Hormonal Activity of Chemicals Detected with Silicone Wristbands

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HEALTHY BUILDINGS

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Hormone receptor activities of complex mixtures of known and suspect chemicals in personal silicone wristband samplers worn in office buildings

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Slides: Anna Young, 2023

About 70,000 chemicals were registered globally in the last decade alone

Wang et al. 2020

are “confidential”

Hormone-Disrupting Chemicals

INFERTILITY

MISCARRIAGE

STUNTED DEVELOPMENT

THYROID DISEASE

DIABETES

OBESITY

BUILDING MATERIALS

FURNITURE

FLOORING

ELECTRONICS

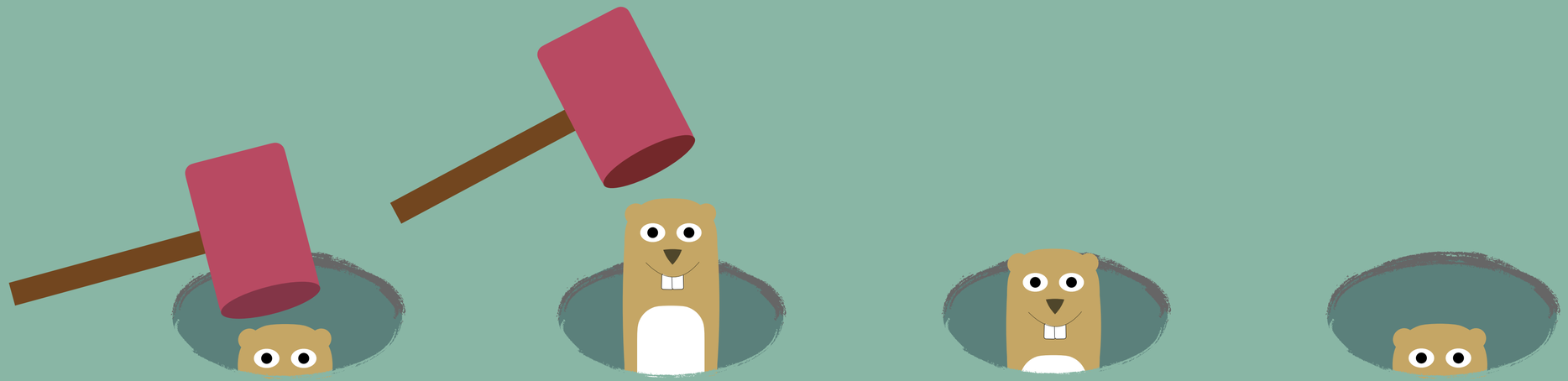
CONSUMER PRODUCTS

PERSONAL CARE PRODUCTS

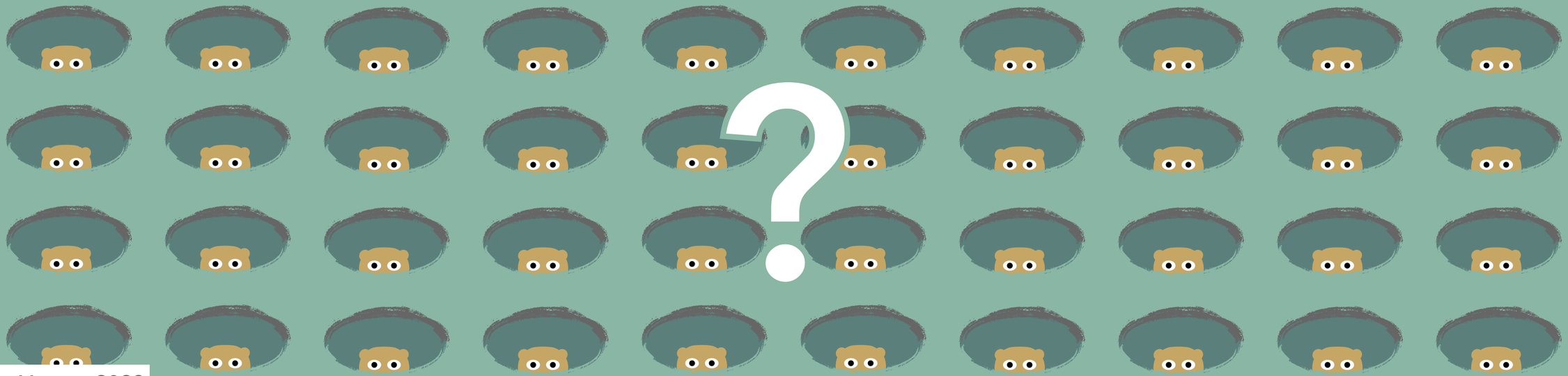
Slides: Anna Young, 2023

Chemical Whack-A-Mole

Example: Flame Retardants



PBDEs OPEs Novel BFRs ?



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Traditional targeted methods that test only one chemical at a time cannot keep up with the rate of new chemicals entering the market

We need to evaluate our exposures to chemicals as the complex mixtures they are in the real world, not just as individual chemicals

Slides: Anna Young, 2023

RESEARCH QUESTION

How hormonally toxic are complex chemical mixtures in buildings?

Slides: Anna Young, 2023

RESEARCH GOAL

Evaluate the
hormone-disrupting potential
of complex mixtures of
known chemicals and
unknown chemicals
that humans are
personally exposed
to in the real-world

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Evaluate the hormone-disrupting potential of complex mixtures of known chemicals and unknown chemicals that humans are **personally exposed** to in the real-world

