WAYNE STATE UNIVERSITY

CLEAR
Center for Leadership in Environmental Awareness and Research

SRP Multiproject Center Grants

Research Across Disciplines Webinar Series

Session IV

Chemical Exposures Across the Life Course

Funded by a grant from

NIH National Institute of Environmental Health Sciences
Superfund Research Program

Grant Number P42ES030991

CLEAR Presenters • 2023 SRP Progress in Research Webinar

Mike Petriello
Introduction to Detroit, CLEAR, and innovative research

Brendan O'Leary
Innovative sensing and remediation technologies

Tracie Baker
Bridging mechanistic, epidemiological, and community engaged research

The National Institute of Environmental Health Sciences Superfund Research Program at
Wayne State University

CLEAR Center for Leadership in Environmental Awareness and Research

Principal Investigators / MPIs

Melissa Runge-Morris, MD
Director,
Institute of Environmental Health Sciences;
Professor, Oncology

Carol J. Miller, PhD, PE
Professor,
Civil and Environmental Engineering

Why is a Superfund Center critical for the citizens of Detroit?

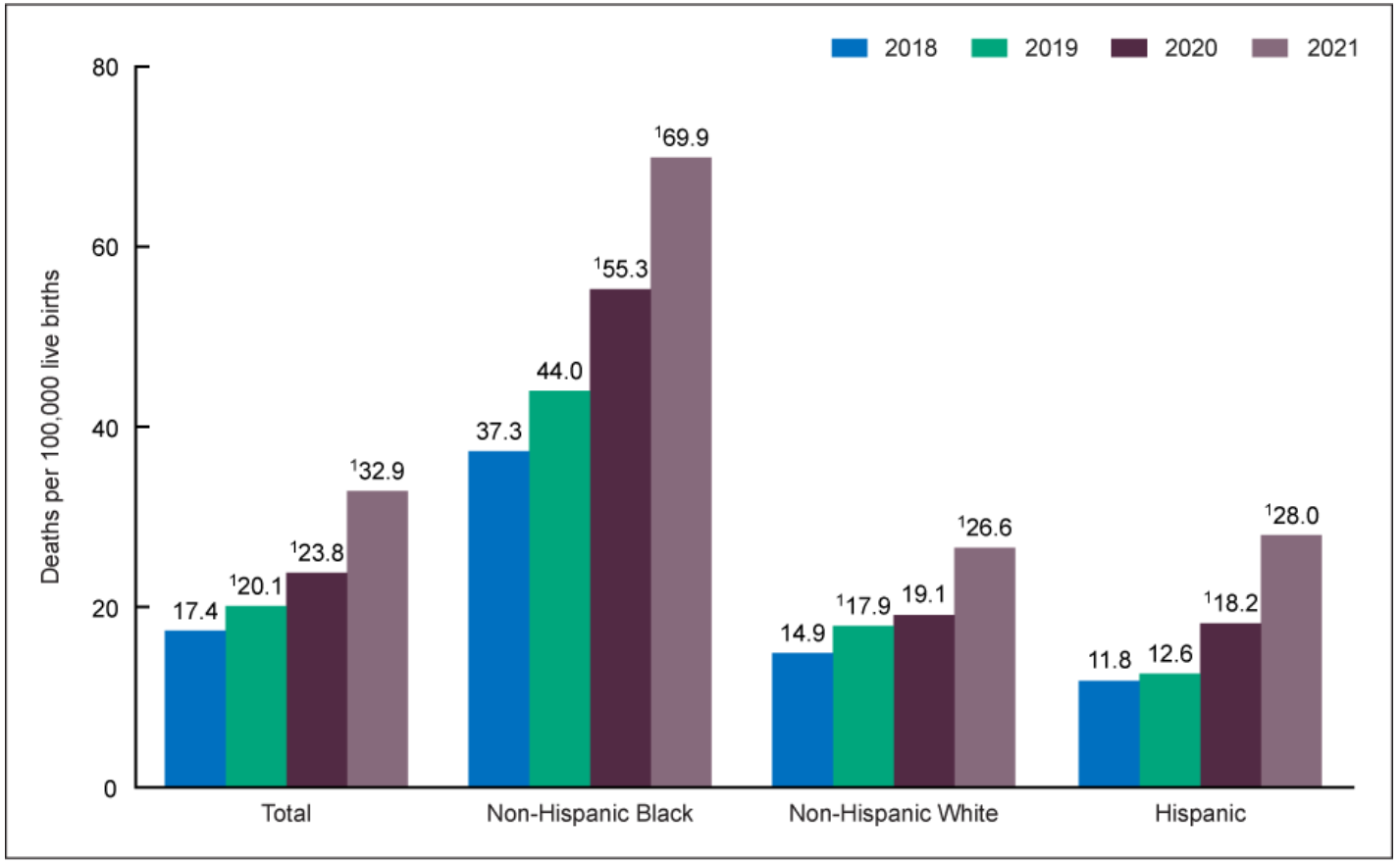
- **Detroit has the highest preterm birth (PTB) rate for any major US city.**[1]

- **In 2020, 1 in 7 babies (14.4% of live births) was born preterm in Detroit.**
  - Black infants (15.9%)
  - Whites (10.4%)
  - Hispanics (10.3%)

[1] March Of Dimes Report Card

What about moms in Detroit?

- **Detroit's maternal death rate is 3 times the national average.**
- **Pregnant Black women are 4.5 times more likely to die than white women.**



[1]Statistically significant increase from previous year ($p < 0.05$).
NOTE: Race groups are single race.
SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality.

Why are rates so high in Detroit?

- **Detroit is 80% African American**
- **Median household income is $35,000**
- **Urban legacy and emerging contaminants contribute to adverse reproductive health effects**

Why Is Giving Birth in Detroit So Dangerous?

Women there die from pregnancy-related causes at three times the national average. A report highlights the dangers of birthing while black.

By Dani McClain

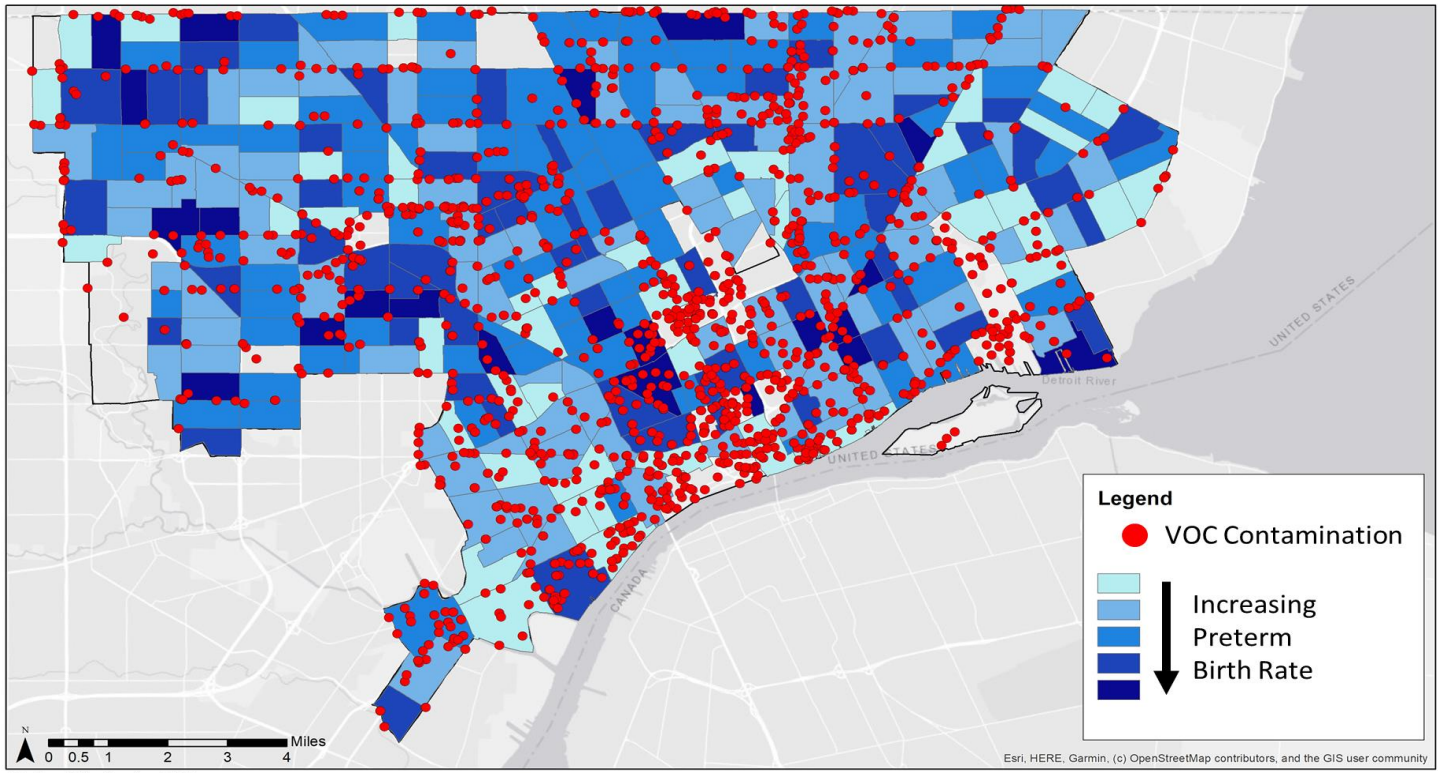
JULY 16, 2014

United States Census Data

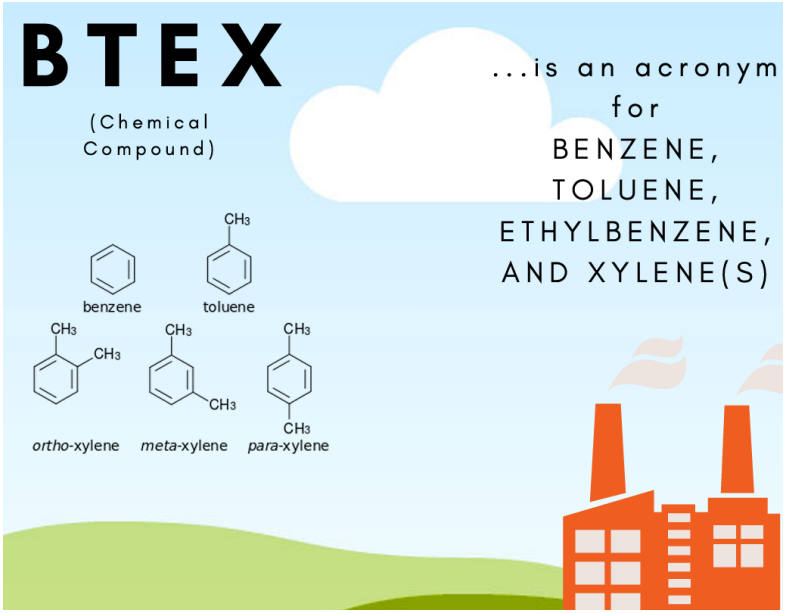
https://www.thenation.com/article/archive/why-giving-birth-detroit-so-dangerous/

Volatile Organic Compounds (VOCs)

Volatile Organic Compounds (VOCs) are a common class of contaminant in Detroit's subsurface and at Superfund sites.



Designed By: Brendan F. O'Leary

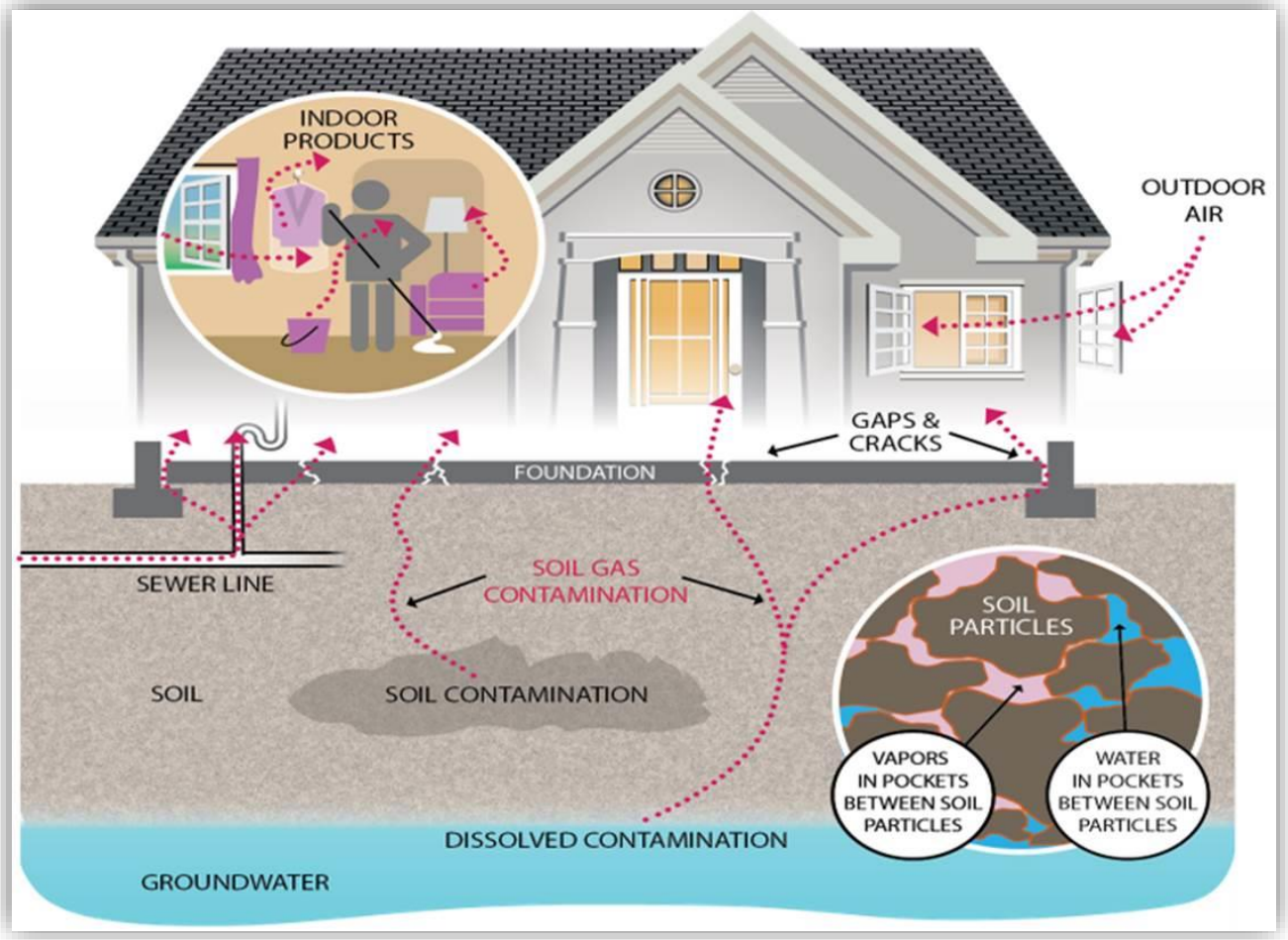


created by Nidhi Shastri; https://publish.illinois.edu/5thandhill/2018/12/12/what-the-deal-about-btex/

