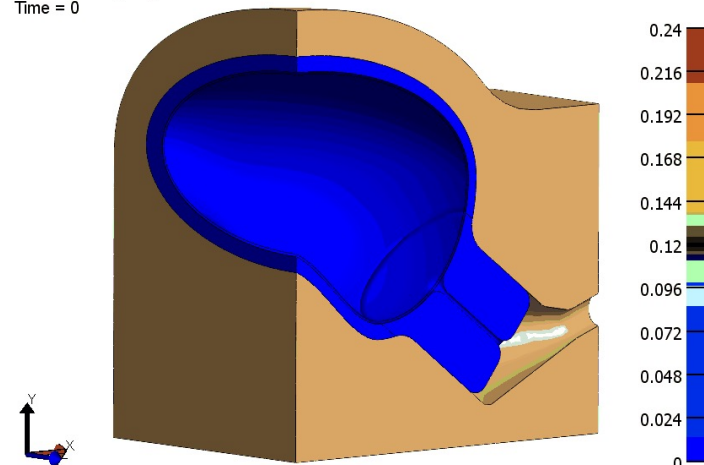


Mechanomics +  
Bioinformatics

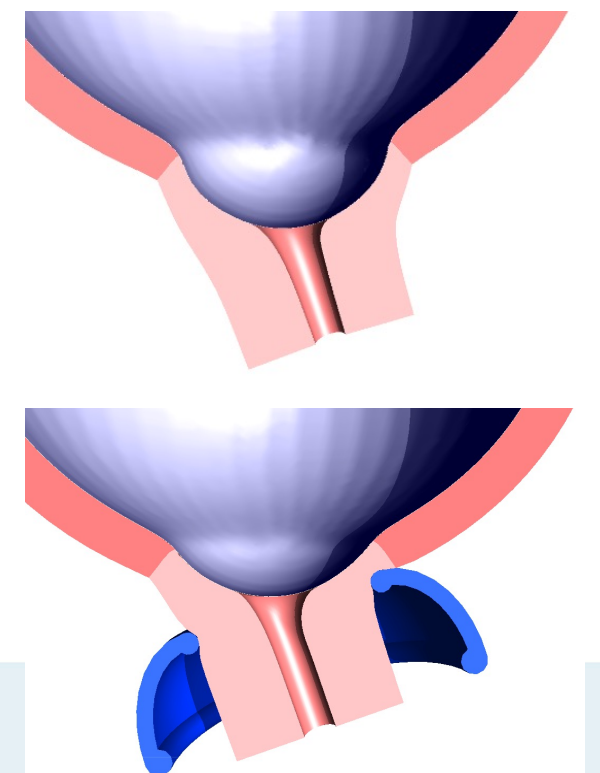
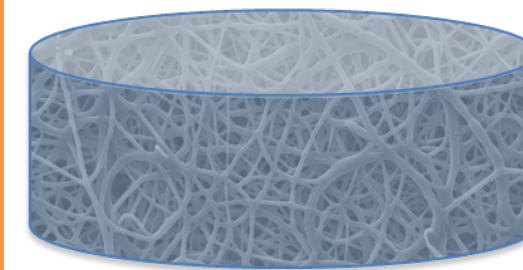


Multiscale  
Simulations

1 Principal Lagrange strain  
Time = 0



Biomechanical  
device design &  
therapeutic drug  
target

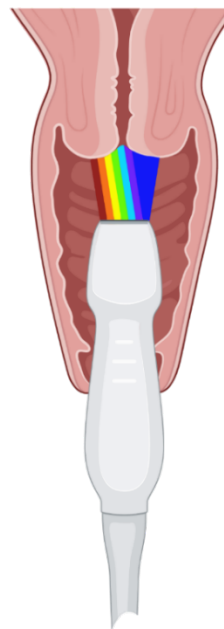


# Changing the Clinical Paradigm

## YEARS 1-2

- Work with Research and Tech leads to exchange information
- Work with clinical and industry partners to initiate human studies on viable monitoring tools
- Work with community and innovation boards to guide device development and to find unmet needs

