Boom or Bust?
Measuring exposures and health risks from oil and gas related chemicals

Tami McMullin, PhD

Senior Toxicologist

REPLACE FEAR WITH DATA

"The oldest and strongest emotion of mankind is fear, and the oldest and strongest kind of fear is fear of the unknown"

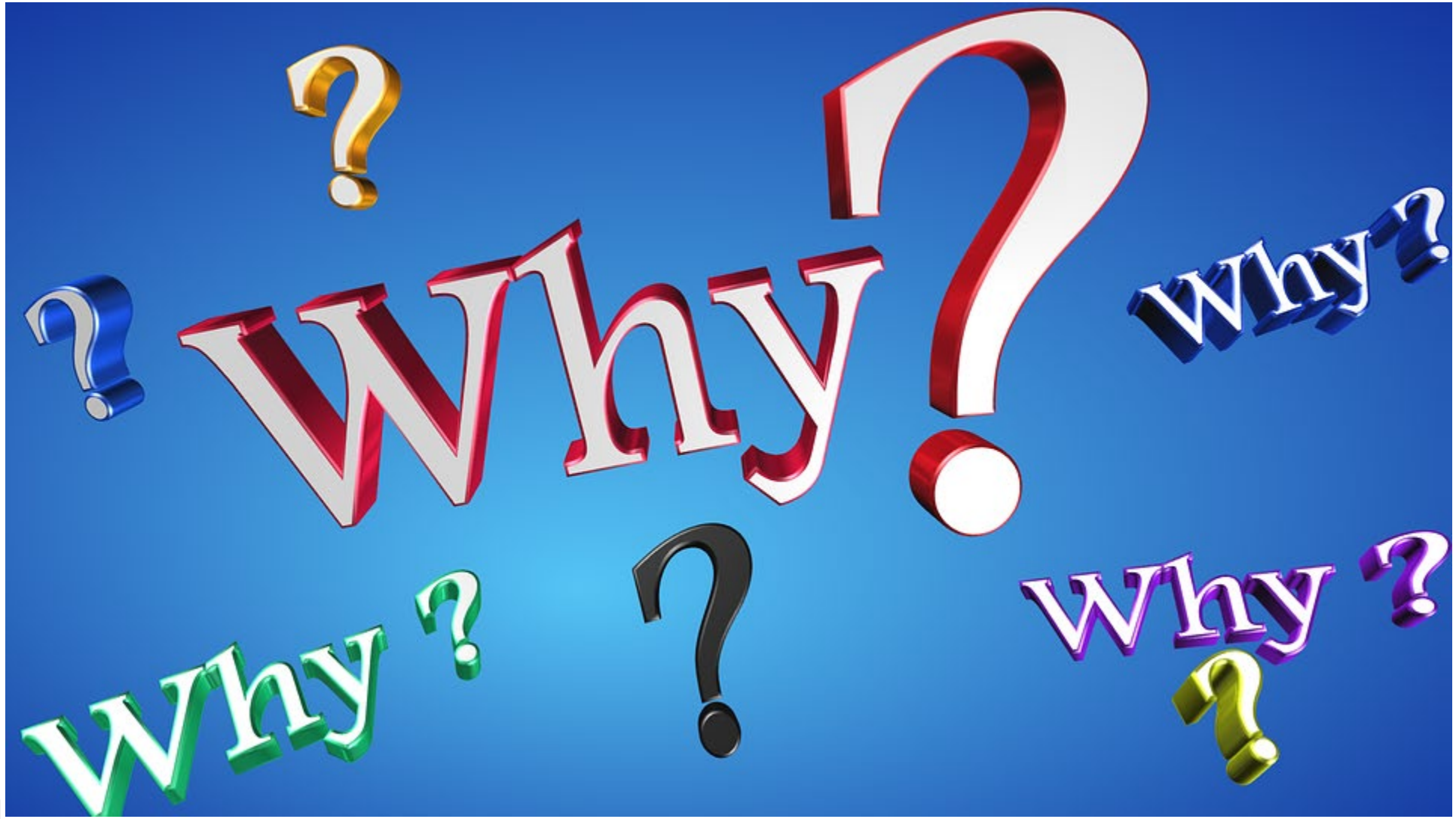
— H.P. Lovecraft, author

OUTLINE

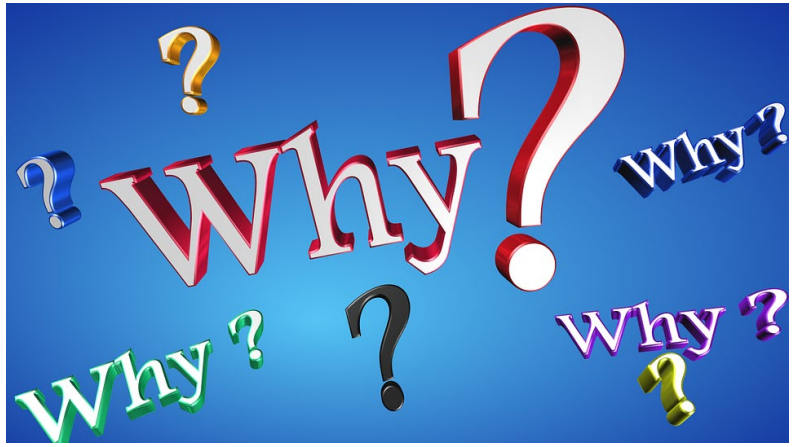
- Health risks do not need to be unknown, they can be measured
- Start with why: assessing risk should be fit for purpose
- Just because a chemical is detected does not mean that it is "toxic" in the *amount* detected
- Not all data are created equal!

Addressing health risk concerns can be a "boom", not a "bust"