Primary Route of Exposure

Vapor Intrusion

Upward migration of VOCs from the subsurface



CLEAR

Center for Leadership
in Environmental Awareness
and Research

Urgent health problem

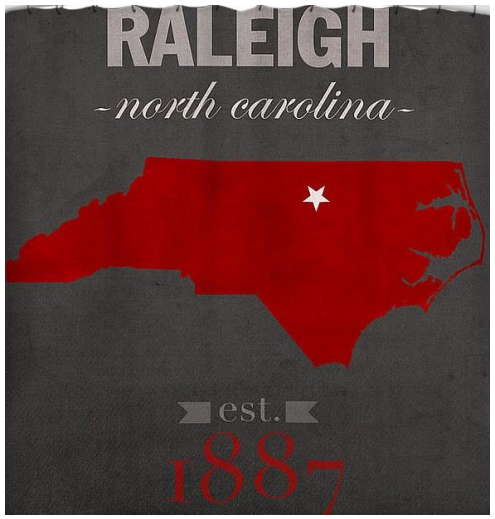
High preterm birth rates in Detroit

The CLEAR approach

Develop data-driven biological and smart engineering solutions to reduce and eliminate complex volatile organic chemical exposures in urban settings

WAYNE STATE UNIVERSITY

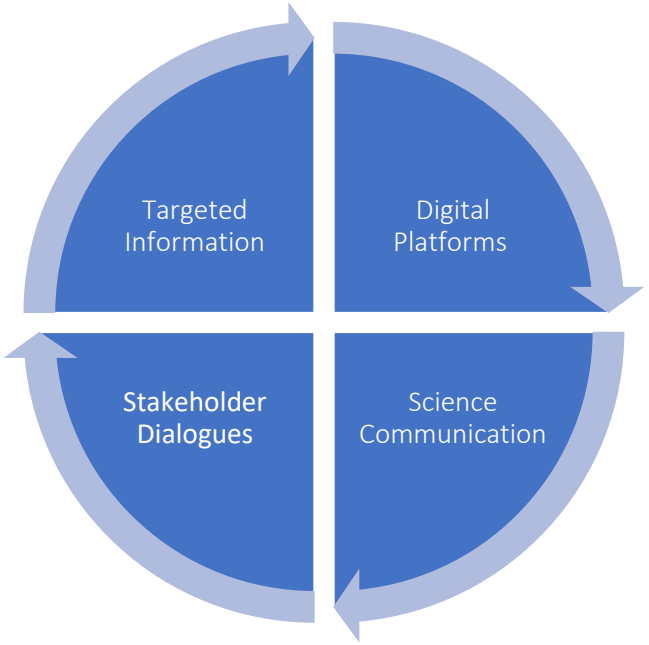
Henry Ford HEALTH SYSTEM



Research Translation at CLEAR (part of the Adminstrative Core)

Primary Aim

To communicate with diverse stakeholders about CLEAR's progress through a targeted multimedia strategy.



Rahul Mitra, PhD
Communication

Lance Gable, JD, MPH
Law

Judith Moldenhauer, MFA
Graphic Design

Rayman Mohamed, PhD
Urban Studies & Planning

Community Engagement Core at CLEAR

Primary Aims

1) To facilitate exchange of knowledge among CLEAR Center researchers, residents, local organizations, and other stakeholders in Detroit and the surrounding region.
2) To improve the health and reduce disparities across the local community through community engagement, outreach and education across Detroit.

Lyke Thompson, PhD
Director of Center for Urban Studies

Our Mission

The Americorps Urban Safety program at Wayne State University's Center for Urban Studies works to promote public health and safety in the City of Detroit.

Get in touch

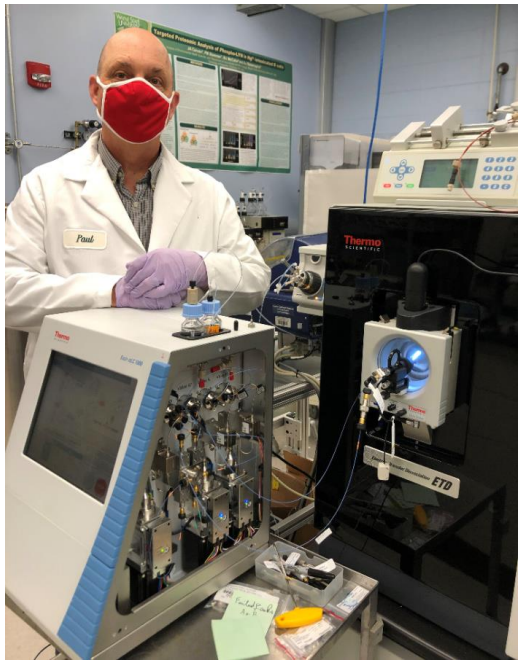
Chemical Analysis Core at CLEAR

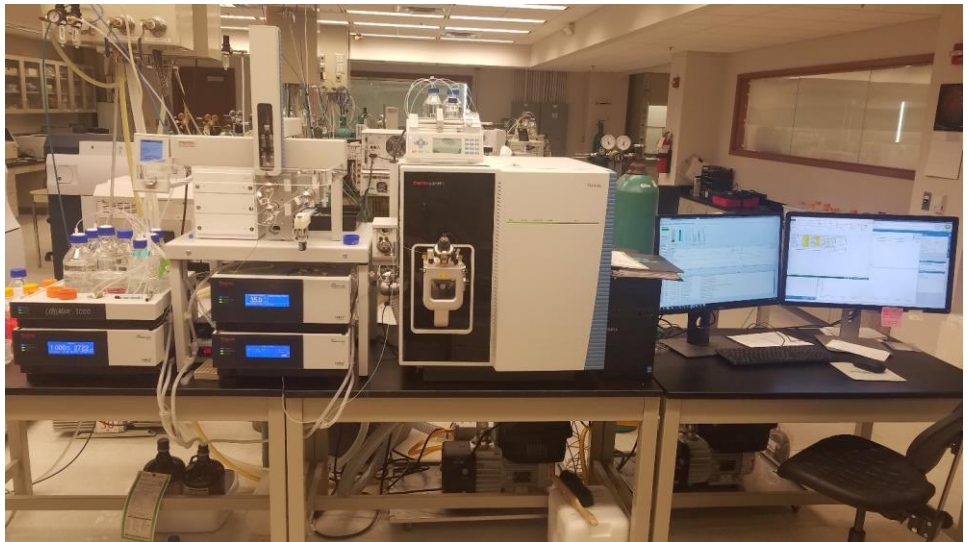
Primary Aim

To provide analytical services and training for project scientists as well as creating and implementing new methods for VOC exposure quantitation.

Judy Westrick, PhD
Mass Spectrometry

Nick Peraino, PhD
Mass Spectrometry





Paul Stemmer, PhD
Proteomics

Data Management and Analysis Core at CLEAR

Primary Aim

Provide integrated data, biostatistics and informatics services and promote collaboration.

Specifically, DMAC will

1) Facilitate communication between Projects, Cores, and other SRP Centers.
2) Manage complex data and use of analytical approaches designed to reduce bias/ confounding to ensure high-quality data and study integrity.
3) Coordinate data sharing and interoperability by integrating geographical and health outcome data using Geographical Information Systems (GIS) to localize VOCs.

Mei Lu, PhD
BioStatistics

Jia Li, PhD
BioStatistics

Erin Bunting, PhD
GIS

Gianluca Sperone, PhD
GIS

Research experience and Training Core at CLEAR

Primary Aim

To provide transdisciplinary training to a diverse group of graduate students and postdoctoral fellows to prepare the next generation of leaders to effectively address complex health problems related to VOCs in urban settings through professional careers in the environmental and/or biomedical sciences.

Donna Kashian, PhD

Mike Petriello, PhD

Katherine Roth, PhD
Trainee Coordinator

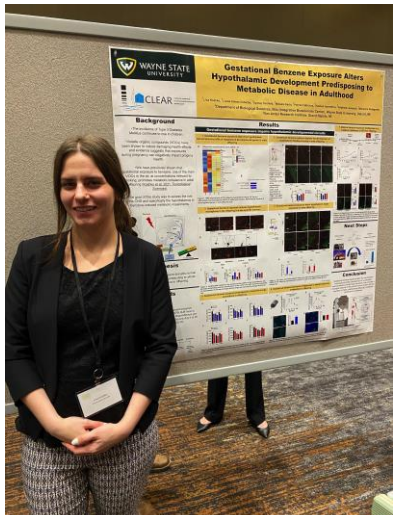
Ingrid Guerra-López, PhD

Innovative approaches to training at CLEAR

- Core micro-internships
- Interdisciplinary Graduate Certificate
- Diverse workshops

Recent Trainee Successes

- Dr. Katherine Roth received an NIEHS F32 fellowship.
- Mackenzie Connell won first place for her poster at SOT's Reproductive and Developmental Tox specialty section.
- CLEAR Trainees at SRP Annual Meeting



CLEAR Projects

Project 1 • Field Study

Project 2 • Sensing/Remediation Study

Project 3 • Zebrafish Model

Project 4 • Placental Mammal Model

Project 5 • Human Population Study

Project 4

Impact of BTEX chemicals exposure during pregnancy to maternal and fetal well-being

Researchers

Lead PI: **Dr. Gil Mor**
OBGYN

Co-I: **Doug Ruden**
OBGYN

Co-I: **Mike Petriello**
IEHS

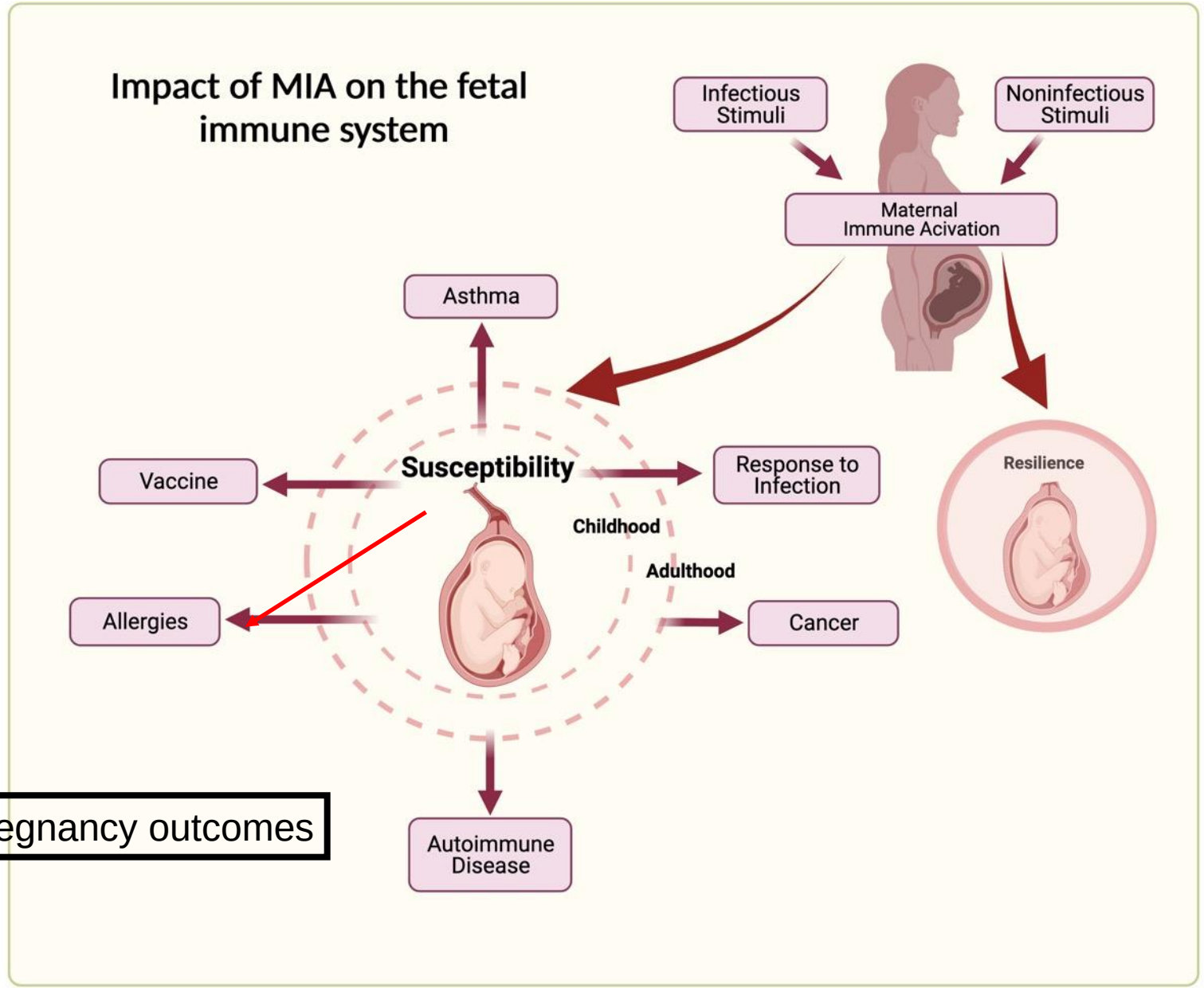
Co-I: **Marianna Sadagurski**
IEHS

Co-I: **Candy Ding**
OBGYN

Trainees

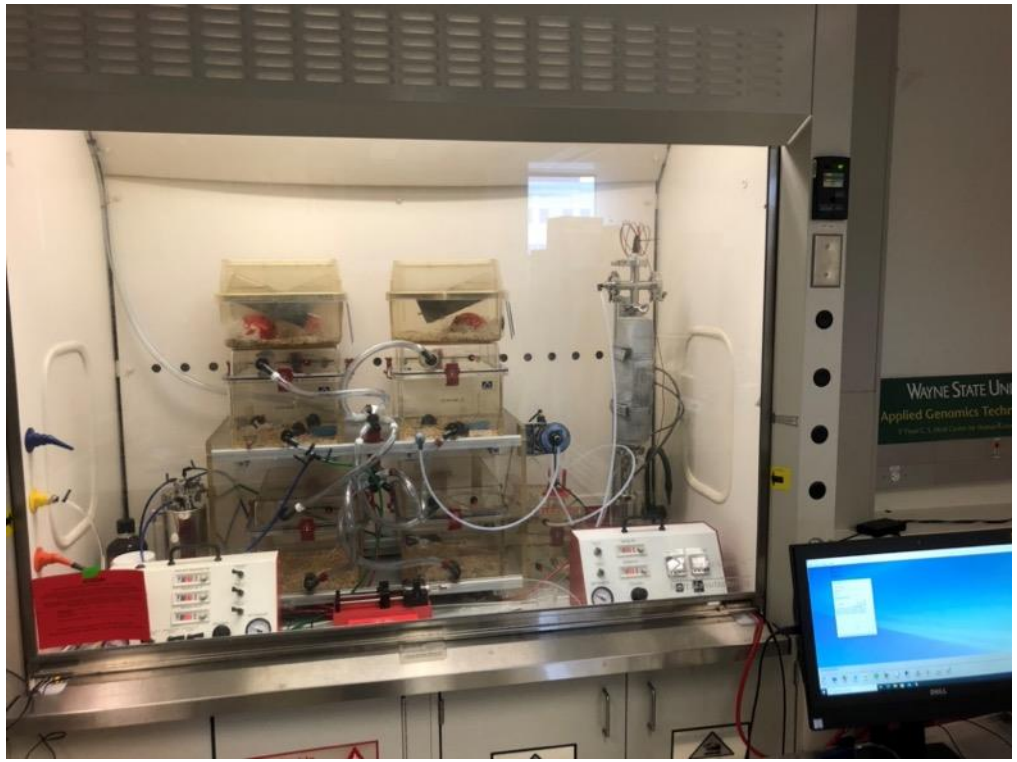
Anthony Maxwell, Annie Thy Nguyen, Lisa Koshko, Sydney Scofield

What is the impact of Maternal inflammation on the fetus?