Slides: Anna Young, 2023

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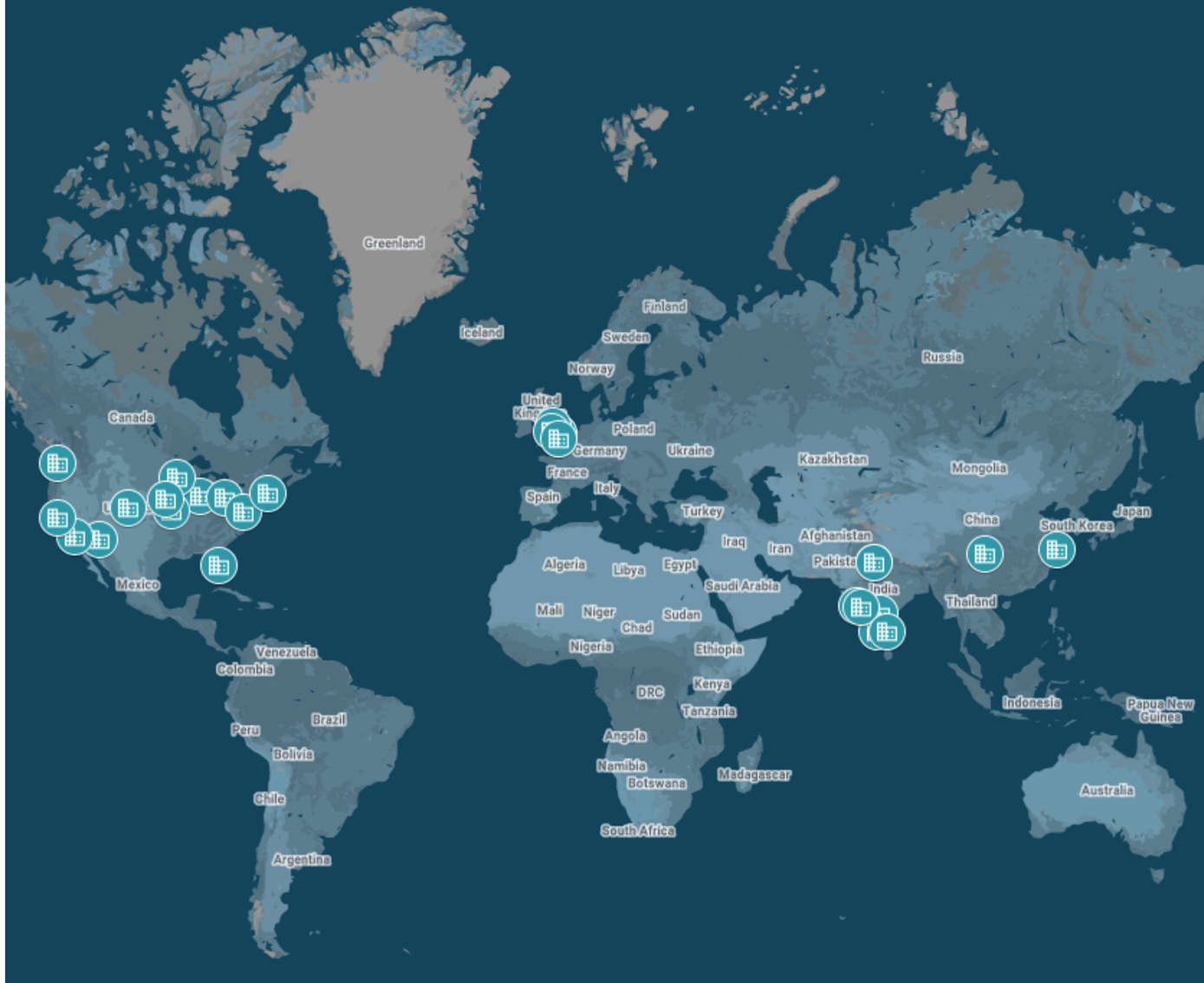
Evaluate the hormone-disrupting potential of complex mixtures of known chemicals and unknown chemicals that humans are **personally exposed** to in the real-world

Recruited from 36 office bldgs in US, UK, CH, and IN in the Global Buildings Study



Slides: Anna Young, 2023

RESEARCH GOAL

Evaluate the hormone-disrupting potential of complex mixtures of known chemicals and unknown chemicals that humans are personally exposed to in the real-world

~100 targeted chemicals in wristband extracts (GC-MS/MS)

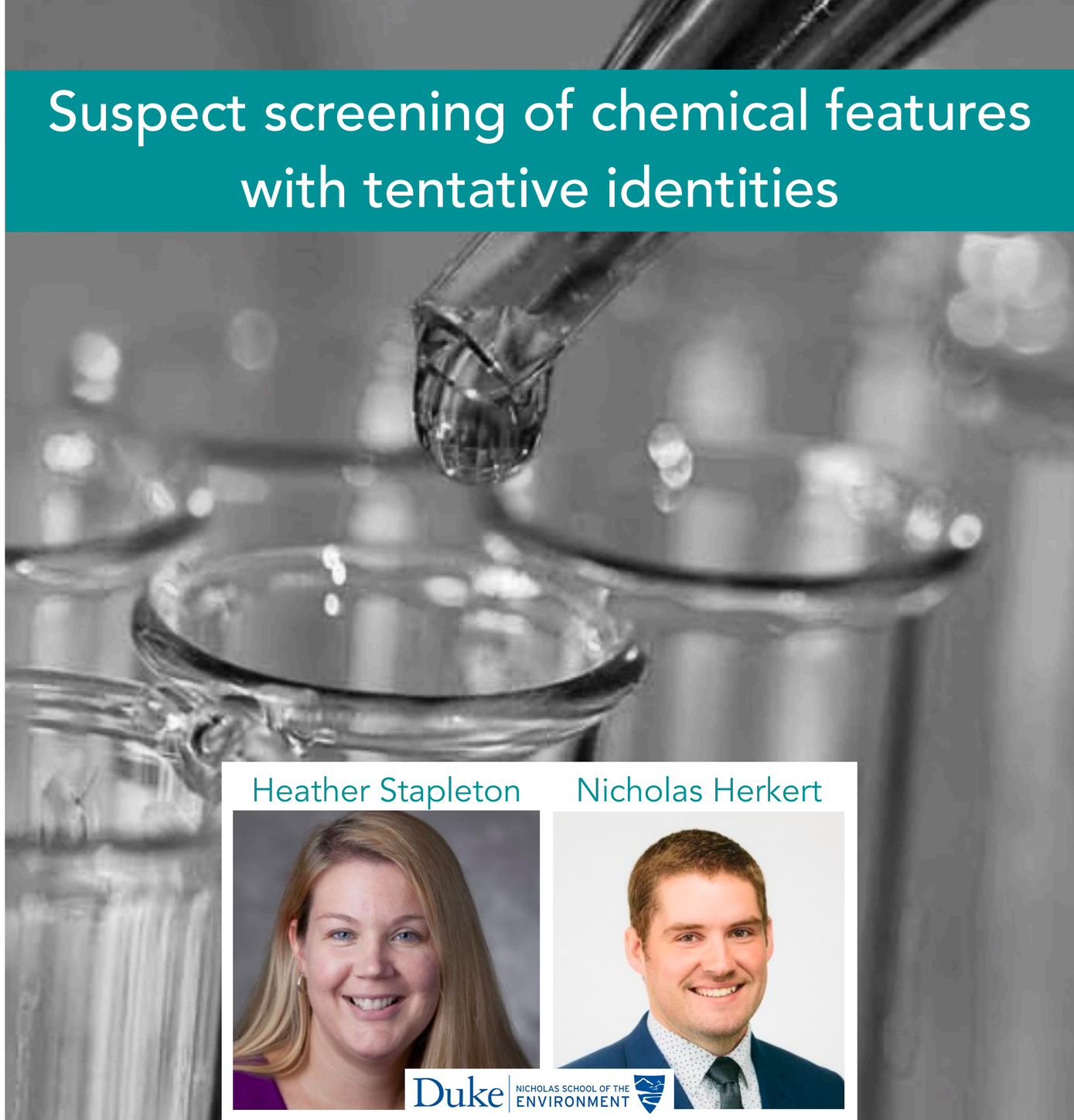
BFRs | OPEs | Phthalates | Pesticides | PCBs | PAHs

Slides: Anna Young, 2023

RESEARCH GOAL

Evaluate the hormone-disrupting potential of complex mixtures of known chemicals and **unknown chemicals** that humans are personally exposed to in the real-world

Suspect screening of chemical features with tentative identities



Slides: Anna Young, 2023

RESEARCH GOAL

Evaluate the

hormone-disrupting potential

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Interference with estrogen, androgen, and thyroid hormone receptors in human cell assays (based on firefly gene)