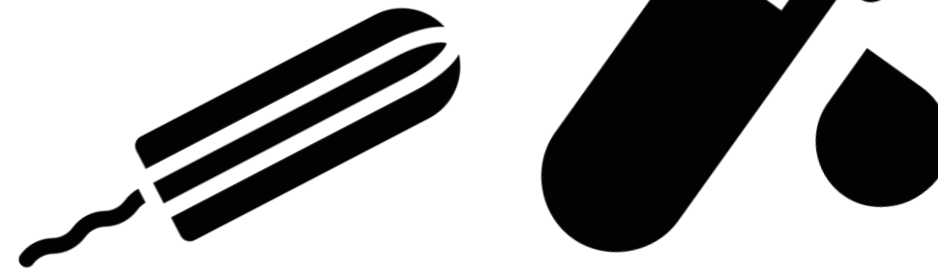
Minimally and non-invasive scans



## YEARS 3-5

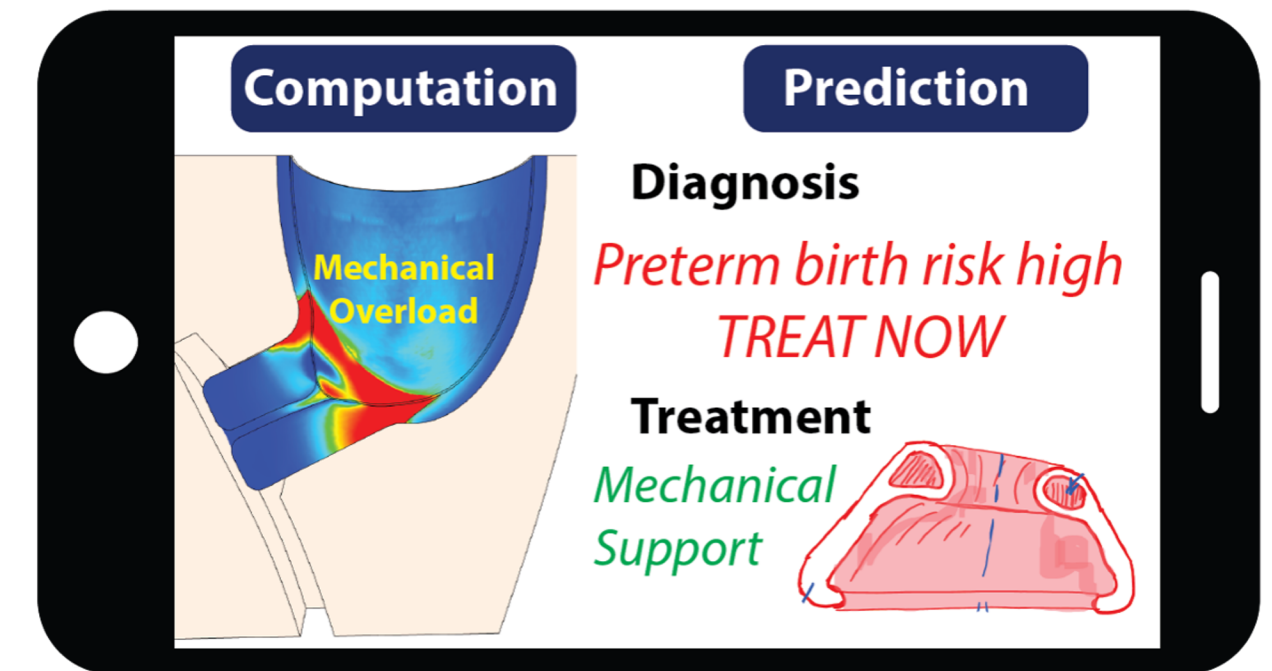
- Integrate biomechanics, mechanobiology, & bioinformatics in computational modeling to understand tissue remodeling and loading
- Validate cross-platform ex vivo systems and computational models
- Develop biomedical devices and/or therapeutic targets to restore maternal and fetal health using ex vivo systems and computational tools.

Mechanobiology  
Fingerprint



## YEARS 5-10

- Work with industry, clinical and community partners
  - Develop preterm birth alert systems to fit within accessible and modern obstetric care
  - Test therapeutics drug targets to restore and maintain the health of pregnancy



# Preterm Birth is an Impactful Systems Testbed

Affects 10% of all pregnancies

Significant long-term consequences for both mother and baby



Huge opportunities for wearable devices and other engineered innovations for intervention



13

## Societal impact in:

- Decreasing racial disparities
- Improving preemie outcomes
- Reducing medical costs