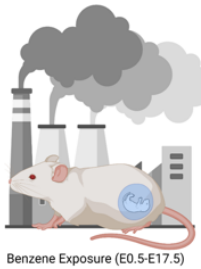


Adverse pregnancy outcomes

VOC exposure paradigm



Anthony Maxwell
Trainee



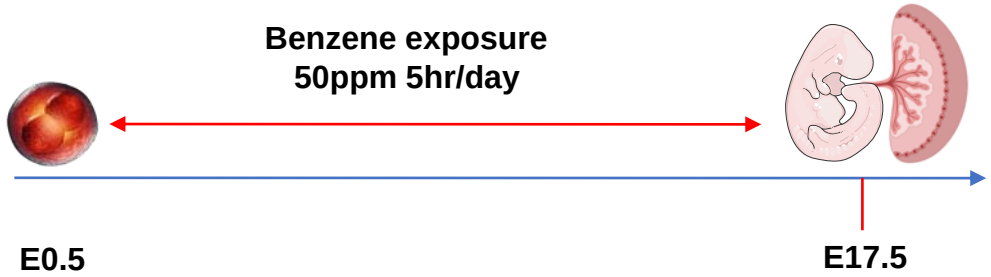
E0.5

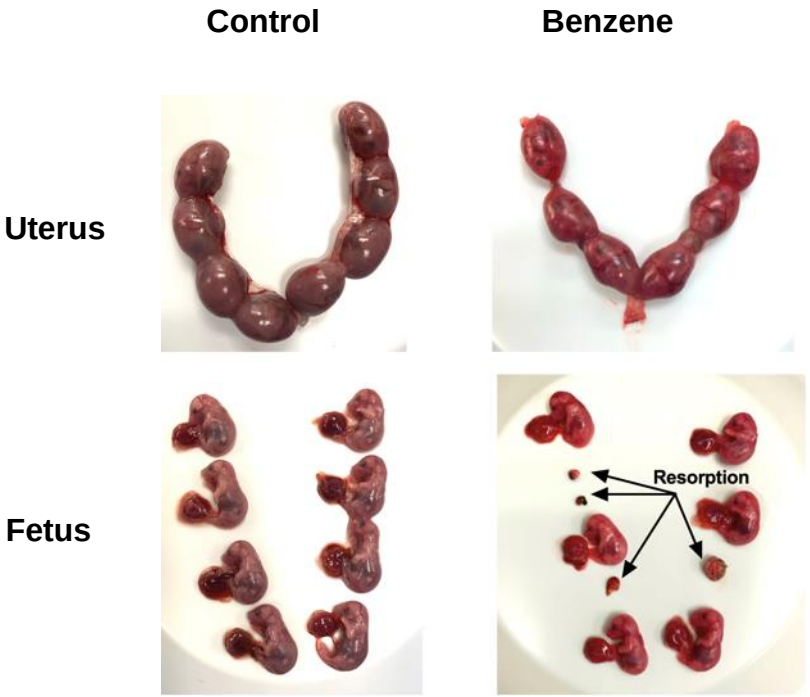
E17.5

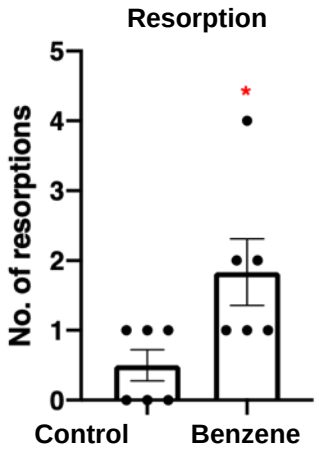
Benzene exposure

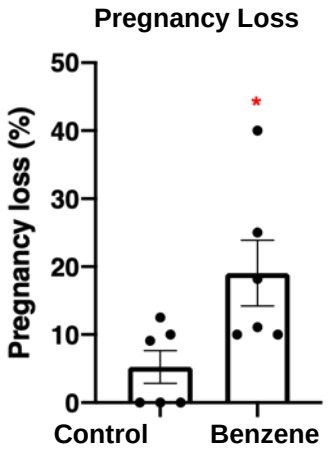
Collect samples

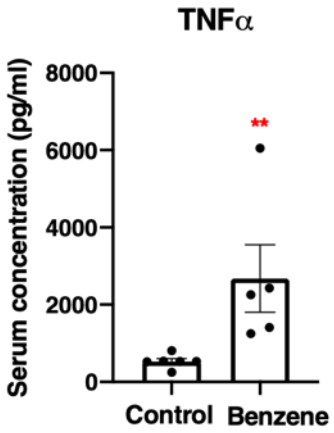
Benzene exposure / Modeling preterm birth



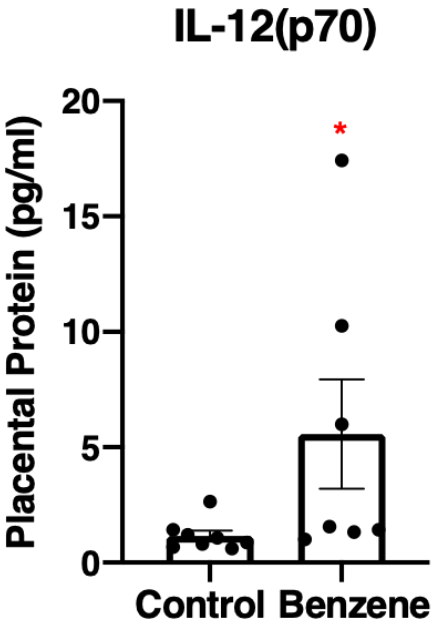


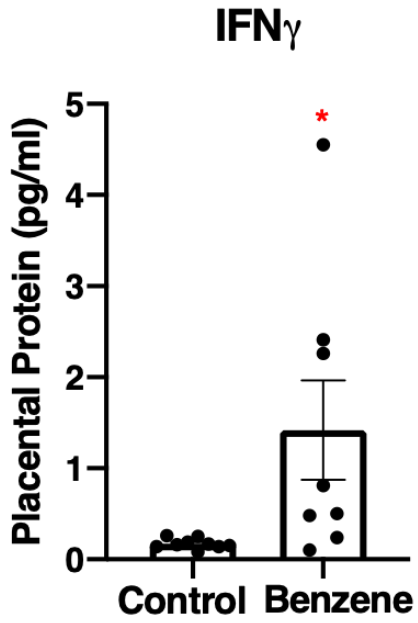


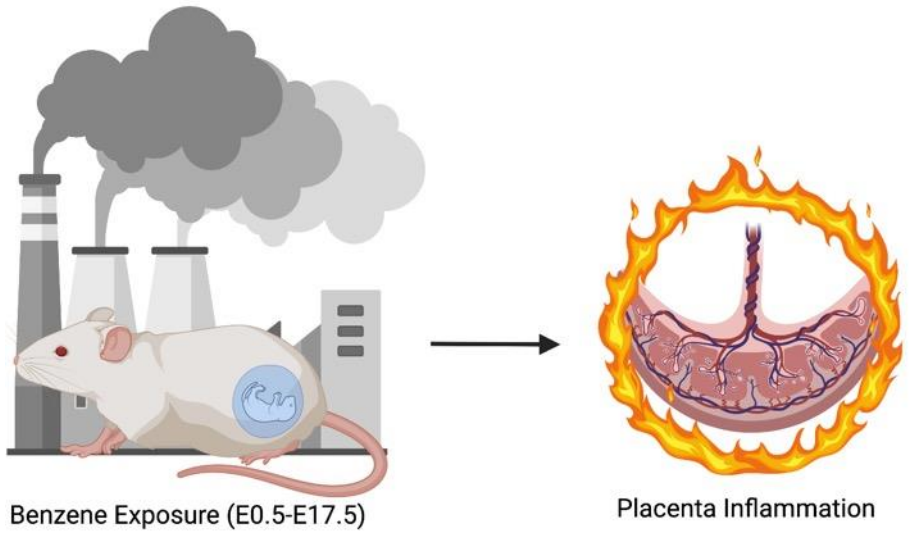




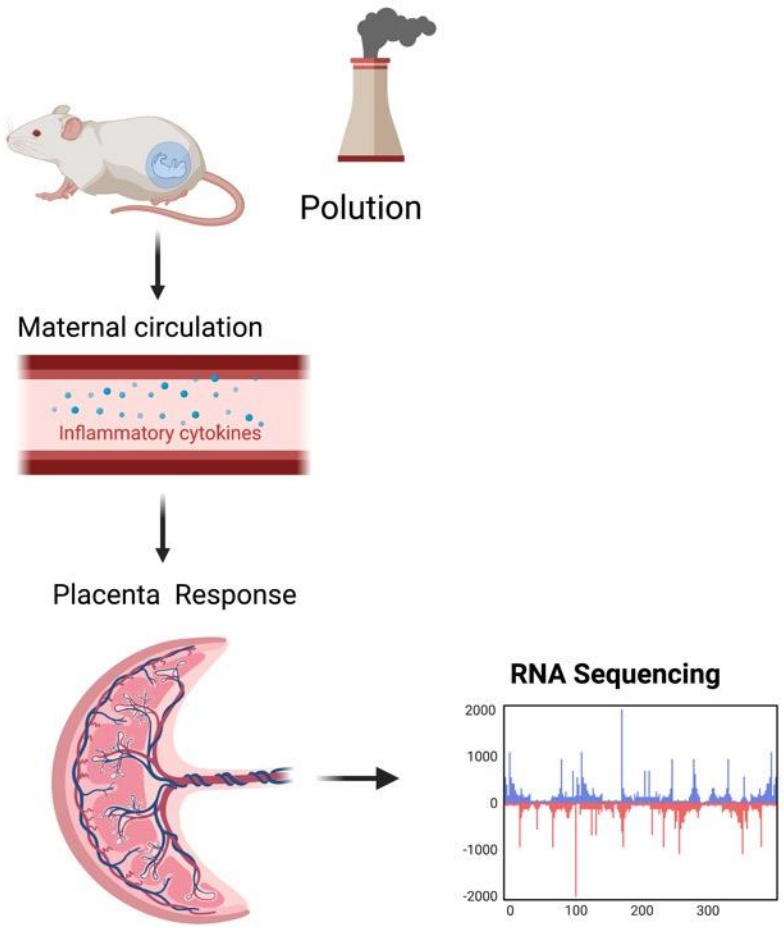
Placental Inflammation following benzene exposure