BioDetection Systems

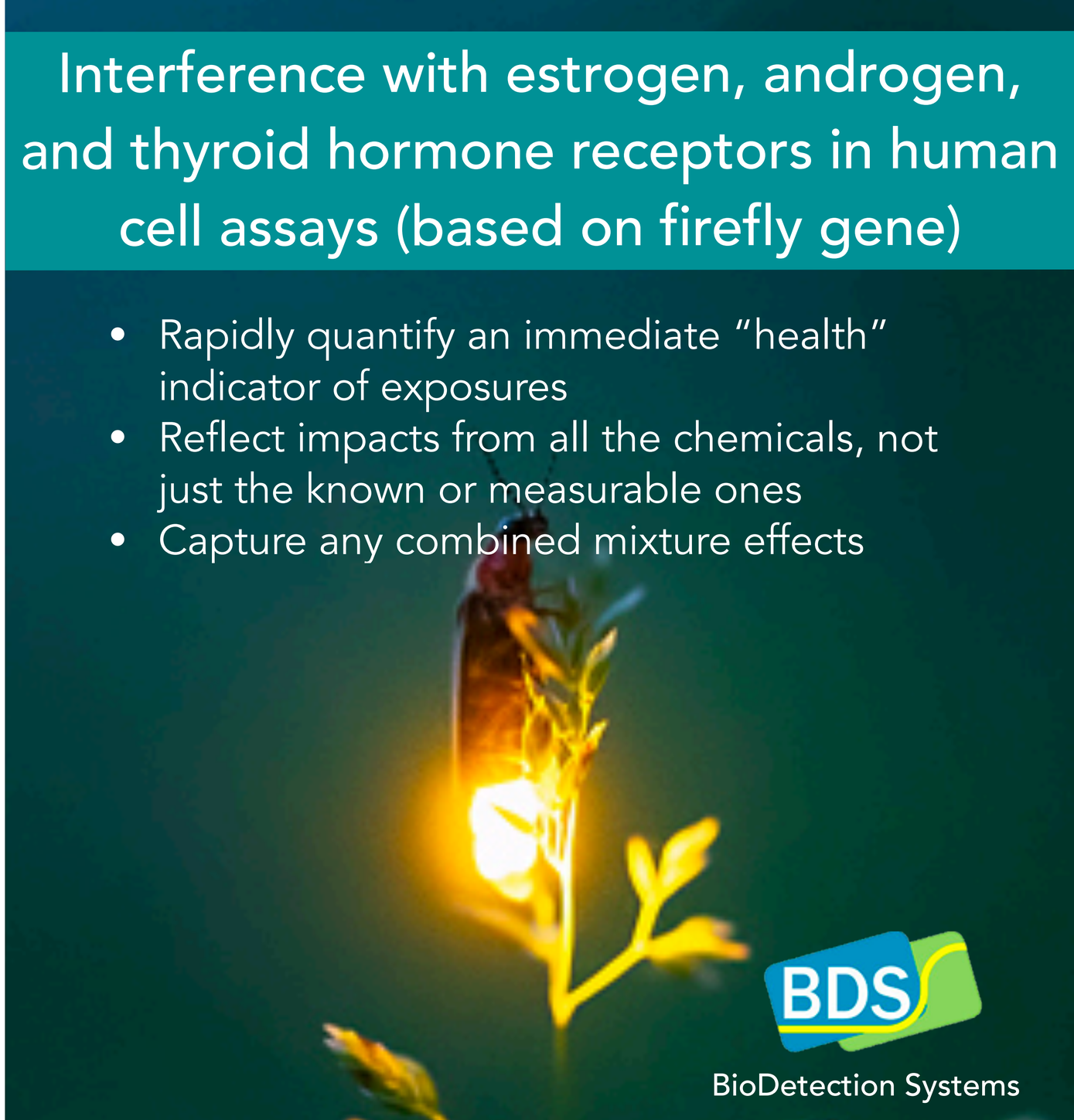
Slides: Anna Young, 2023

RESEARCH GOAL

Evaluate the **hormone-disrupting potential** of complex mixtures of known chemicals and unknown chemicals that humans are personally exposed to in the real-world

Interference with estrogen, androgen, and thyroid hormone receptors in human cell assays (based on firefly gene)

- Rapidly quantify an immediate “health” indicator of exposures
- Reflect impacts from all the chemicals, not just the known or measurable ones
- Capture any combined mixture effects



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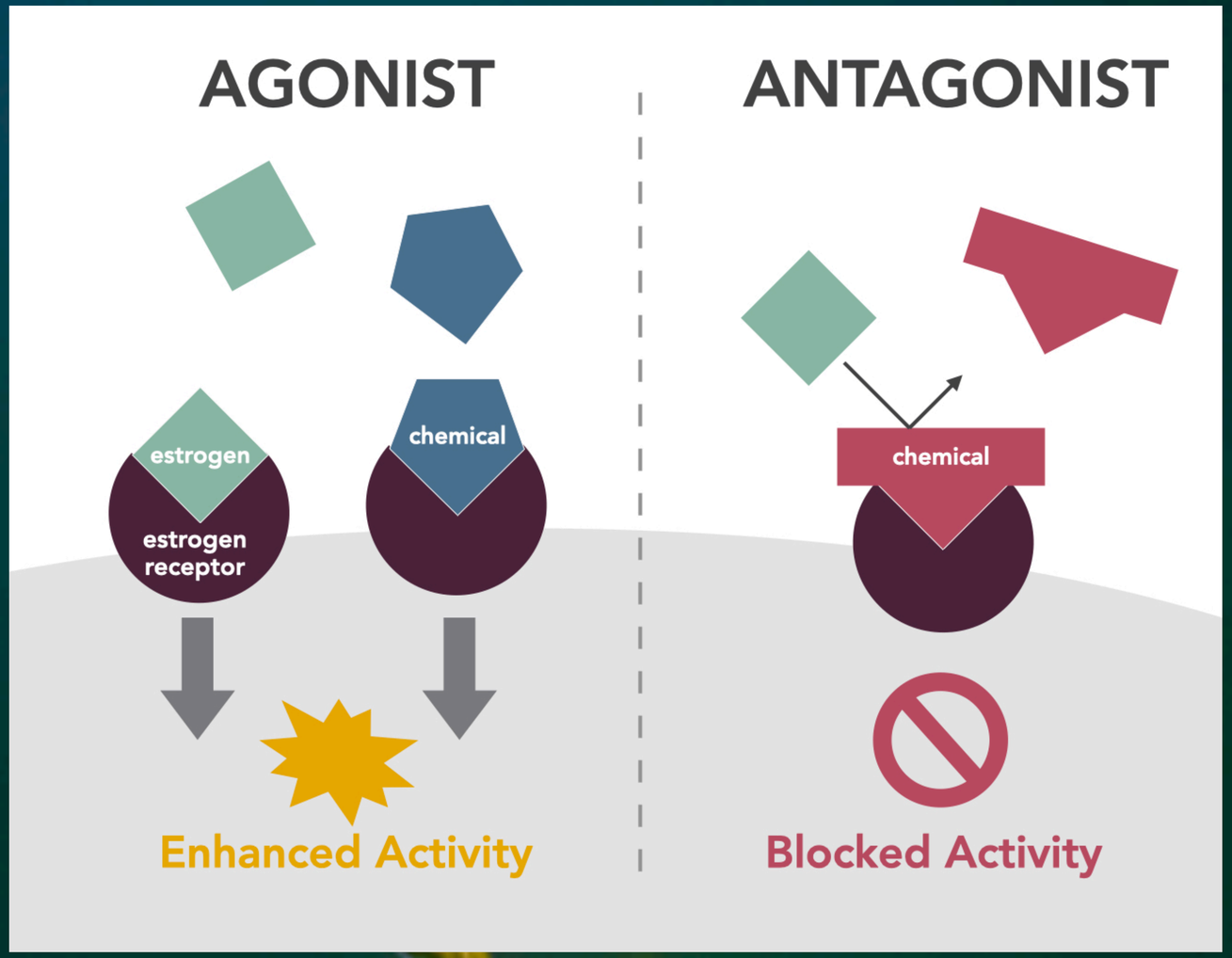