START WITH WHY



START WITH WHY



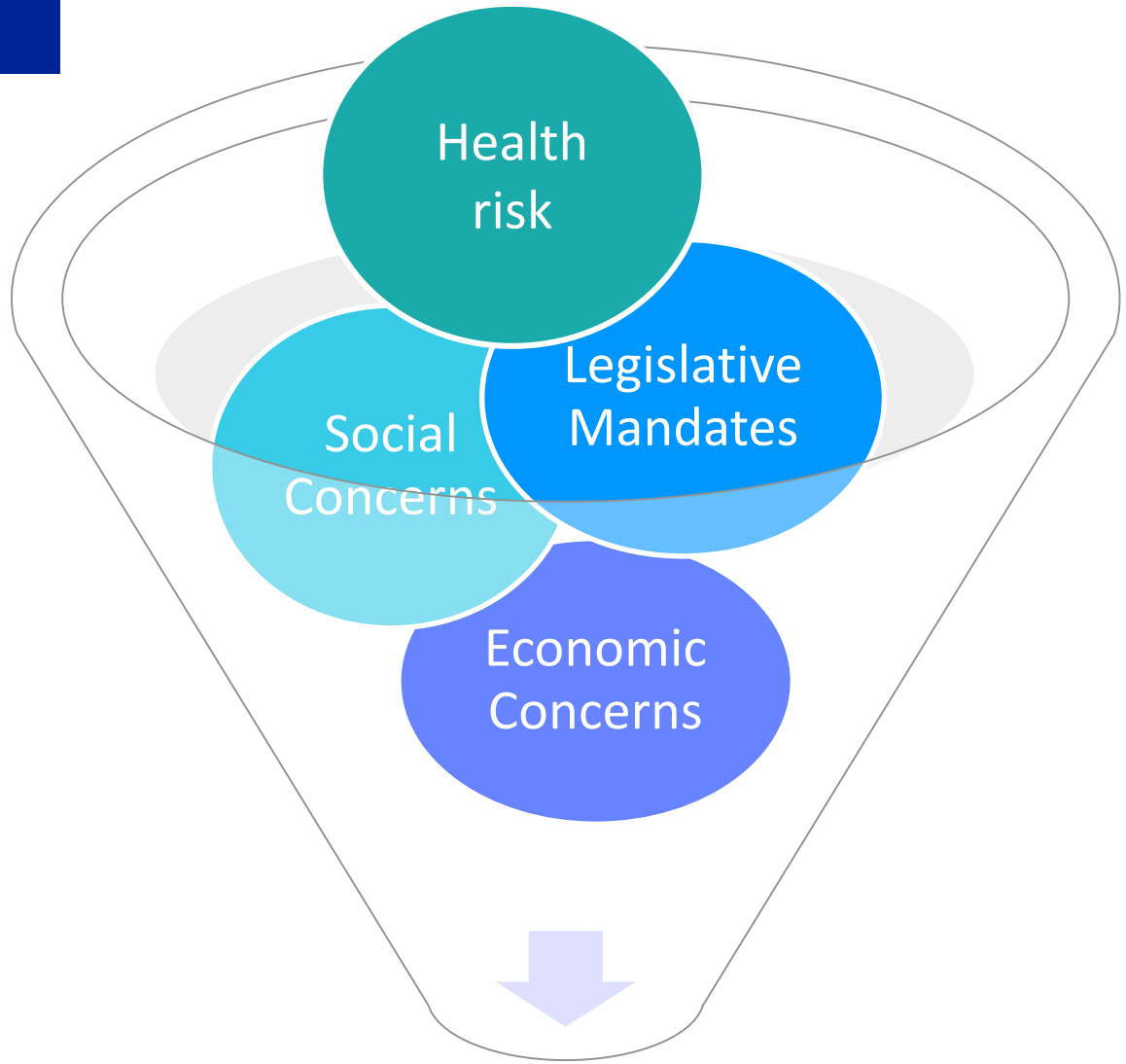
Prop 181

"Can regulate to minimize adverse impacts to public safety, health, welfare"

- *What will you determine is adverse?*
- *How will you determine this?*
- *What actions will you take from the information?*
  - *Setbacks? BMPs? Air monitoring?*

WHY DOES RISK MATTER TO YOU?

"Risk assessment .. is not an end in itself but *a means to develop policies* that *make the best use of resources* to *protect the health of the public and of ecosystems*"
-(National Academy of Sciences 2009, 240)



CTEH® THE SCIENCE OF READY℠

WHAT IS RISK?

HAZARD

The inherent ability of a chemical cause harm

EXPOSURE

Contact between a chemical and a person

RISK

The possibility of a harm arising from exposure to a chemical, ***under specific conditions***.

CTEH® THE SCIENCE OF READY℠

MEASURING HAZARD

WHAT'S MISSING?

Hazardous air pollution

At every stage in oil and gas extraction, toxic chemicals are released into the air.

AND CONSTRUCTION