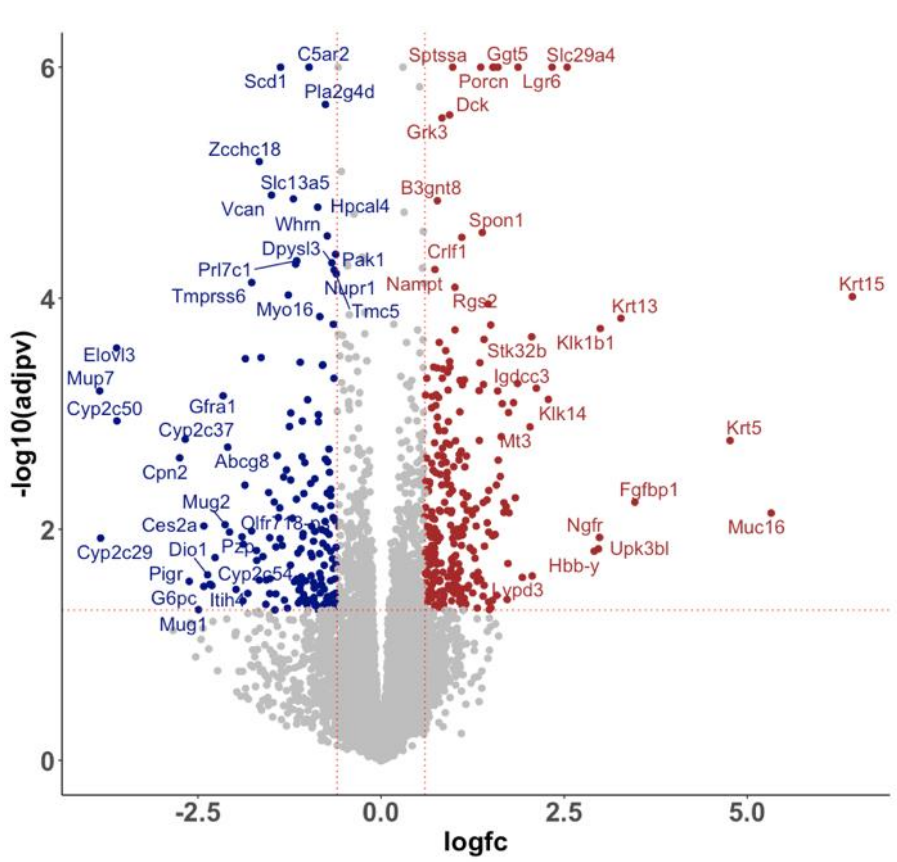


Innovative Concept / Placental sex differences

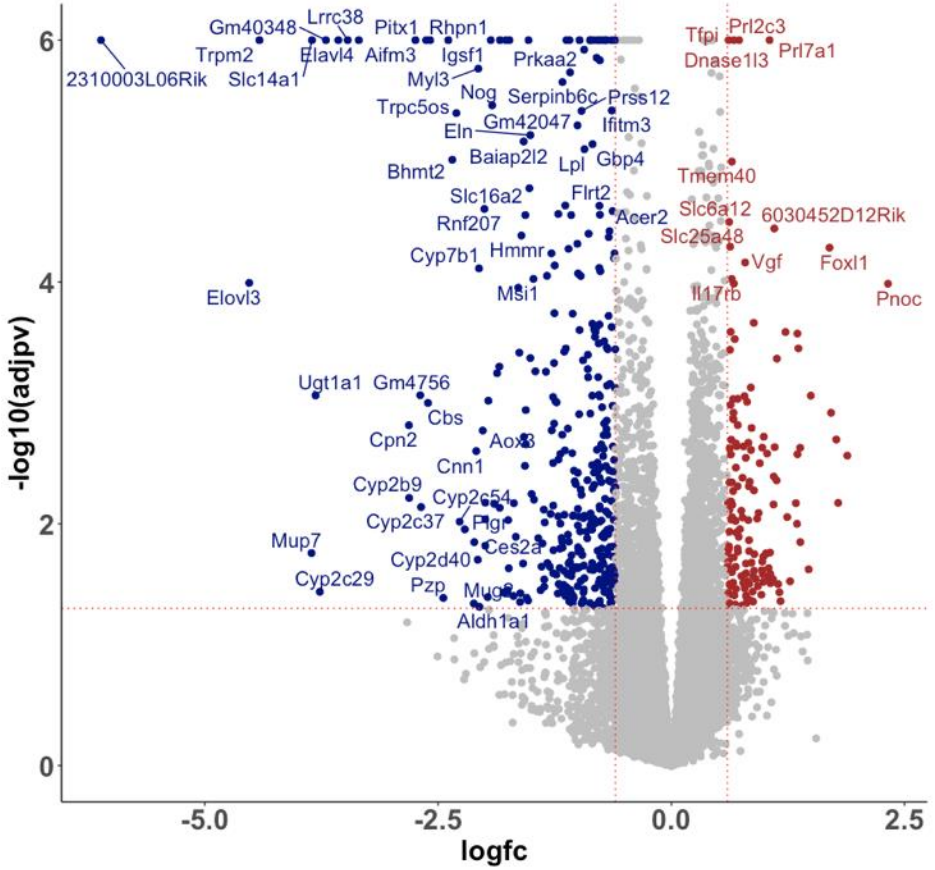


Impact of Benzene exposure on the Placenta

Male placenta

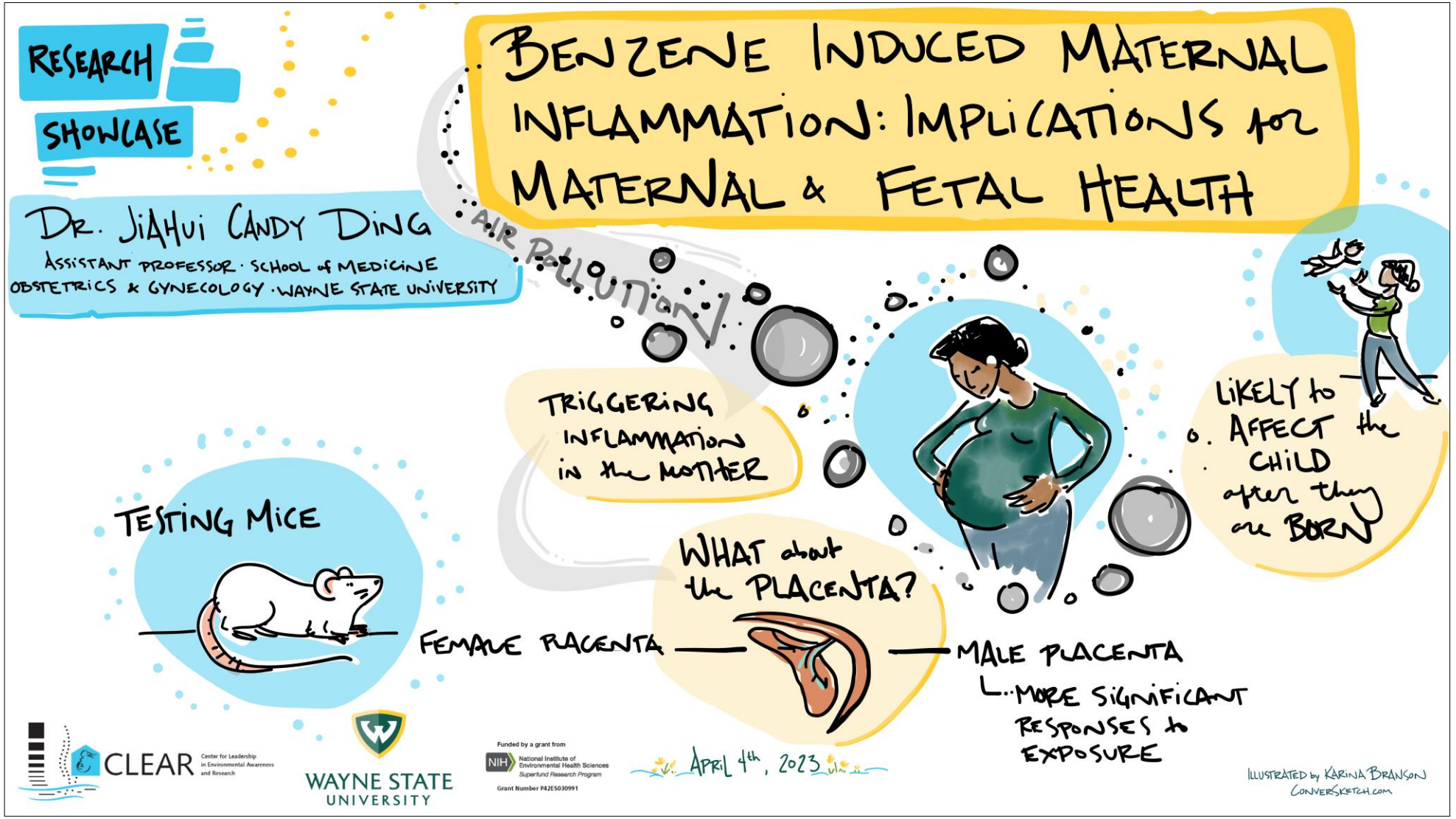


Female placenta



Graphic recording of the research for Project 4 presented at the CLEAR Symposium 2023

All the presentations at the Symposium were visually interpreted in real-time into meaningful and evocative art by the graphic recording artist, ***Karina Branson****.*



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Brendan O'Leary
Innovative sensing and remediation technologies

Tracie Baker
Bridging mechanistic, epidemiological, and community engaged research

Project 1

Building aboveground strategies to identify and address belowground hot spots for VOC vapor intrusion in complex urban settings

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Researchers

Lead PI: **Dr. Glen Hood**
Biological Sciences

Co-PI: **Gianluca Sperone**
Environmental Science and Geology

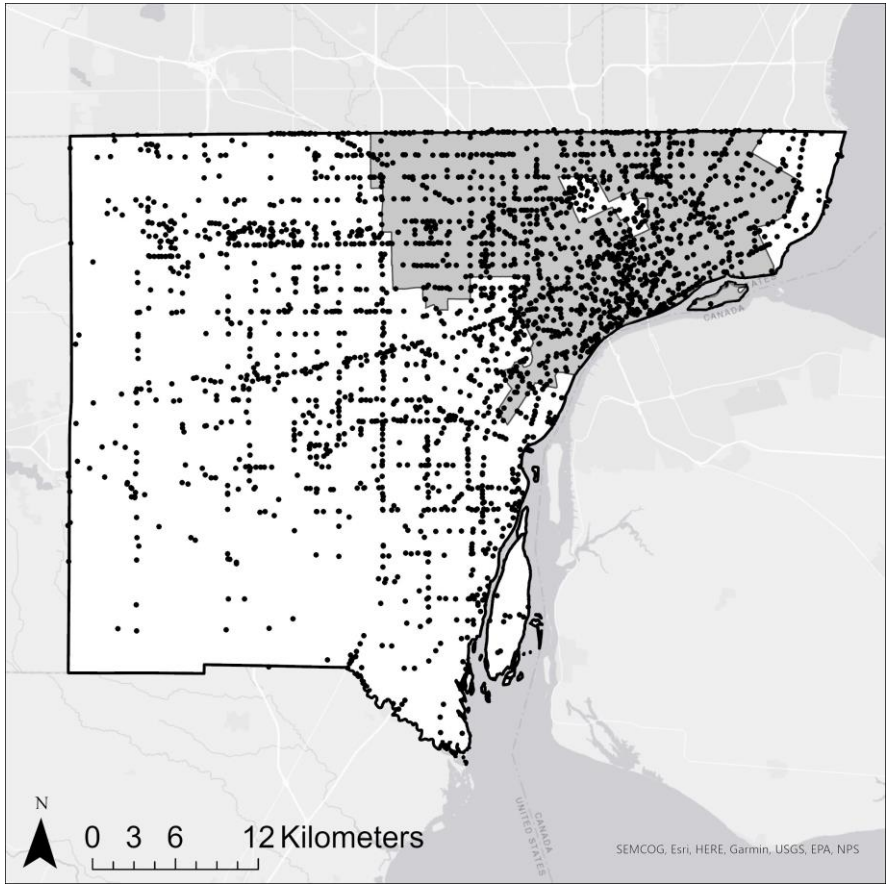
Ph.D. Student: **Sarah Black**
Biological Sciences

Postdoctoral Scholar: **Dr. Brendan O'Leary**
Biological Sciences, and Civil and Environmental Engineering

Undergraduate Researchers

Kyla Keyes, Grace Szewc, Gwendolyn Schmidt

Problem / Many sites of potential VOC contamination are untested.



The Detroit News

NEWS

Mich. DEQ chief: 'Vapor intrusion' poses health threat

Michael Gerstein The Detroit News
Published 7:55 p.m. ET Feb. 16, 2017 | **Updated 10:27 a.m. ET Feb. 17, 2017**

Lansing — A "significant public health threat" is brewing i
percolate up from the ground of former industrial or comm
Department of Environmental Quality Director Heidi Gret

Grether told lawmakers during a Tuesday budget presenta
Michigan, many in Metro Detroit, where potentially harm
health. She asked legislators to consider beefing up the de
million to dedicate eight employees to the issue full time.

"We're concerned that this could pose a significant public
additional staff and resources to evaluate the sites" and sta

Detroit Free Press

OAKLAND

As many as 4,000 Michigan sites could be hiding toxic fumes

Bill Laitner
Detroit Free Press
Published 6:01 a.m. ET March 31, 2018 | **Updated 10:14 a.m. ET March 31, 2018**

The toxic fumes that were seeping into some shops in Oakland County's upscale Franklin village are all but gone, state environmental officials said.

But a consultant was still conducting tests of the air quality this week inside Franklin Village Plaza, a row of five shops at a 90-year-old building that's a few blocks south of the historic Franklin Cider Mill, and where the Oakland County Health Division on March 6 ordered a mandatory evacuation.

Some of the shop owners were allowed to reopen last week, after the Michigan Department of Environmental Quality directed a contractor to rip up the floor in a tailor's shop, uncovering a long-abandoned tank half-filled with a toxic, cancer-causing solvent.

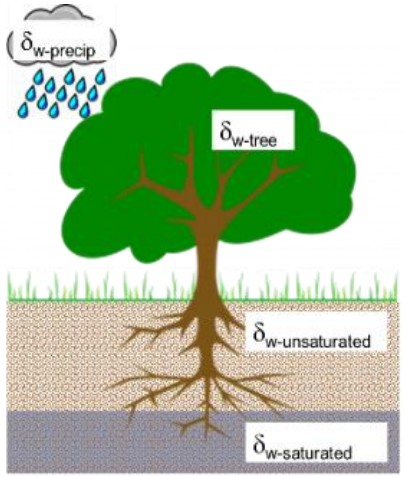
Technicians in hazmat suits, breathing through respirators, sliced off the top of the four-foot steel tank and removed the solvent, thought to be left from a former dry-cleaning business. That eliminated the retail strip's key source of what pollution fighters call vapor intrusion — the seepage of contaminated air into a building, according to MDEQ.

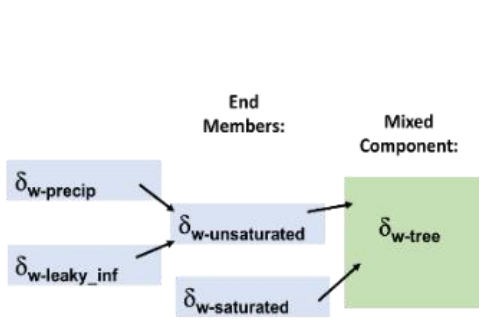
Aims

Aim 1

Developing methods to use aboveground plant tissues to identify VOC hotspots

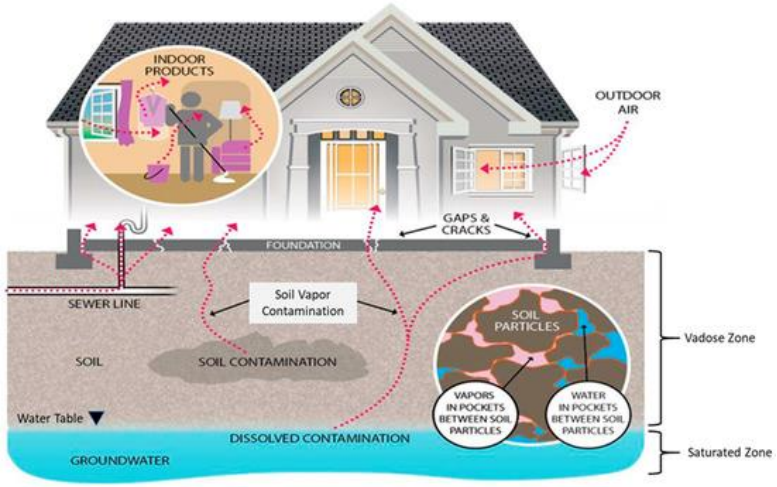
Aim 2





Identify belowground source water for urban plants to isolate possible sources of VOC contamination

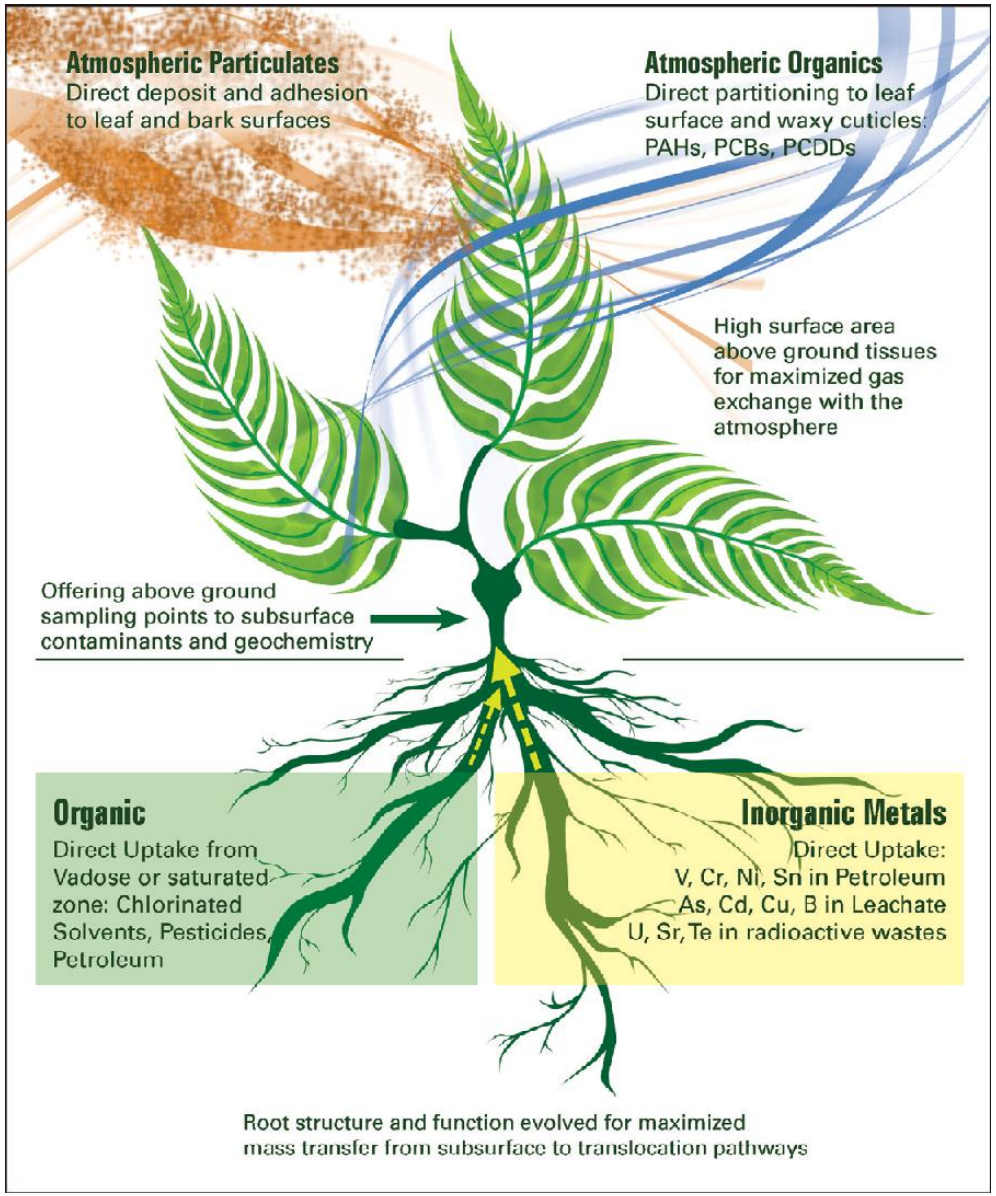
Aim 3



Verify belowground presence of VOCs and link to indoor VOCs

In our innovative approach, we couple **phytoscreening** – a cost-effective, minimally invasive approach in contaminant transport applications – with a ***stable isotope technique*** – a mixing model to identify source waters for plants – to inform our understanding of VOC VI in urban landscapes.