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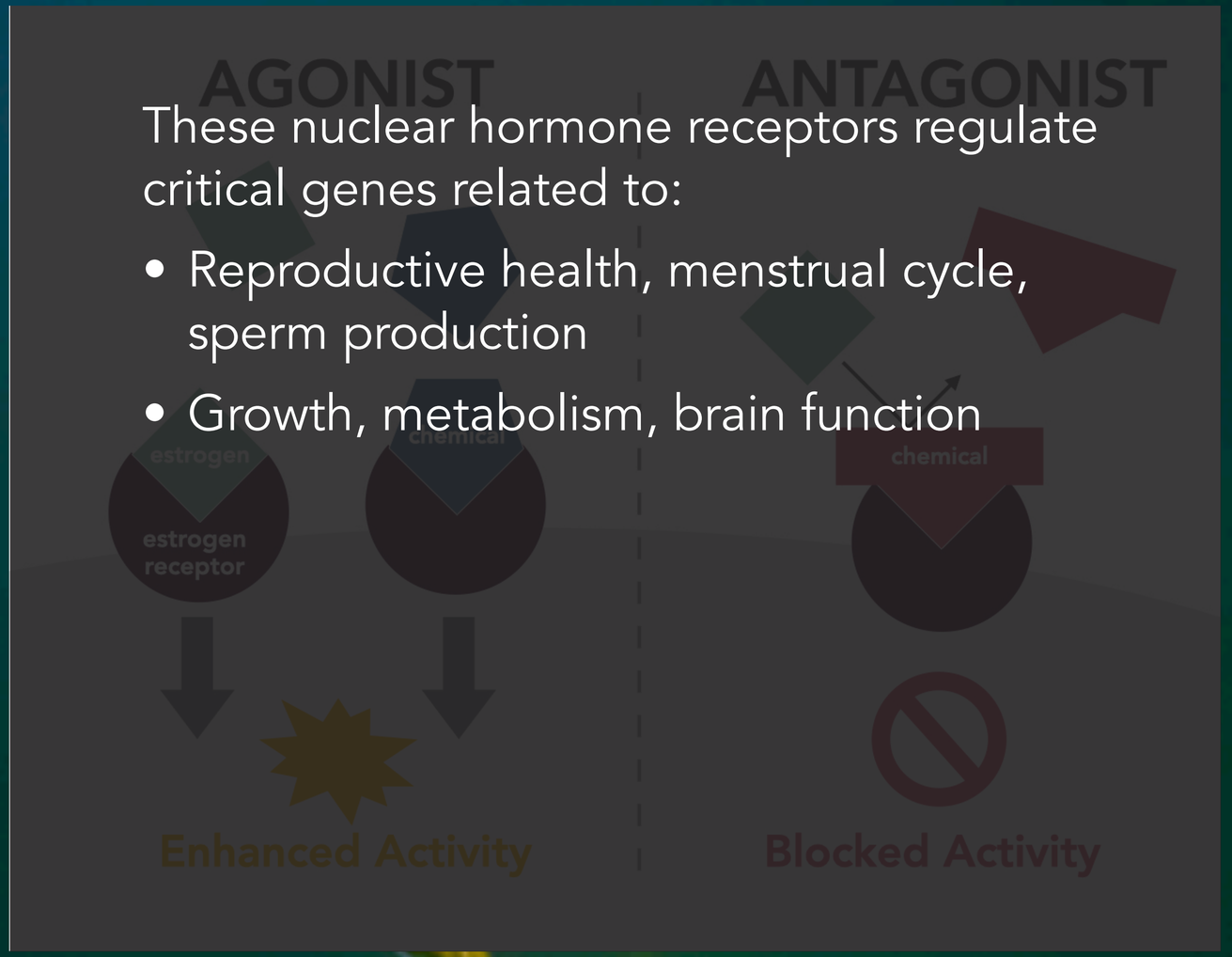

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RESEARCH GOAL

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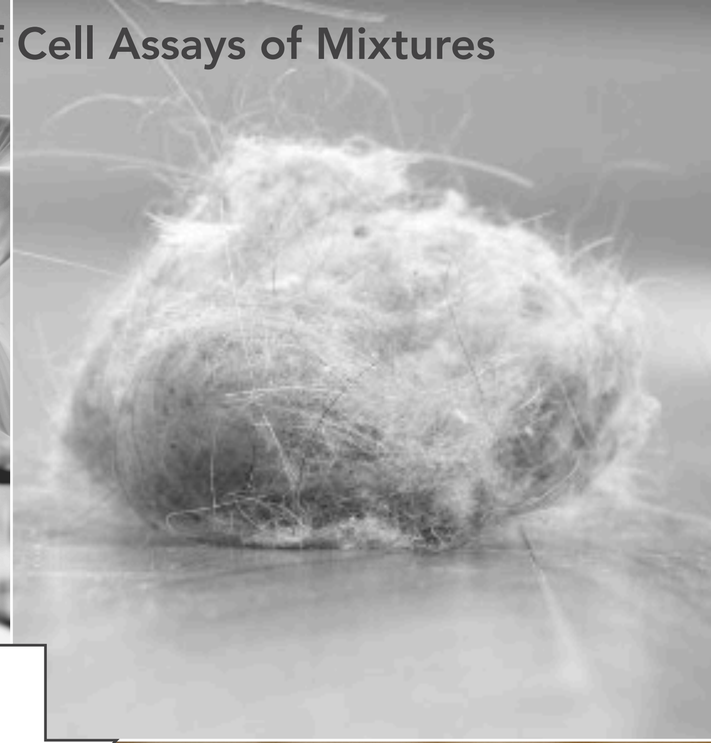
Previous Research of Cell Assays of Mixtures



Personal **Environmental Exposures**

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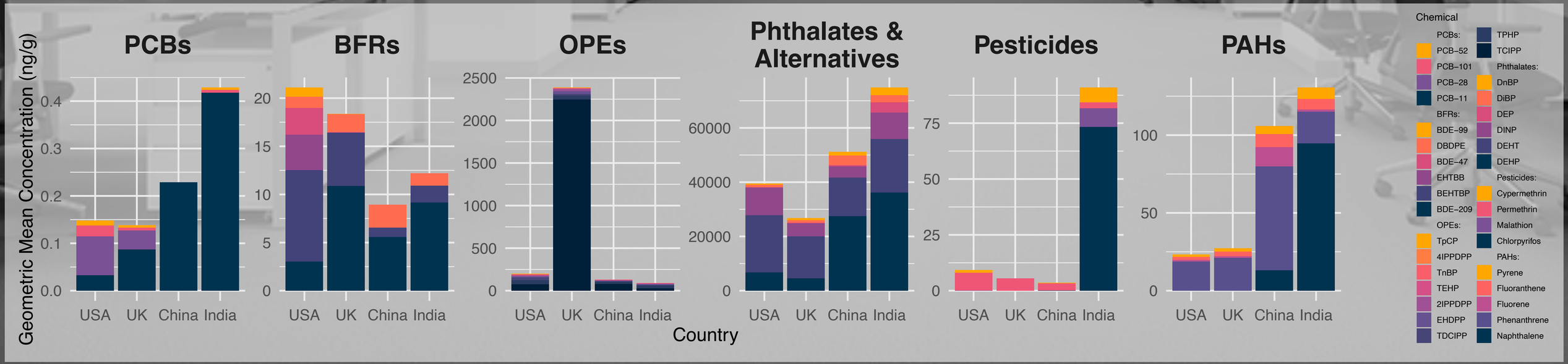
RESULTS

Previous Paper: Targeted Chemicals

The office workers were often exposed to:

1. Legacy chemicals even after being eliminated decades ago
2. Chemicals not yet banned in some of the countries
3. Substitute chemicals used to replace the legacy chemicals



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What about other unknown chemicals?