Chemicals released

Polycyclic organic matter (POMs) including:
Naphthalene
Phenanthrene
Fluorene
Indeno(1,2,3-cd)pyrene
Benzo(g,h,i)perylene
Dibenzo(a,h)anthracene
Benzo(a)pyrene
Benzo(b, k)fluoranthene
Benzo(a)anthracene
Chrysene
Acenaphthylene

Health effects

- Neurological damage
- Hemolytic anemia
- Damage to liver
- Skin/respiratory irritant

May cause confusion, nausea, vomiting, diarrhea, blood in the urine, and jaundice. Possibly carcinogenic to humans.

AND COMPLETION

Chemicals released

2,2,4-trimethylpentane
Benzene
Ethylbenzene
n-Hexane
Hydrogen sulfide
Methylchloride
Naphthalene
POMs
Toluene
Xylenes

Health effects

- Carcinogenic
- Bone marrow damage
- Damage to immune system
- Neurological damage
- Blood disorders
- Damage to liver
- Pulmonary damage
- Damage to reproductive system
- Skin/respiratory irritant

AND PROCESSING

Chemicals released

1,3-butadiene
2,2,4-trimethylpentane
Benzene
Cumene
Ethylbenzene
Formaldehyde
n-Hexane
Hydrogen sulfide
Mercury
Methanol
Styrene
Toluene
Xylenes