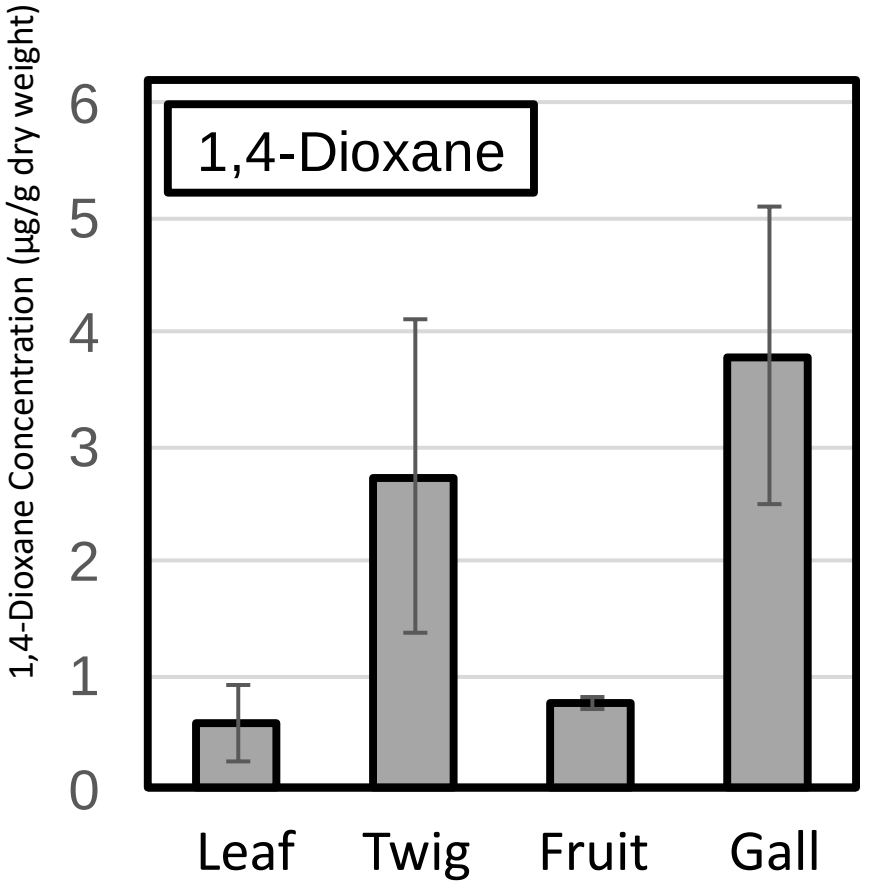
- **Phytoscreening** is the chemical analysis of plant tissue to provide evidence for belowground contamination.
- Vascular plants grow belowground network of roots that facilitate the uptake and transport of water, nutrients to aboveground plant tissues



Project 1 / Building aboveground strategies to identify and address belowground hot spots for VOC vapor intrusion in complex urban settings

Riverbank grapevine (Vitas riparia)

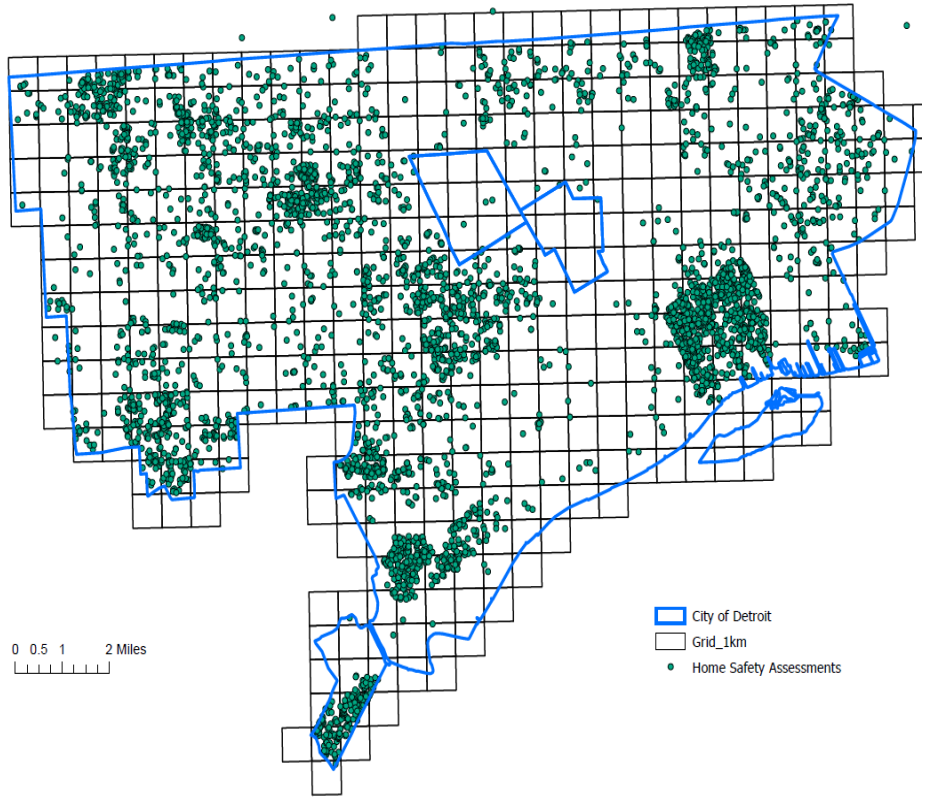
Galls on grapevine



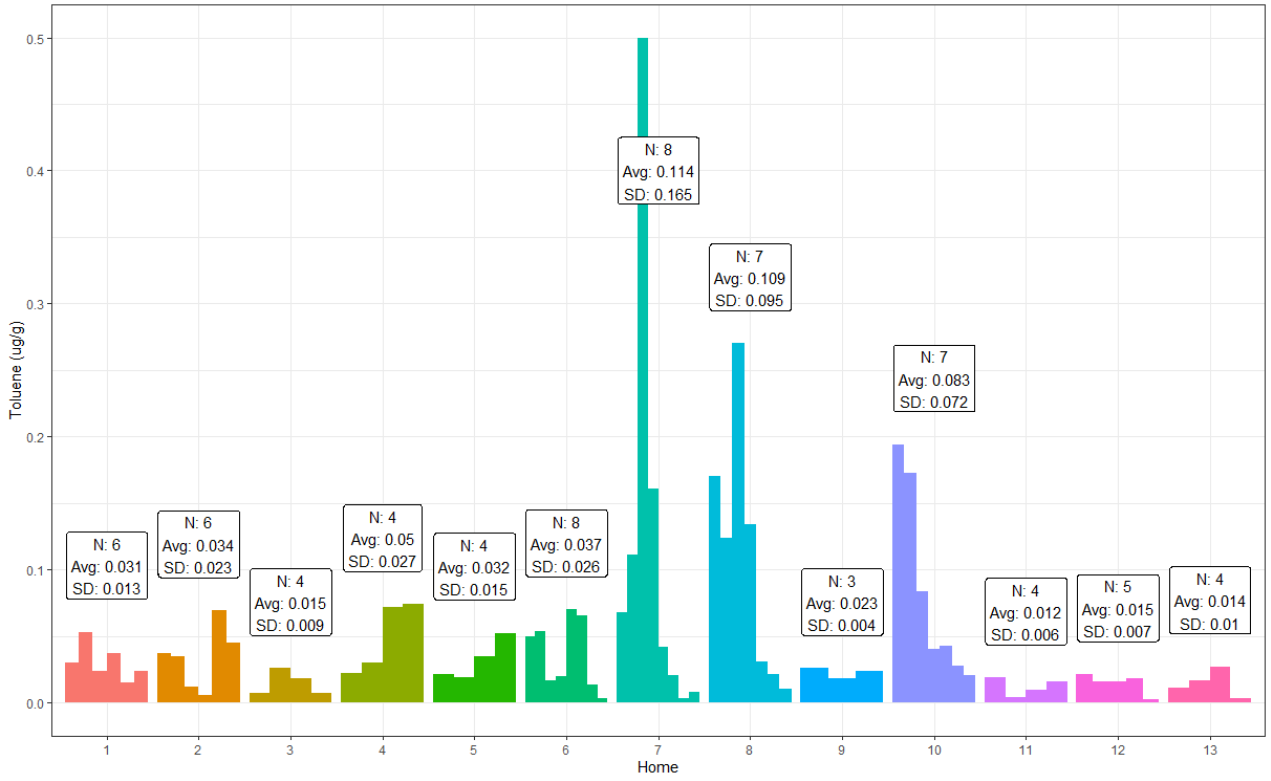
Hood et al. 2021; Plant and Soil

Working with the Community Engagement Core (CEC) to Phytoscreen Detroit

CEC Home Safety Assessments



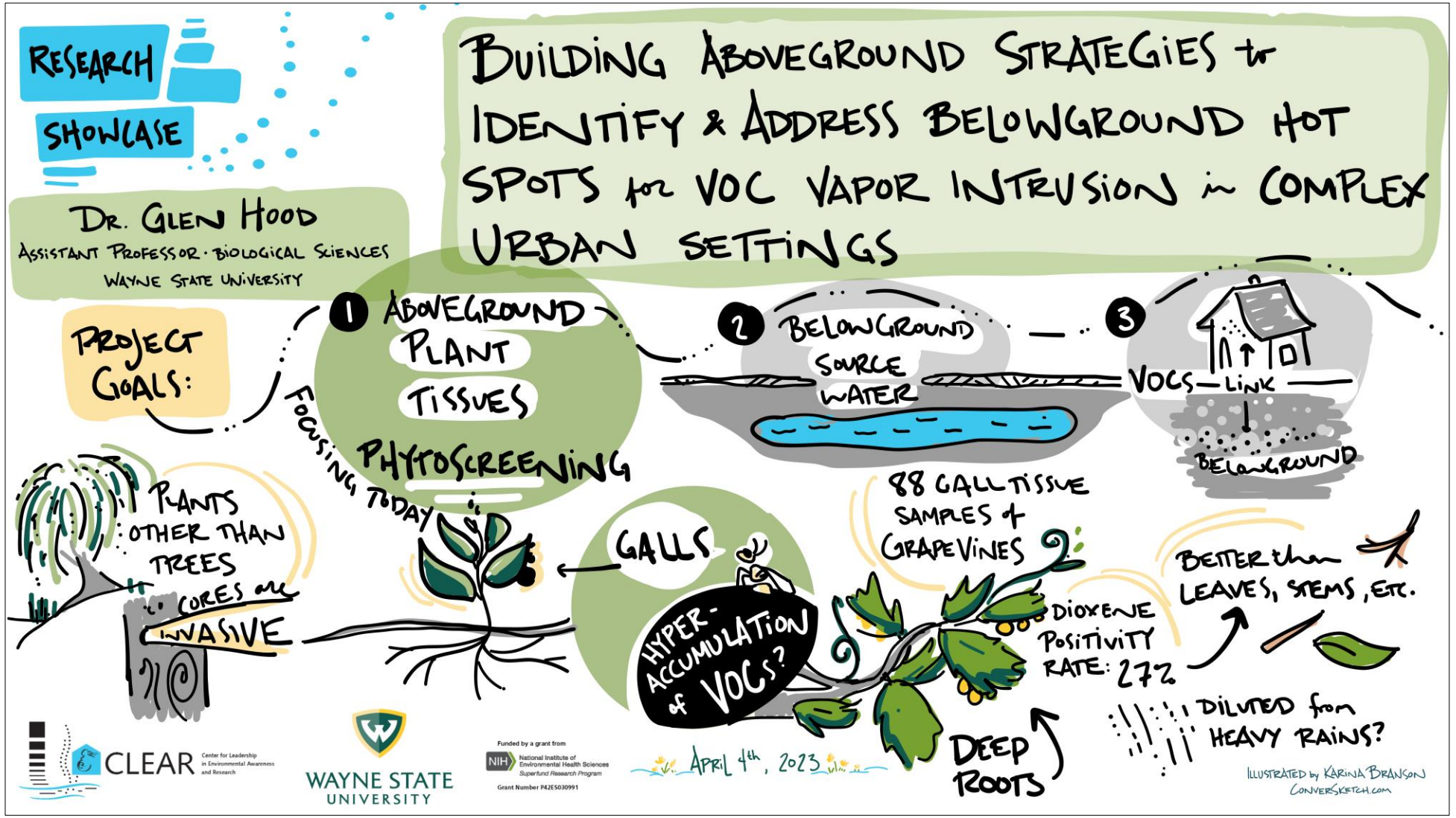
Phytoscreening homes of pregnant women for VOCs



Preliminary data collected with Andrea Cassidy-Bushrow and Jennifer Straughen from Henry Ford's Public Health Sciences department (Project 5)

Graphic recording of the research for Project 1 presented at the CLEAR Symposium 2023

All the presentations at the Symposium were visually interpreted in real-time into meaningful and evocative art by the graphic recording artist, ***Karina Branson****.*



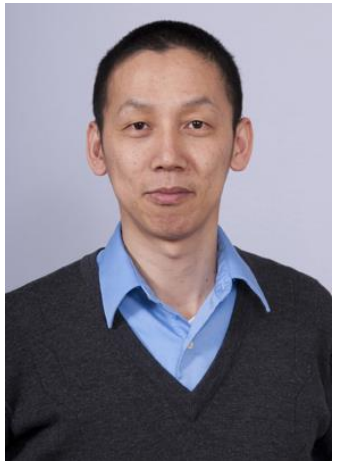
Project 2

Real-Time Monitoring and Remediation of Vapor Intrusion

Researchers

Dr. Yongli Wager
Civil and Environmental Engineering

Dr. Carol Miller
Civil and Environmental Engineering



Dr. Yong Xu
Electrical and Computer Engineering

Dr. Weisong Shi
Computer and Information Sciences at the University of Delaware

Dr. Timothy Dittrich Civil and Environmental Engineering

Dr. Jacqueline MacDonald Gibson
Civil, Construction, and Environmental Engineering at North Carolina State University

Dr. Brendan O'Leary
Biological Sciences, and Civil and Environmental Engineering

Media and Depth	Spatial Variations	Temporal Variations
Indoor air	Unknown	1000X
Sub-slab soil gas	10-100X	10X
3-ft below sub-slab soil gas	10X	2X
6-ft below sub-slab soil gas	3X	50% (about mean)

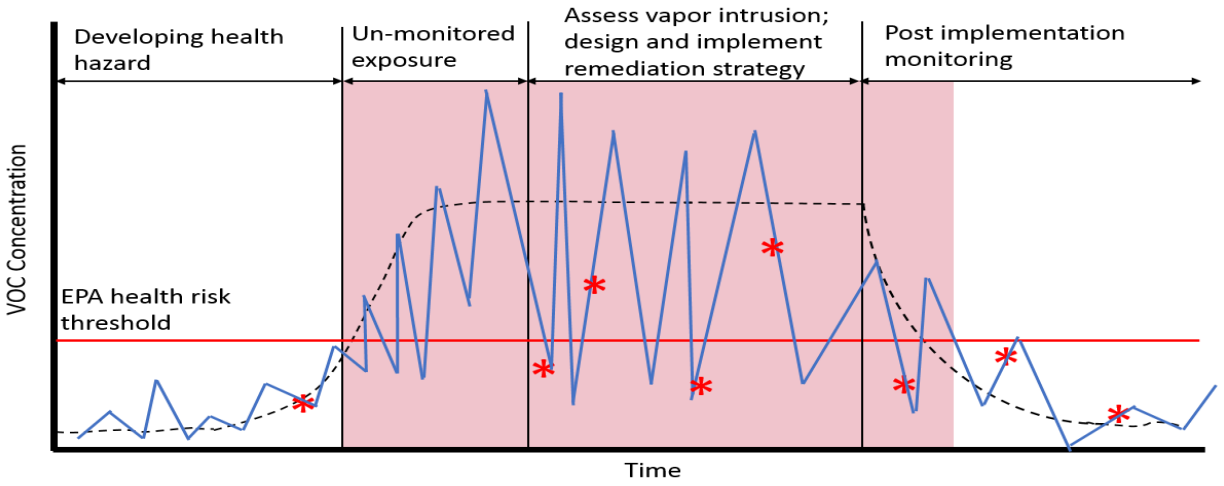
Spatial and temporal variation of vapor intrusion (Johnson, P.C., et al., 2016)