>1,000 chemical signatures in the wristbands

~587 were detected in at least half of samples
(with potential duplicates condensed)

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The average participant was exposed to ~800

"Fragrance" was the most common reported functional use among the identifiable features

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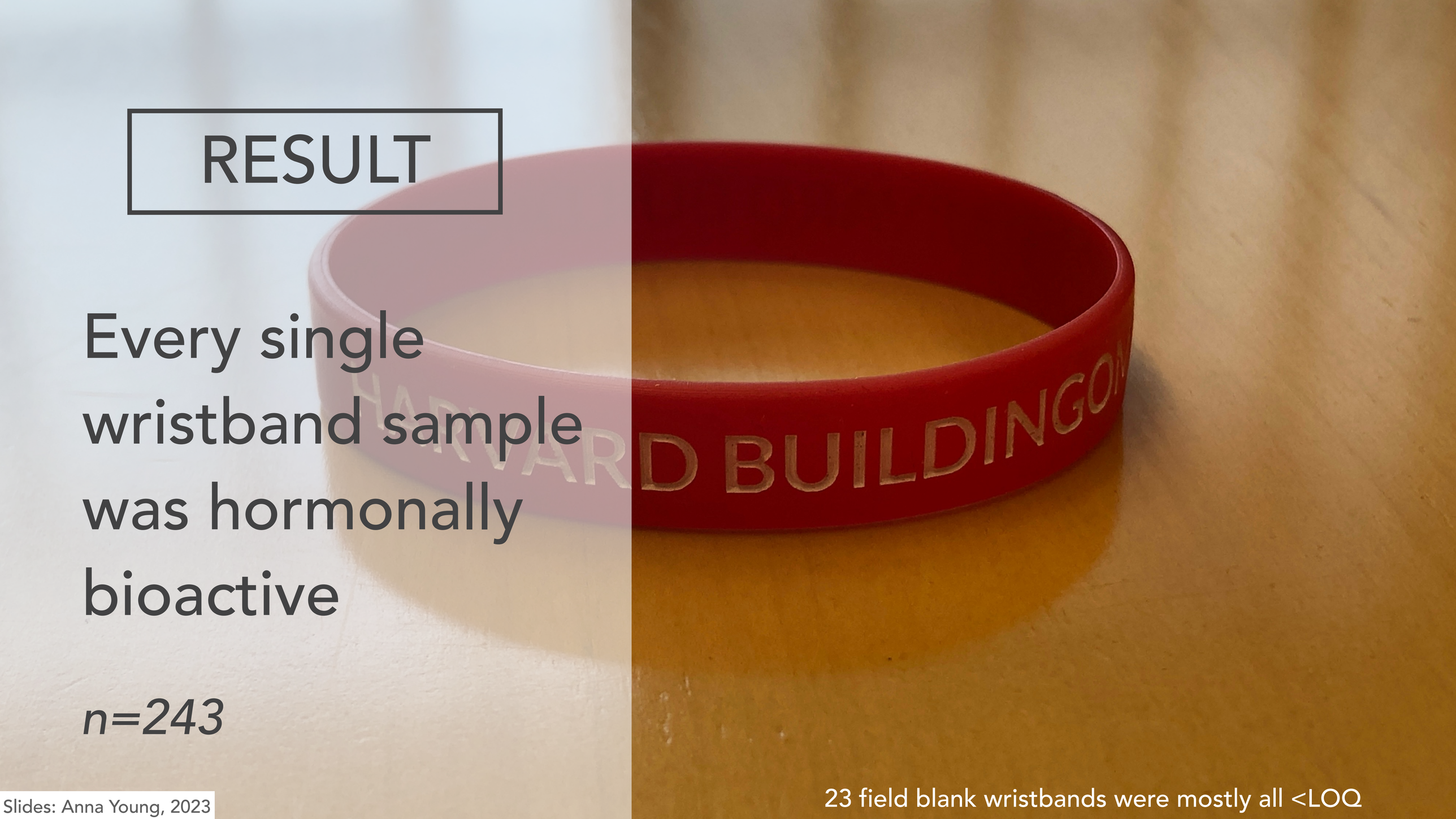
How much can these complex and unknown mixtures of chemicals disrupt hormones?

RESULT

Every single wristband sample was hormonally bioactive

n=243



23 field blank wristbands were mostly all <LOQ

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RESULT

In human cells, the chemical mixtures that we are exposed to in office buildings mimick or block hormones

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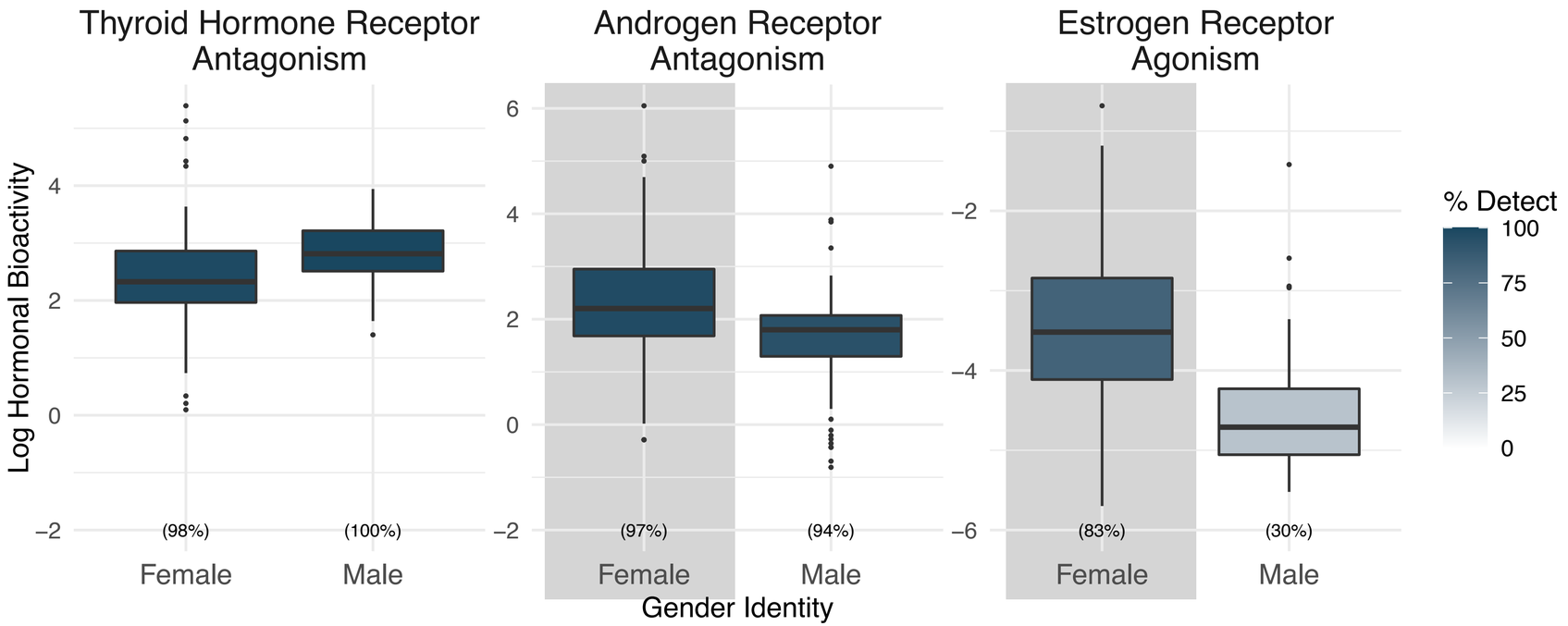
GENDER DISPARITY?