Factors affecting vapor intrusion (VI):

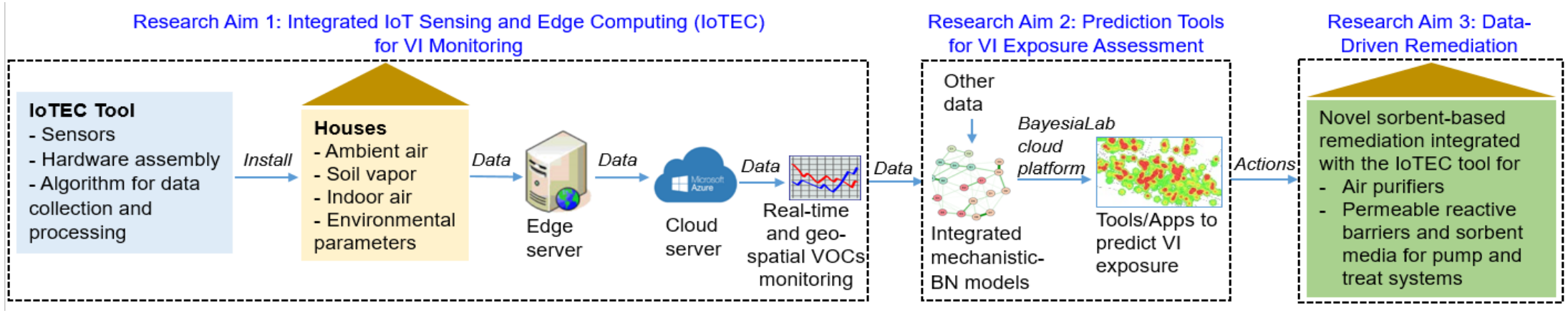
- Geospatial variations (water table, soil, climate, etc.)
- Seasonal and weather changes (temperature, wind, humidity, etc.)
- House conditions (basement, ventilation, etc.)

Challenges of VI assessment and remediation

- Labor intensive, time consuming, expensive
- High frequency of missing harmful exposure window
- Hard to assess the effectiveness of VI remediation



Problem-based, solution-oriented research: approaches to addressing challenges of VI assessment and remediation



Solution 1: real-time VI monitoring

- Low cost
- Real time data collection and monitoring
- Reducing missing of detection of harmful exposure
- Easy to install and use

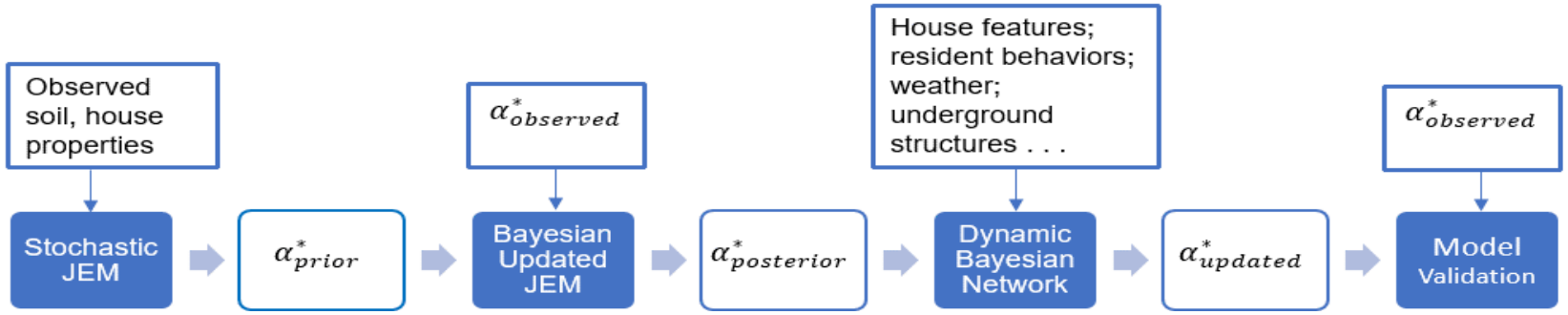
Solution 2: VI prediction models/apps

- Predict VI exposure risks in various areas and house conditions
- Screening tool for potential VI hot spots
- Prioritize/optimize VI assessment and remediation

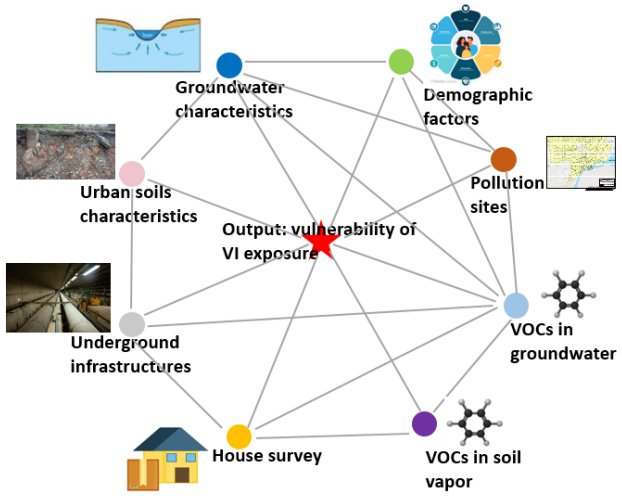
Solution 3: Novel sorbent-based remediation systems

- High sorption capacity
- Slow desorption
- Integration with real-time VI monitoring that supports the triggering of and assesses the effectiveness of remediation

Innovative solution 2: VI prediction model/app



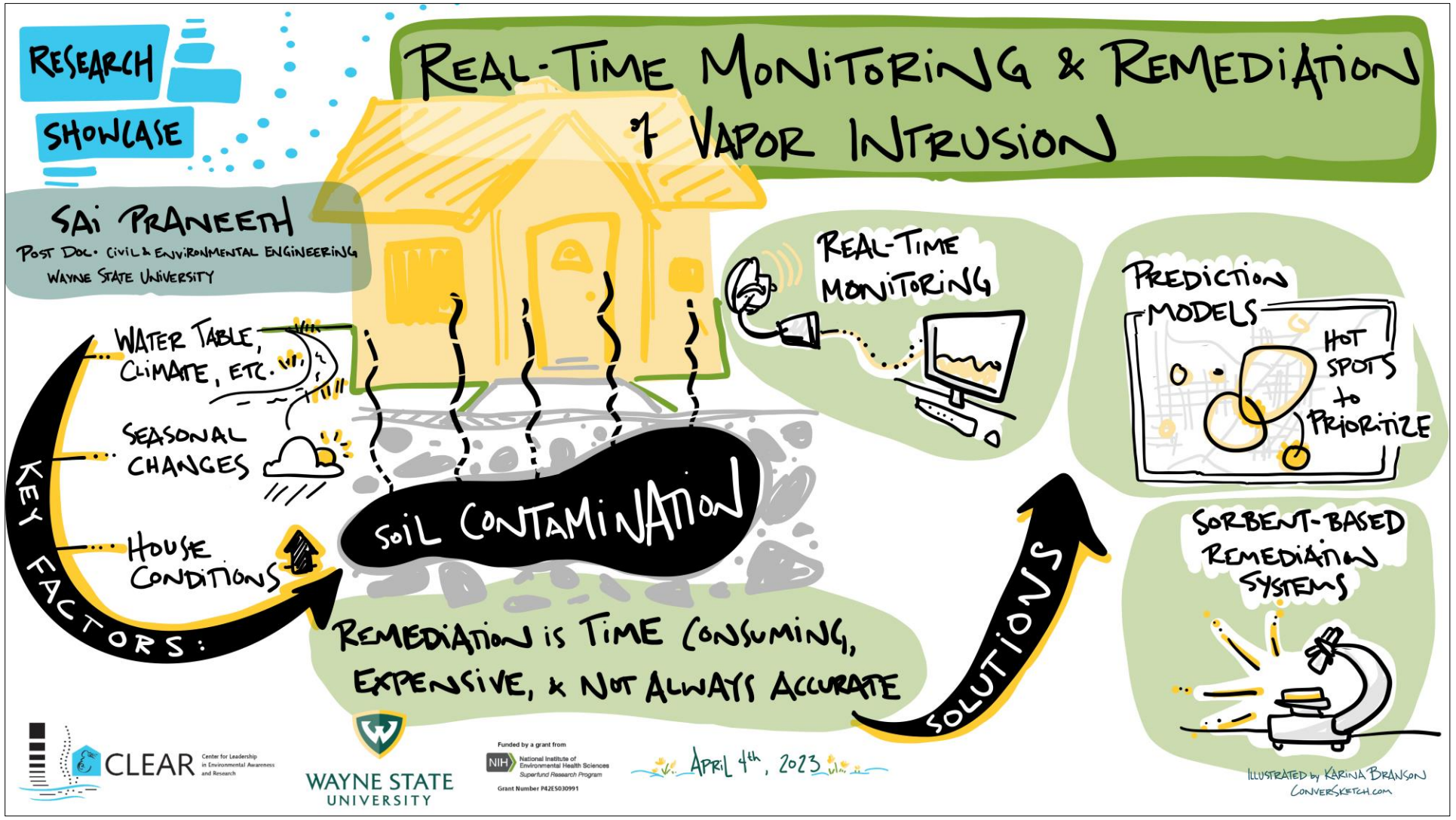
Process for building the integrated mechanistic–BN model for predicting VI risk at the household scale across an entire community. α^*= VOC indoor concentration/VOC concentration at source (soil vapor).



- Screening tool for potential VI exposure
- Predict VI exposure risks in various areas and house conditions
- Prioritize/optimize VI assessment and remediation

Graphic recording of the research for Project 2 presented at the CLEAR Symposium 2023

All the presentations at the Symposium were visually interpreted in real-time into meaningful and evocative art by the graphic recording artist, ***Karina Branson****.*



CLEAR Presenters • 2023 SRP Progress in Research Webinar

Mike Petriello
Introduction to Detroit, CLEAR, and innovative research

Brendan O'Leary
Innovative sensing and remediation technologies

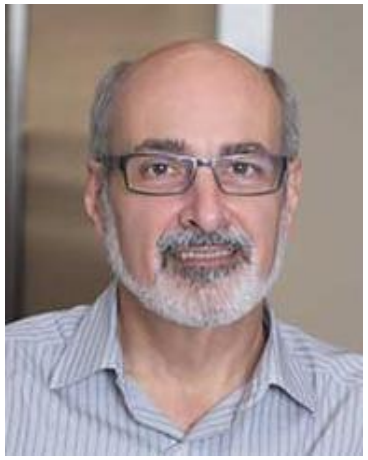
Tracie Baker
Bridging mechanistic, epidemiological, and community engaged research

Project 3

Developmental VOC exposure in zebrafish: Toxic mechanisms and biomarkers

Researchers

Lead PI: **Dr. Tracie Baker**
Environmental and Global Health



Co-I: **Dr. David Pitts**
Pharmaceutical Sciences

Co-I: **Dr. Shawn McElmurry**
Civil and Environmental Engineering

Co-I: **Dr. Thomas Backhaus**
University of Gothenburg

Trainees

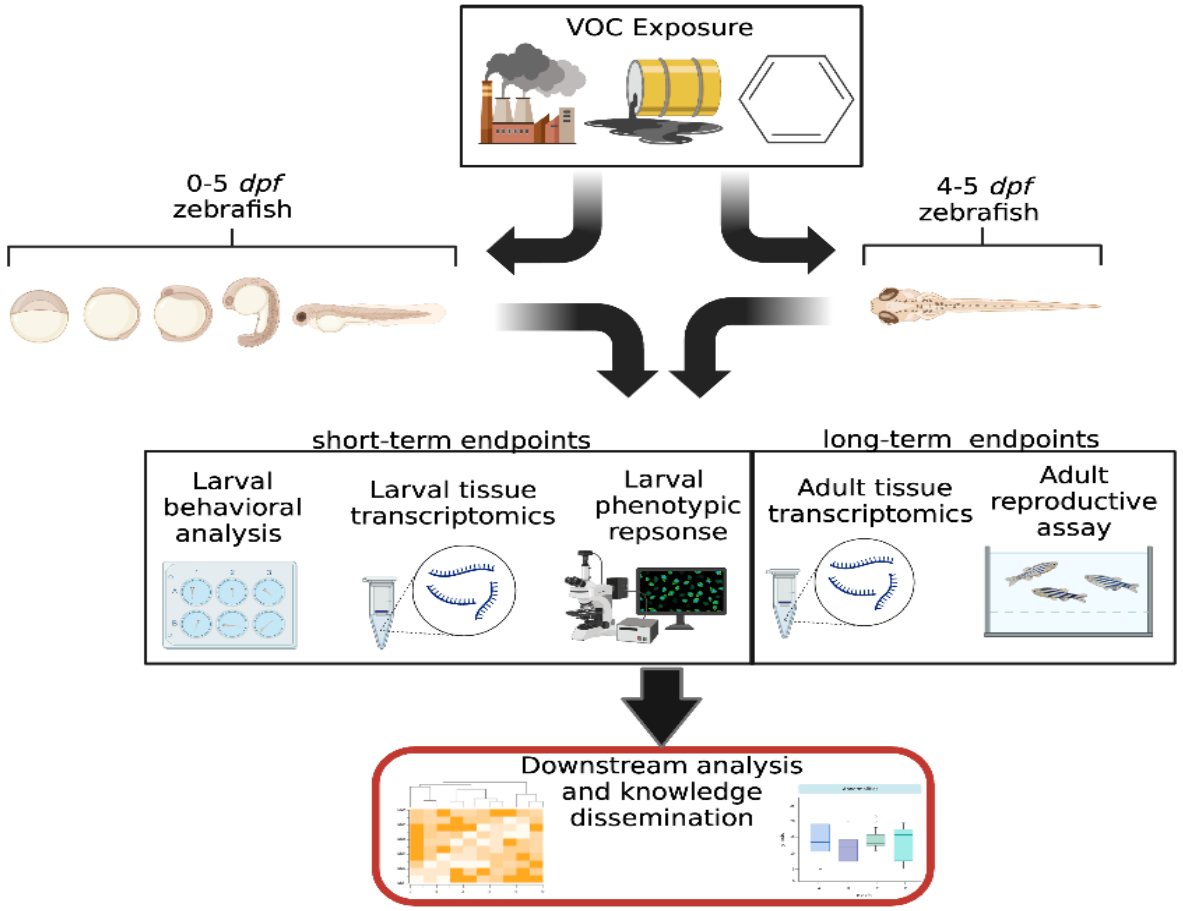
Mackenzie Connell

Zoha Siddiqua

Emily Kintzele

Dima Awad

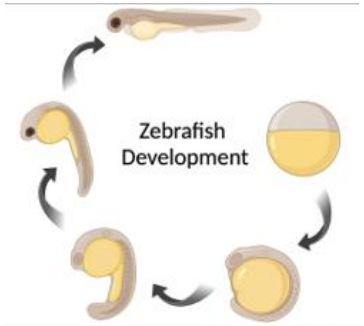
Developmental VOC exposure in zebrafish / Toxic mechanisms and biomarkers