- Female office workers had exposures that were more estrogenic, more anti-androgenic, and more complex
- They were also heavier cosmetic users (based on product surveys)



Adjusted for country, age, and squalene (~sebum skin oil) as detected in suspect screening.
Cannot exclude possibility of influence by endogenous molecules from skin that differ by sex.

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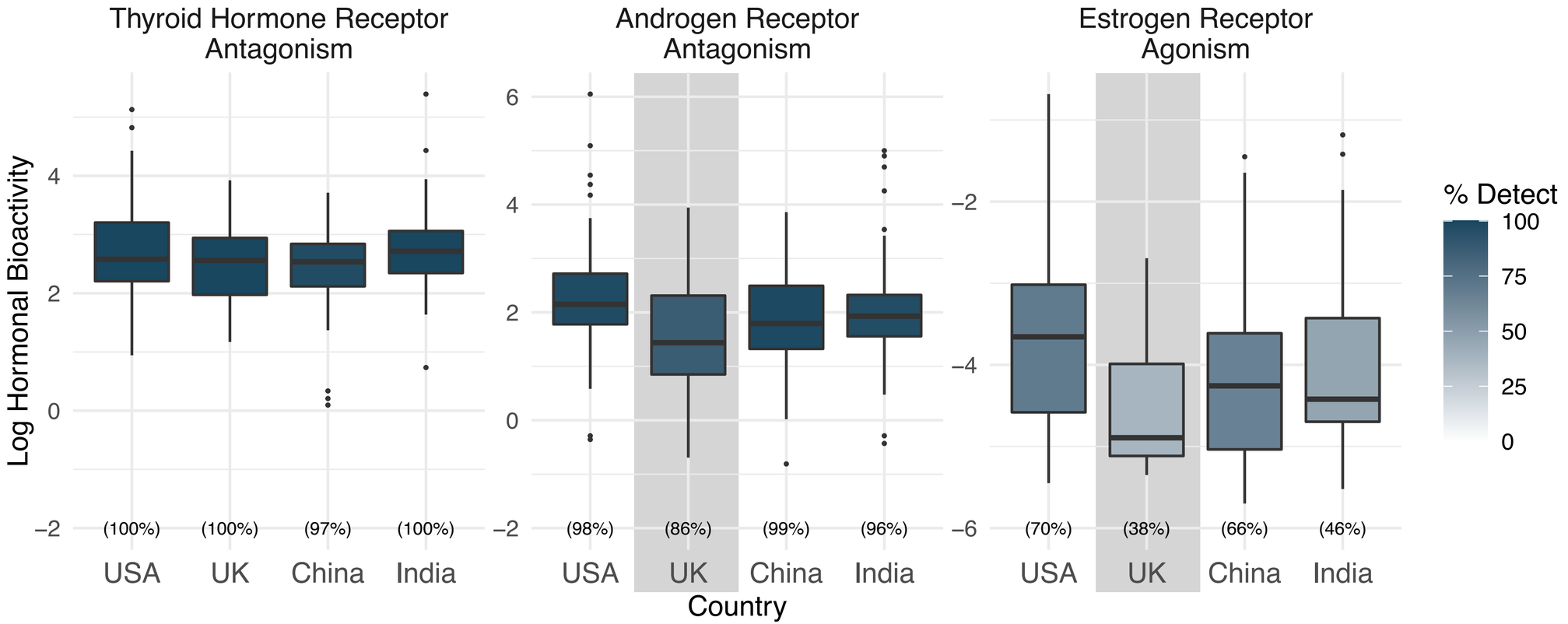
COUNTRY EFFECTS

- Workers in the UK tended to be exposed to less hormonally active mixtures



Adjusted for gender, age, and squalene (~sebum skin oil) as detected in suspect screening.

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MIXTURE EFFECT

- How to analyze the effects of many collinear chemicals in the same model?

Bayesian kernel machine regression (BKMR) models:

1. Evaluate *cumulative* mixture effect
2. Identify effects of *individual* mixture components (‘bad actors’)
3. Allow non-linear, non-additive, and multi-directional effects
4. Investigate potential interactions between chemicals

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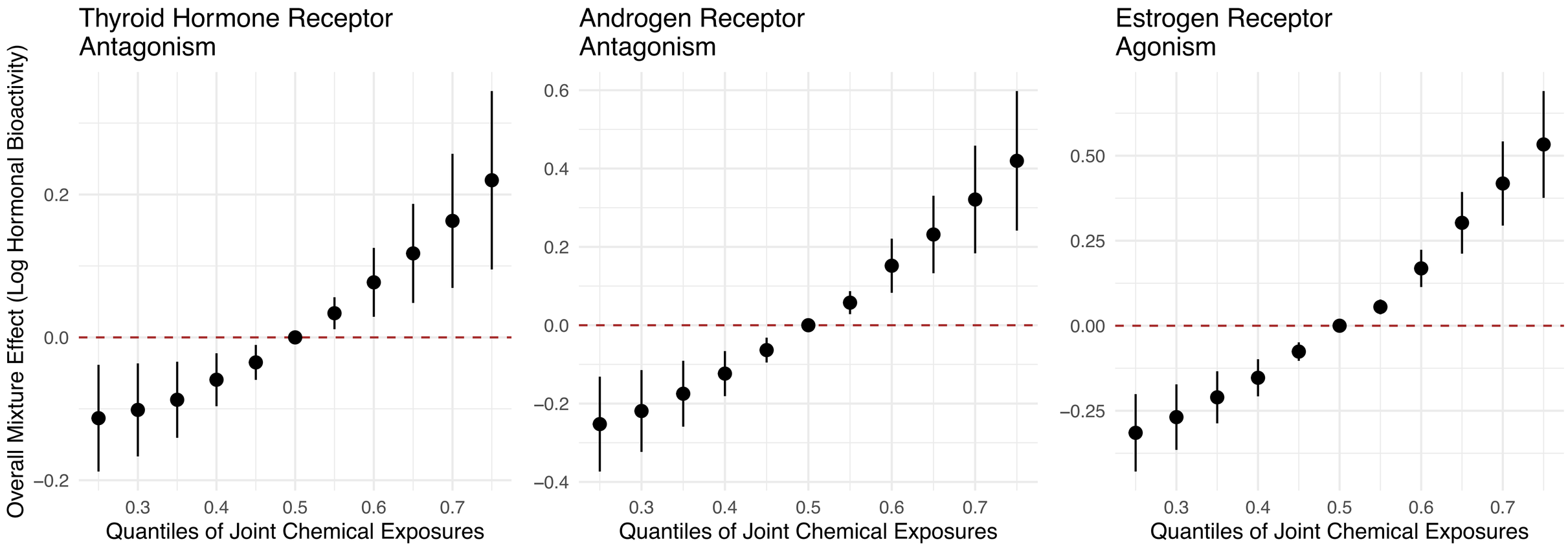
MIXTURE EFFECT

- The higher the levels of all chemicals in the samples, the higher hormonal activity
- True for separate BKMR models of the targeted mixtures *and* the suspect mixtures



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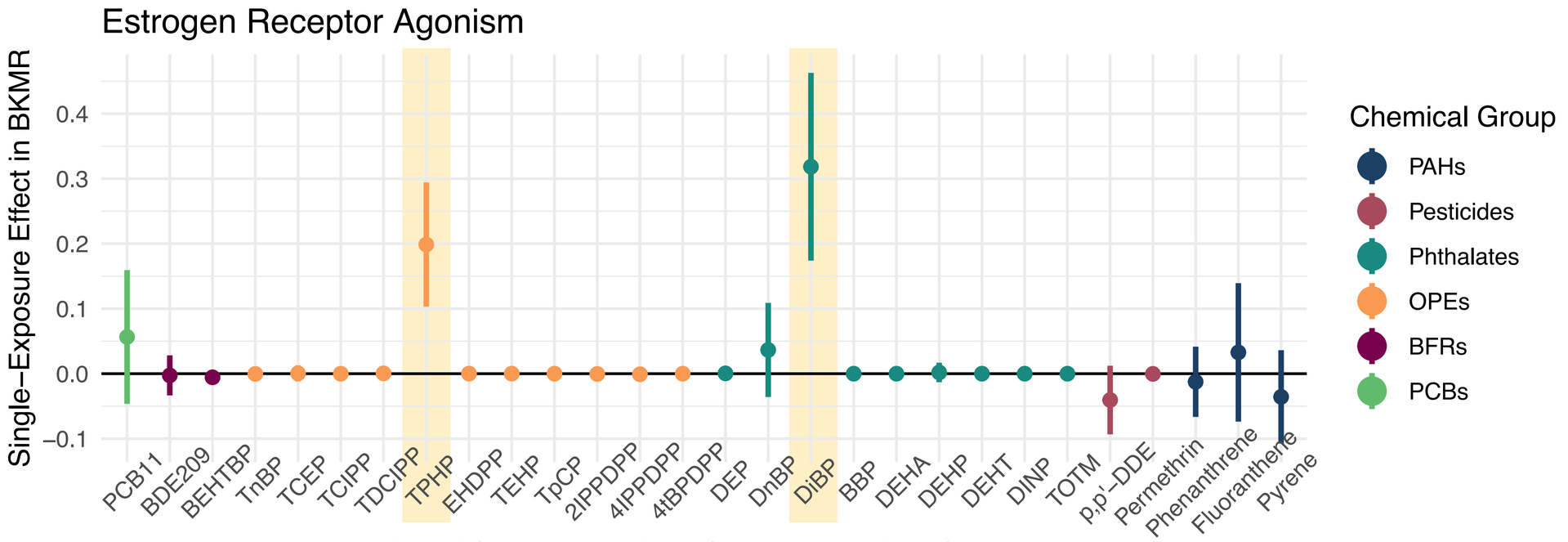
Adjusted for country and squalene (~sebum skin oil)

SINGLE EFFECTS

- **Several known *and* unknown chemicals were important individual drivers of the mixture effects (when holding other chemicals constant)**
  - Including known plasticizers, fragrance, sunscreen, and pesticide ingredients

EXAMPLE FOR BKMR MODEL OF TARGETED CHEMS:



Adjusted for country and squalene (~sebum skin oil)

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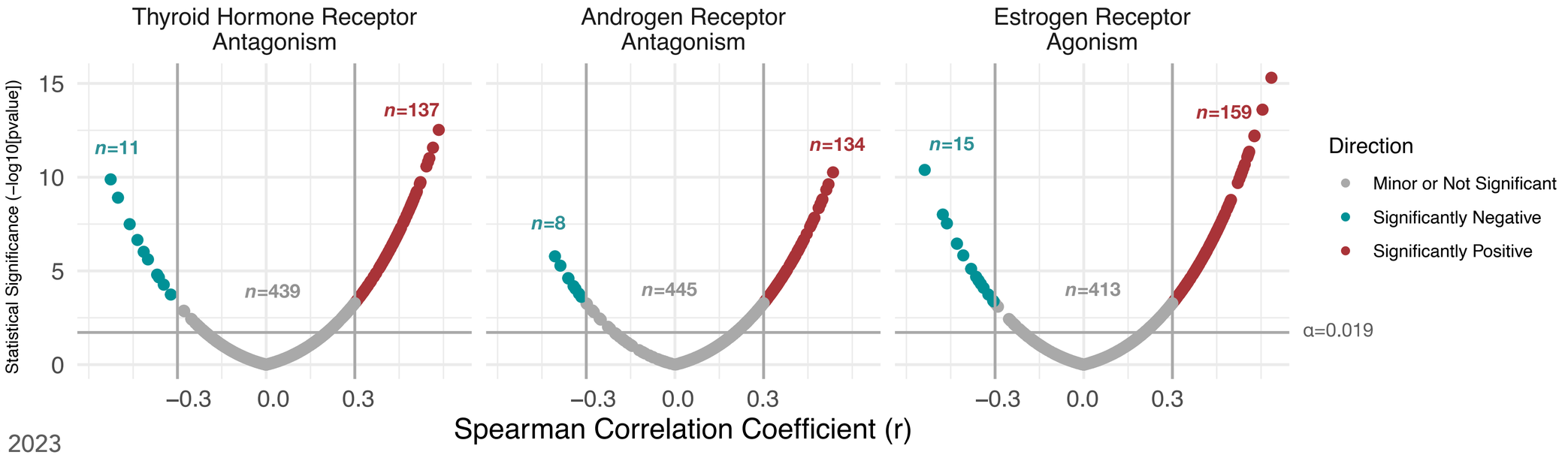
SINGLE EFFECTS

- **Several known *and* unknown chemicals were important individual drivers of the mixture effects (when holding other chemicals constant)**
  - Many other chemicals may have still had contributing effects:

Over 130 chemical signatures were significantly correlated with each hormonal activity outcome



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SINGLE EFFECTS

- **Several known *and* unknown chemicals were important individual drivers of the mixture effects (when holding other chemicals constant)**