VOCs of interest

Benzene
Toluene
Ethylbenzene
Xylene
Trichloroethylene
Perchloroethylene
1,4, dioxane

Mixtures



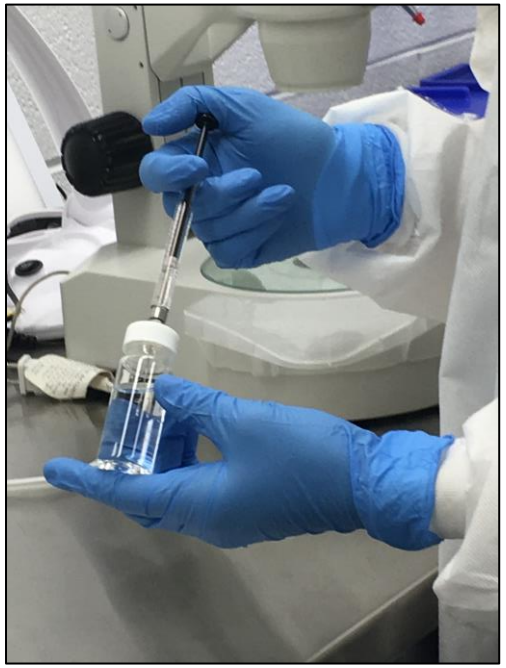
Innovative methods / VOC exposures to live aquatic species

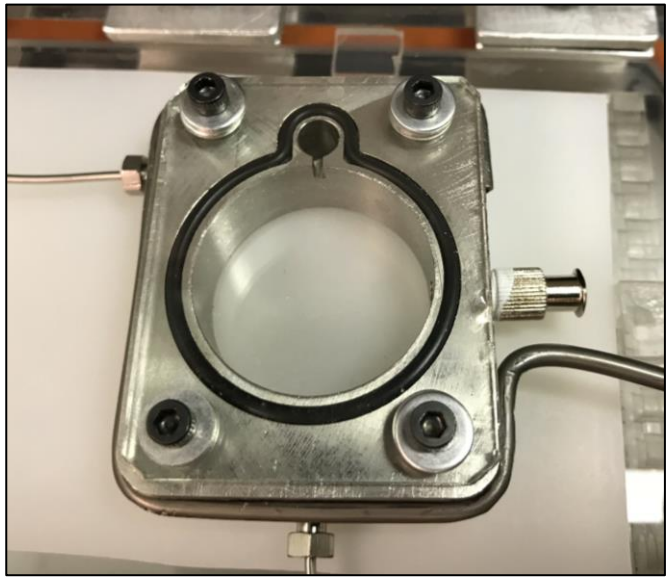
Benzene

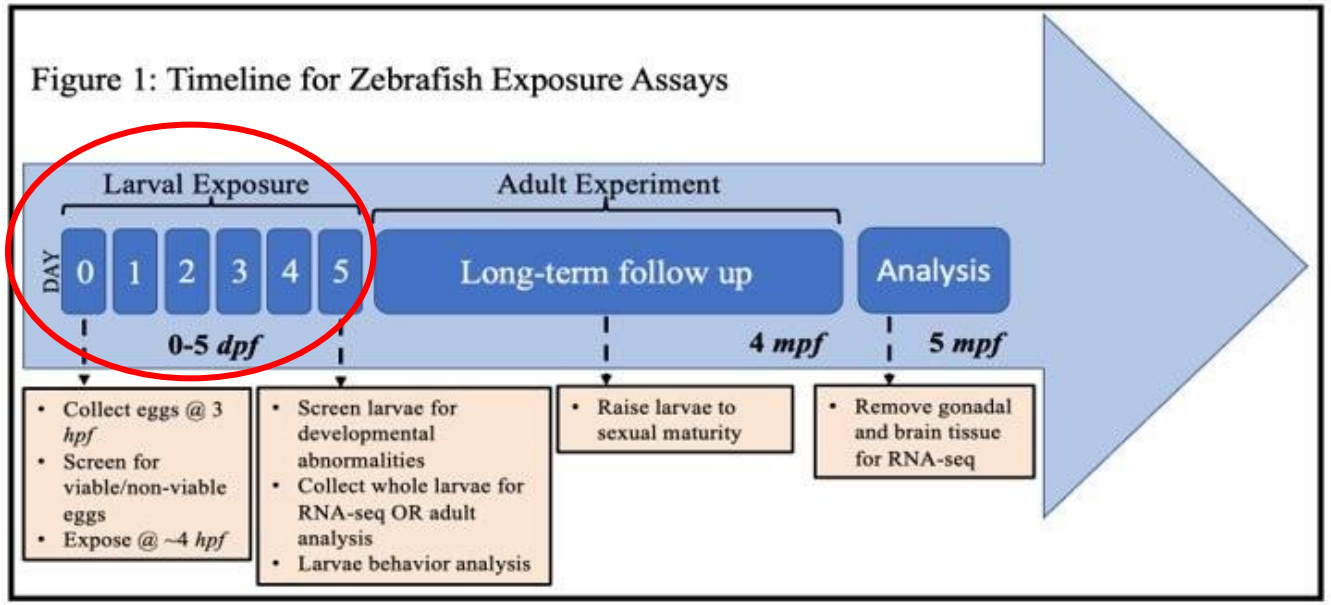
- Control
- 0.1 ppm
- 1 ppm

1,4-dioxane

- Control
- 0.004 ppm
- 0.4 ppm
- 40 ppm







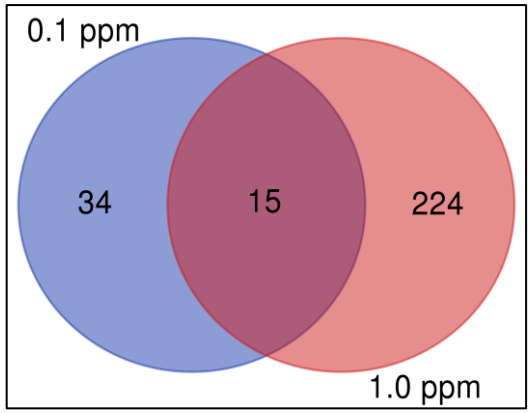
Toxics. 2022 Jun 27;10(7):351. doi: 10.3390/toxics10070351.

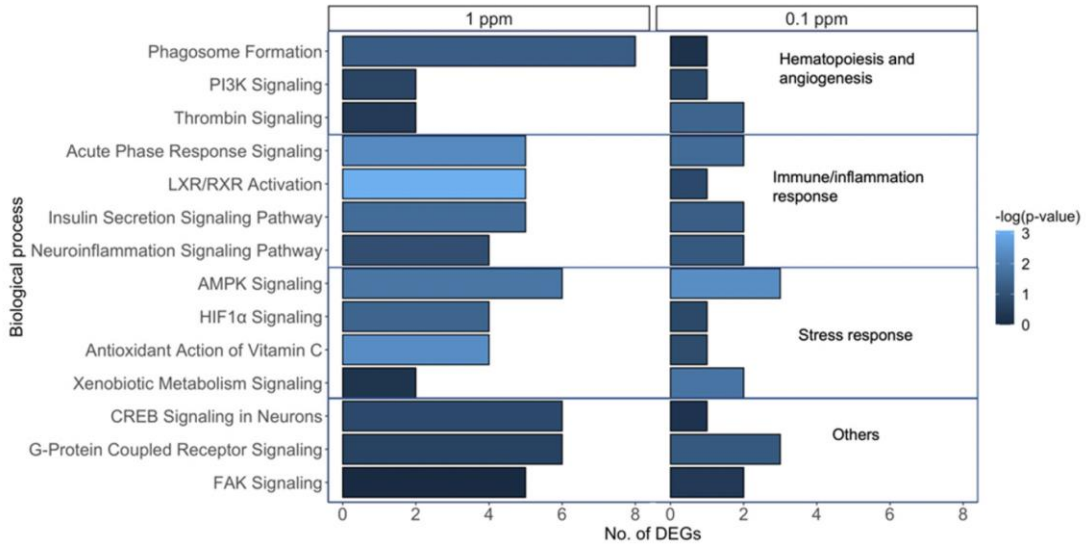
Evaluating Phenotypic and Transcriptomic Responses Induced by Low-Level VOCs in Zebrafish: Benzene as an Example

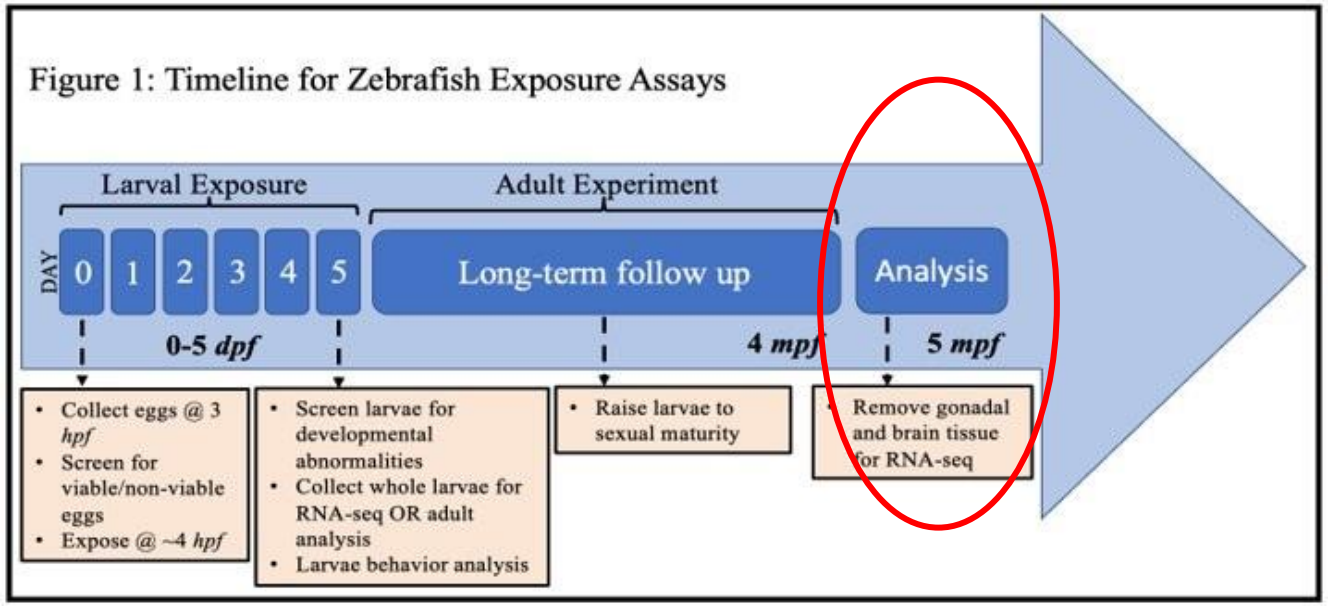
Chia-Chen Wu [1], Jessica R Blount [2], Alex Haimbaugh [2 3], Samantha Heldman [2 3], Jeremiah N Shields [2], Tracie R Baker [1 2 3]

DEGs of interest involved in cytokine signaling and inflammatory response

APOA1	**MAP2K2**
APOB	**MAP2K6**
CYP19A1	**MAPK11**
DDR2	MERTK
EPHA5	NCF2
GDPD2	NFKBIA
GGT5	**PIK3C2B**
GHDC	**PRKCB**
GNAT2	**RASD1**
HSP90AA1	**RBP4**
IGF1	**SLC2A1**
IRS2	SOS2
LGALS1	**TNFRSF1A**



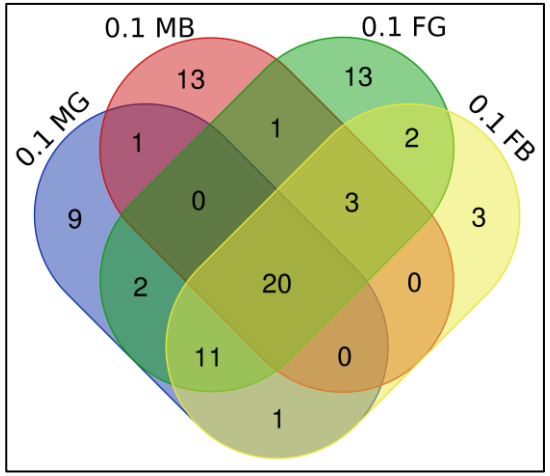


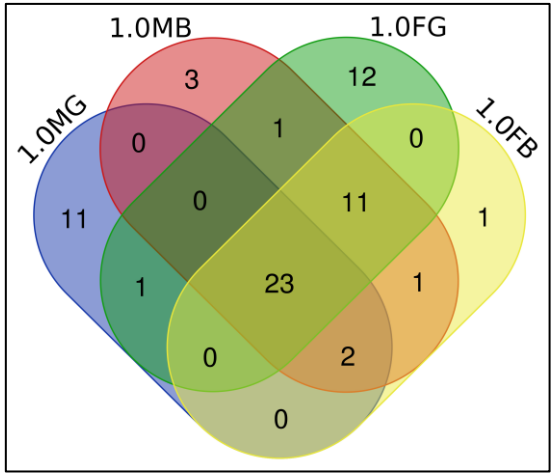


Top IPA pathways affected by benzene exposure

Benzene Exposure Levels	0.1 ppm				1 ppm			
Diseases and Disorders	**FB**	**MB**	**FG**	**MG**	**FB**	**MB**	**FG**	**MG**
Cancer	2,162	98	520	1082	884	1329	202	258
Organismal Injury and Abnormalities	2180	101	522	1100	894	1340	204	261
Endocrine System Disorders	1878	89	480	953	795	1208	184	219
Gastrointestinal Disease	1938		491	956	827	1228	189	
Neurological Disease	1607	85	402	782				191
Reproductive System Disease		80				1022	151	199

Concentration (ppm)	Sex	Tissue	# DEGs
0.1	Female	Brain	1110
0.1	Male	Brain	1
0.1	Female	Gonad	459
0.1	Male	Gonad	818
1	Female	Brain	154
1	Male	Brain	887
1	Female	Gonad	79
1	Male	Gonad	61





15 reproductive system pathways (all tissues and concentrations):

- Endometrial adenocarcinoma
- Development of genital tumor
- Uterine carcinoma
- Tumorigenesis of reproductive tract
- Female genital neoplasm
- Breast or gynecological cancer

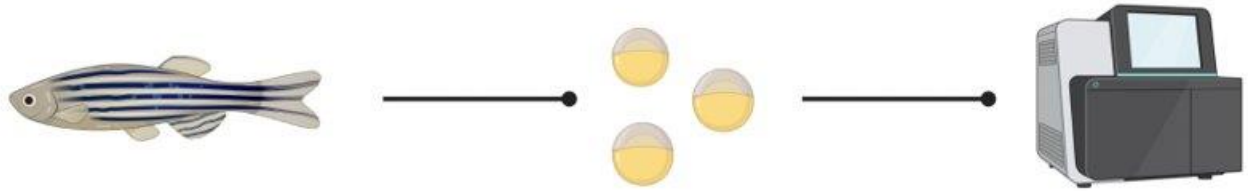
Low-level benzene induces disease in adulthood

- **Low-level benzene exposure** of 0.1 ppm and 1 ppm can induce alterations associated with **reproductive system disorders later in life.**

- Adult tissue and larval DEGs were implicated in **cancer, endocrine system, gastrointestinal disease, and reproductive system disease.**

Continued research

- Adult behavior, fertility/fecundity, epigenetics, transgenerational effects.
- Assess the risk of benzene exposure in a complex mixture (BTEX).