Traditional targeted analyses alone likely miss many hormonally active chemicals

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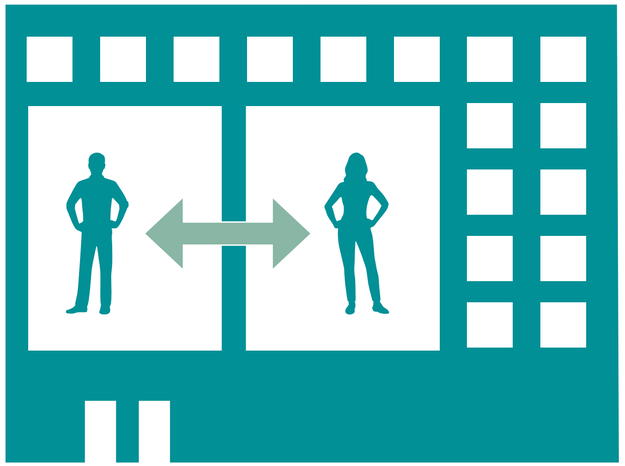
SHARED BUILDINGS

- Micro-environments, personal “activity clouds”, and personal care products are important

Within buildings:



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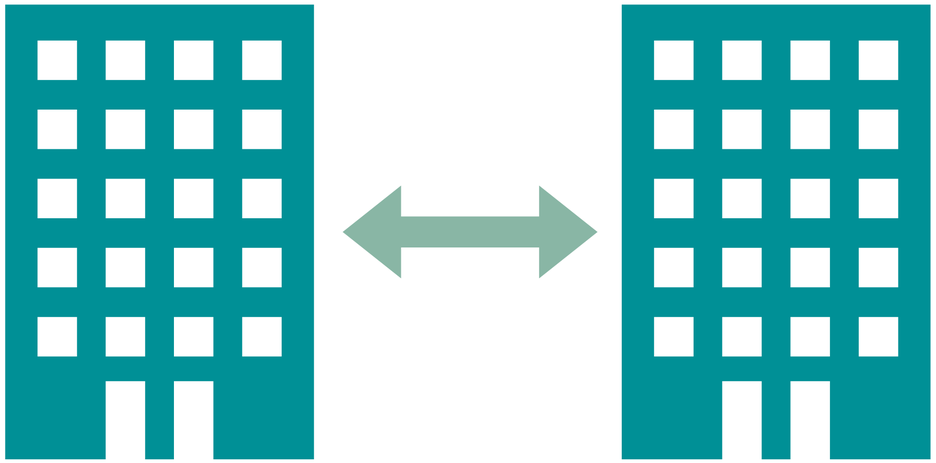
Between buildings:



77-99%

1-23%

of the variability in hormonal bioactivities in basic multilevel models

Adjusted for country, age, gender, squalene. Some endogenous molecules from skin contact could potentially contribute to individual variability, too.

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SHARED BUILDINGS

- Micro-environments, personal “activity clouds”, and personal care products are important

In previous study, 100% of indoor dust samples were hormonally active in the same assays, and the levels varied between rooms within the same building

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Their exposures:

- were highly complex chemical mixtures
- included many usually-unknown chemicals
- showed strong interference with hormone receptor fx
- demonstrated potential gender disparities
- were influenced by personal care products & buildings

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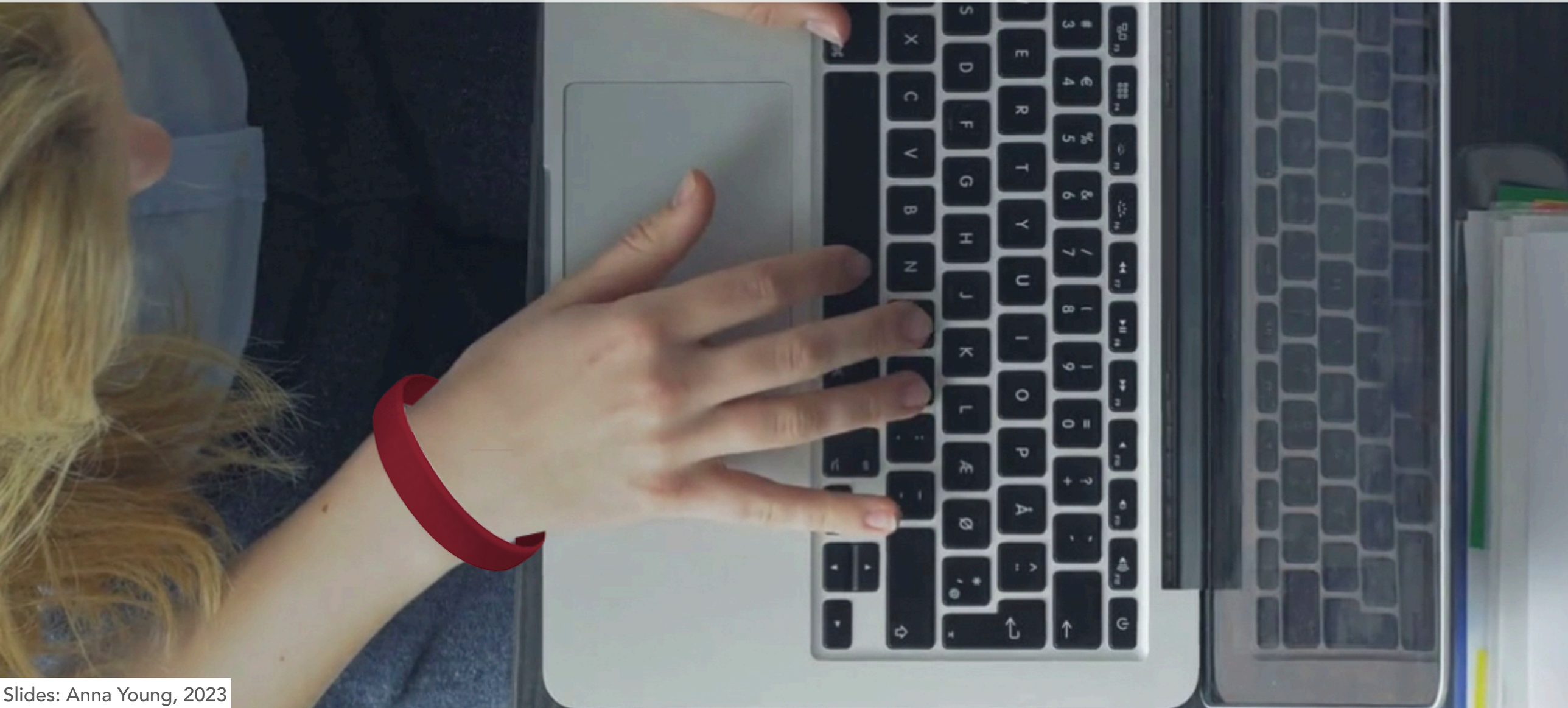
Silicone wristbands were a novel, useful way to sample complex external exposures in workplaces across the world



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Feb 2023:
cell assays + suspect chemicals

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Nov 2021:
targeted chemicals

ELSEVIER

Environment International

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Chemical contaminant exposures assessed using silicone wristbands among occupants in office buildings in the USA, UK, China, and India

Anna S. Young [a b], Nicholas Herkert [c], Heather M. Stapleton [c], Jose Guillermo Cedeño Laurent [a], Emily R. Jones [a b], Piers MacNaughton [a], Brent A. Coull [a], Tamarra James-Todd [a], Russ Hauser [a], Marianne Lahaie Luna [a d], Yu Shan Chung [a], Joseph G. Allen [a]

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HARVARD T.H. CHAN SCHOOL OF PUBLIC HEALTH

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Peter Behnisch
Abraham Brouwer
Emiel Felzel

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- Harvard Campus Sustainability Innovation Fund
- Research gifts (JLL & Carrier) for parent cohort study

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