Graphic recording of the research for Project 3 presented at the CLEAR Symposium 2023

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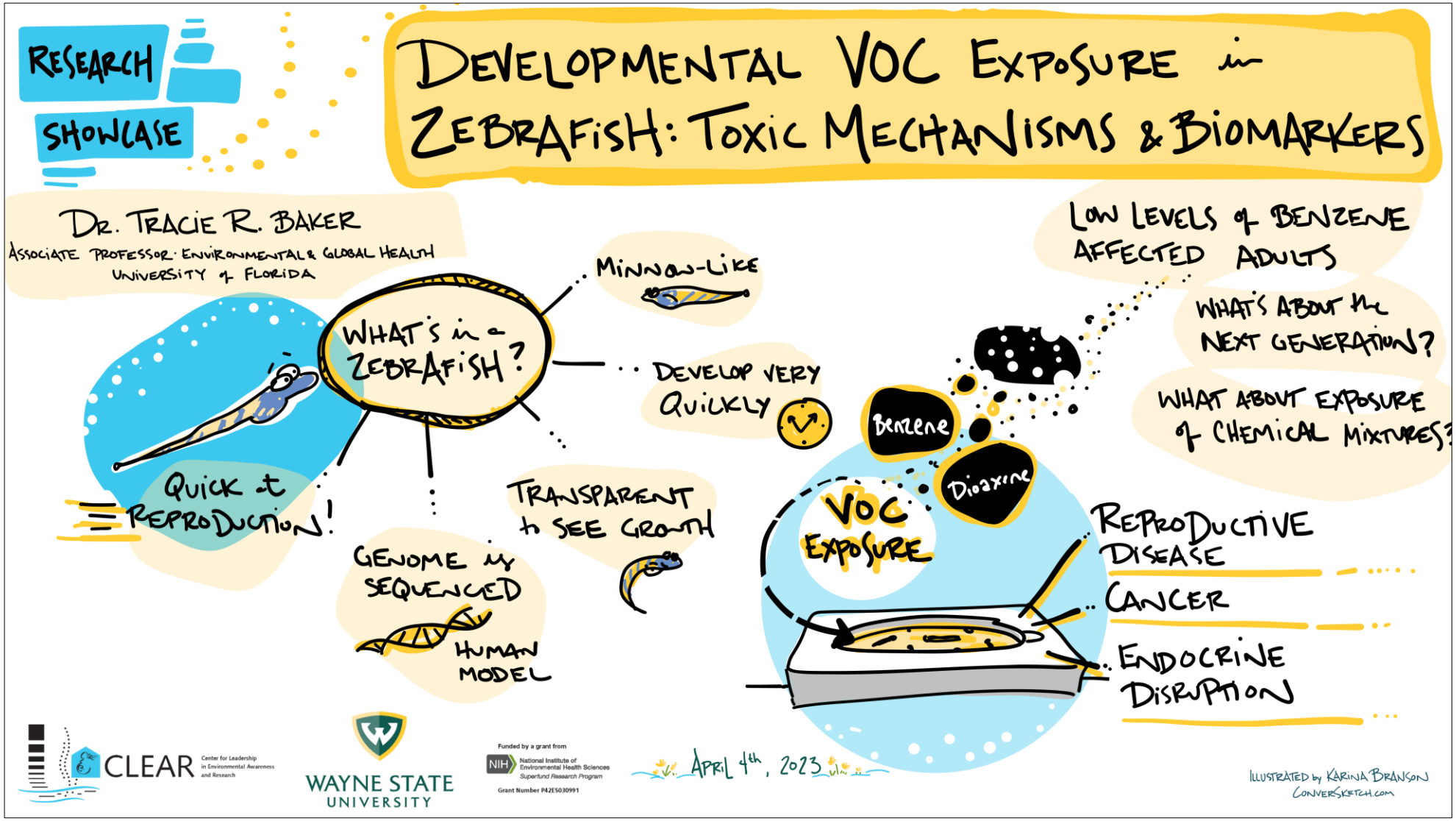

Project 5

Epidemiological study of volatile organic compounds and preterm birth in Detroit

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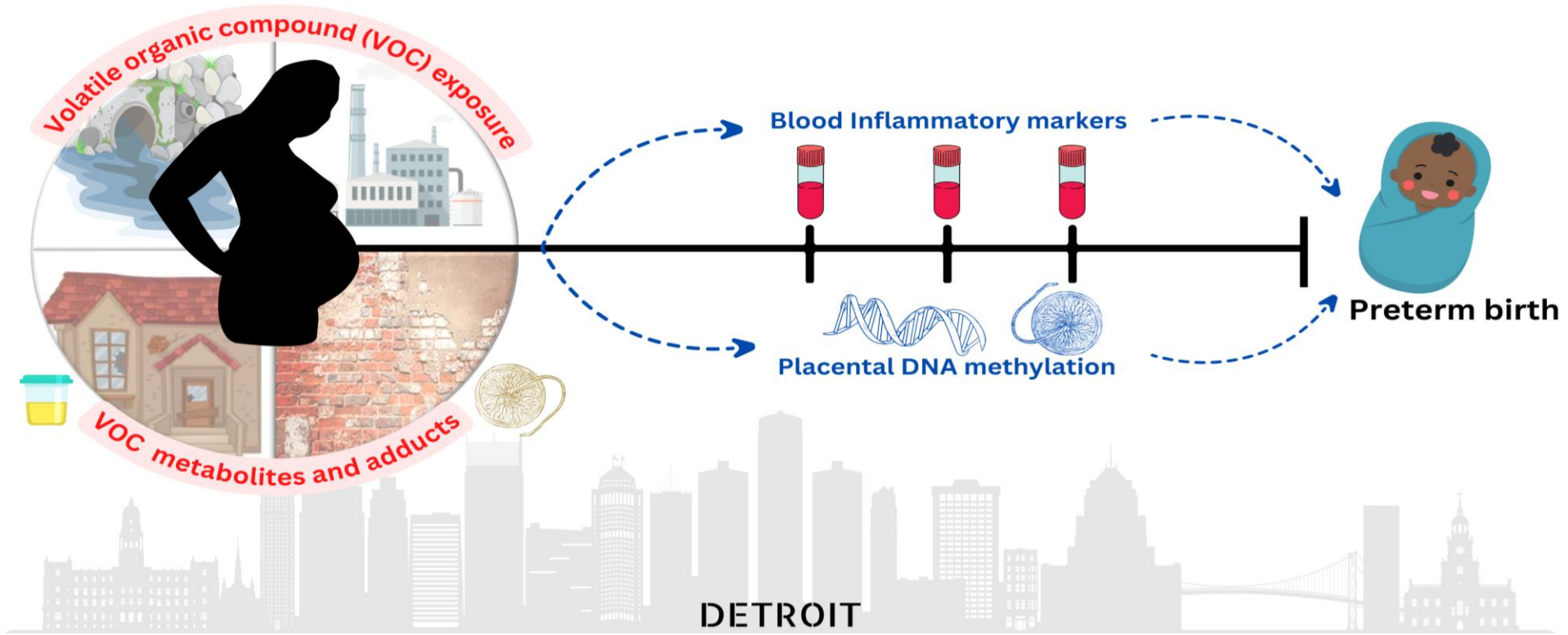
Researchers

Dr. Jennifer K. Straughen
Public Health Sciences

Dr. Andrea Cassidy-Bushrow
Public Health Sciences

HENRY FORD HEALTH®

Epidemiological study of volatile organic compounds and preterm birth in Detroit



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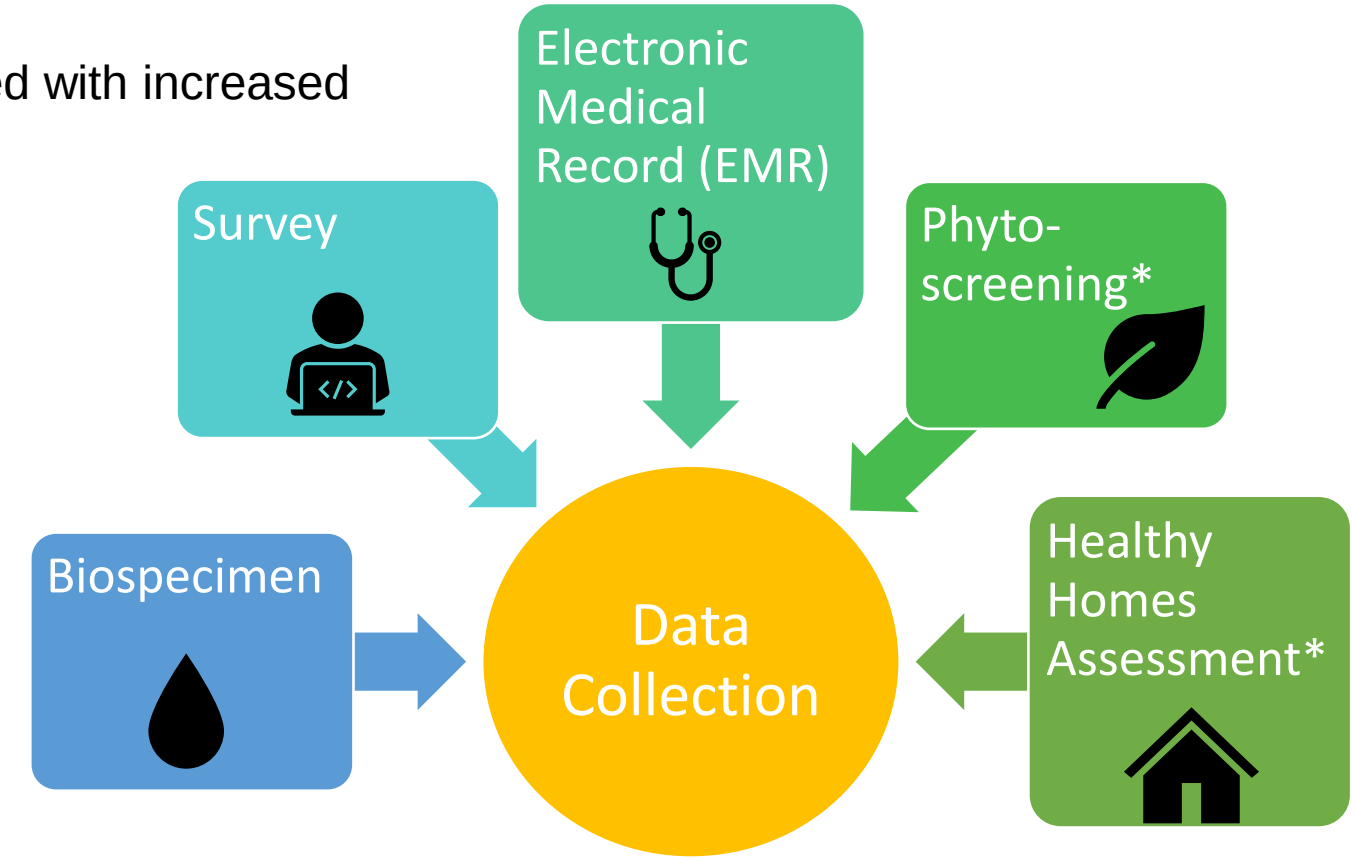
The CLEAR birth cohort

- Detroit preterm birth (PTB) rate: 14.5%
- Preterm birth (<37 weeks) associated with increased infant mortality and chronic disease
- Data suggests that airshed VOCs are associated with PTB
- Prospective cohort study
  - Nested case-control of PTB
- Recruitment of ~ 1,100 pregnant persons
- Cross-project collaboration with CEC and phytoscreening (*)



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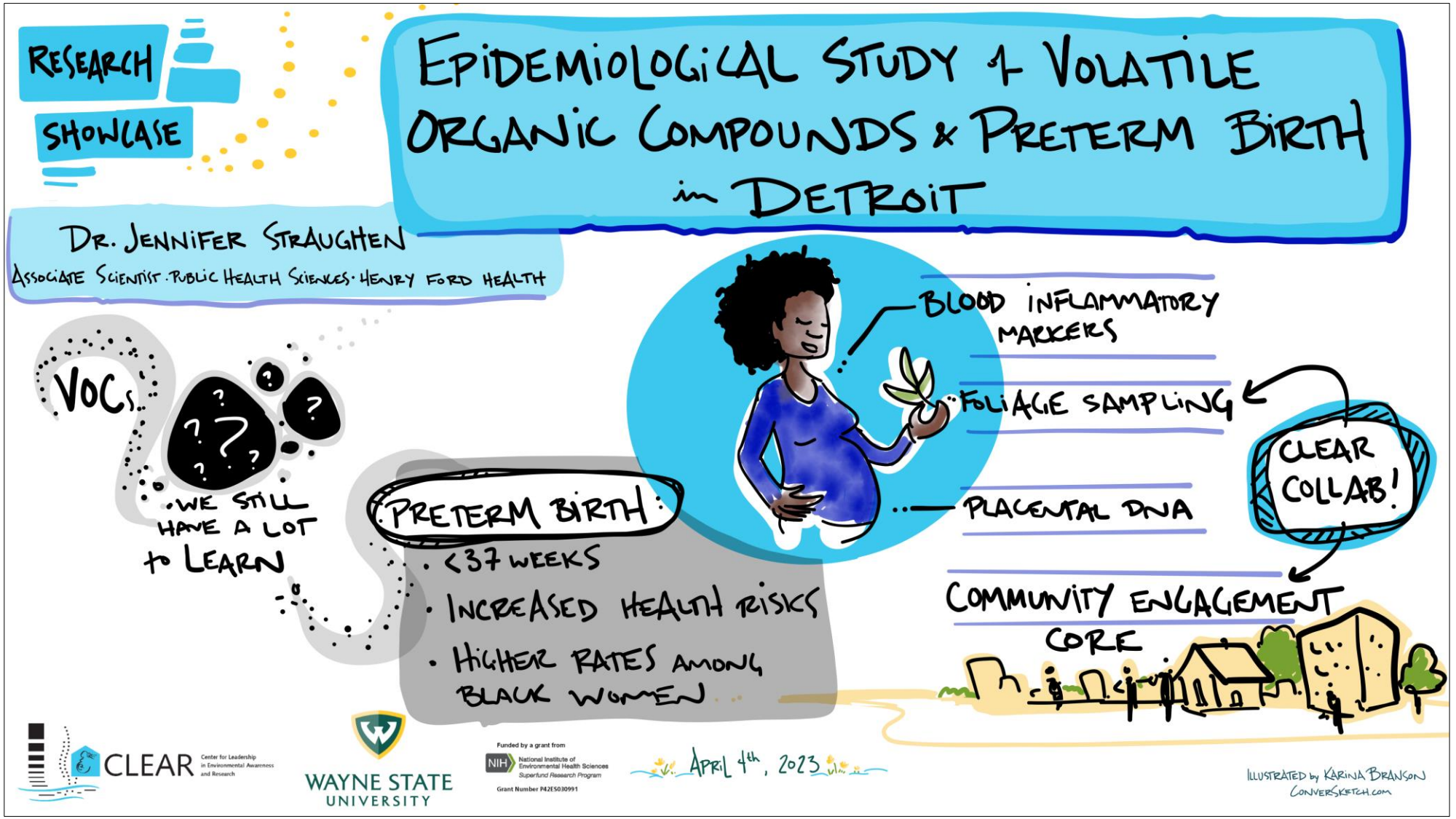

Thank you!

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