Health effects

- Carcinogenic
- Bone marrow damage
- Damage to immune system
- Blood disorders
- Damage to liver
- Pulmonary damage
- Damage to brain, kidneys, and developing fetus
- Skin/respiratory irritant

AND IMPOUNDMENTS

Chemicals released

2,2,4-trimethylpentane
Benzene
Ethylbenzene
Hydrogen sulfide
Methanol
n-Hexane
Styrene
Toluene
Xylenes

Health effects

- Carcinogenic
- Bone marrow damage
- Damage to immune system
- Blood disorders
- Damage to liver
- Pulmonary damage
- Skin/respiratory irritant

May cause nervous system effects such as changes in color vision. Burning, wheezing, and dyspnea may also occur

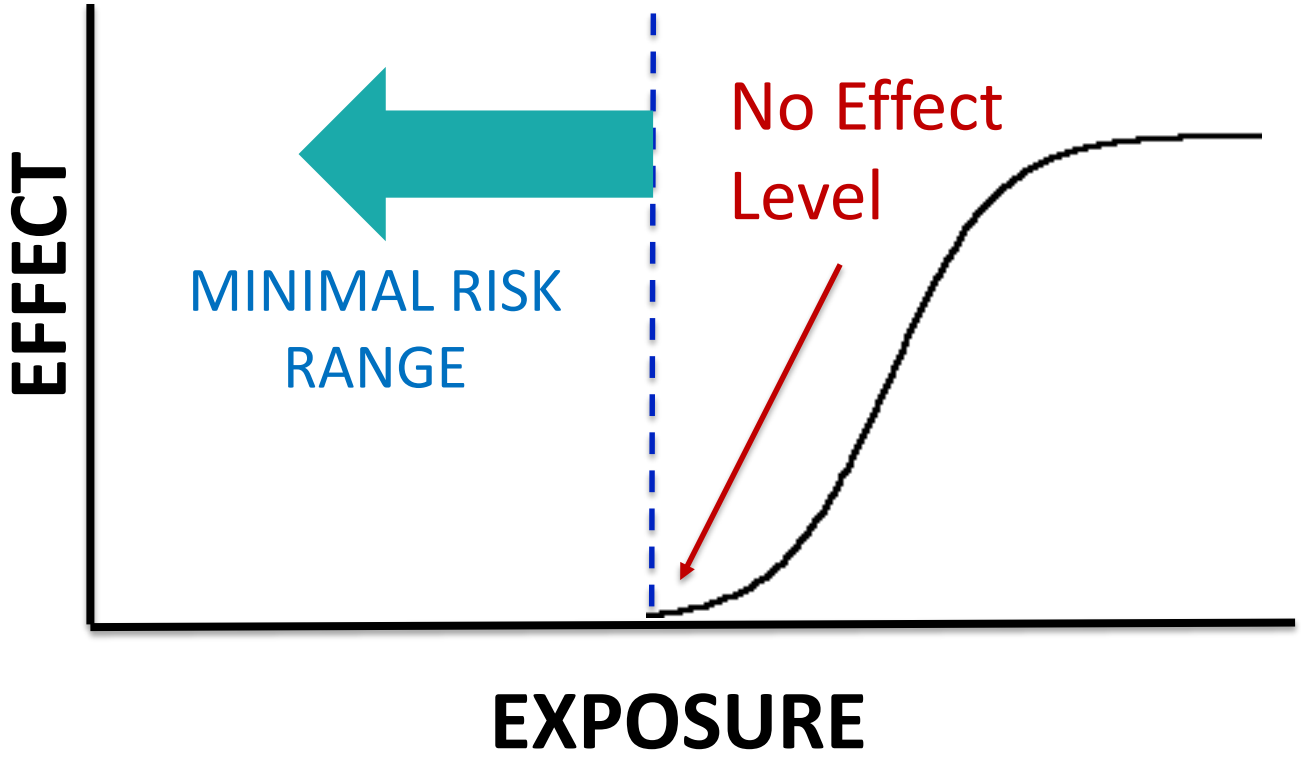
EXPOSU
RE

Denver Post, 4/7/19

CTEH® THE SCIENCE OF READY℠

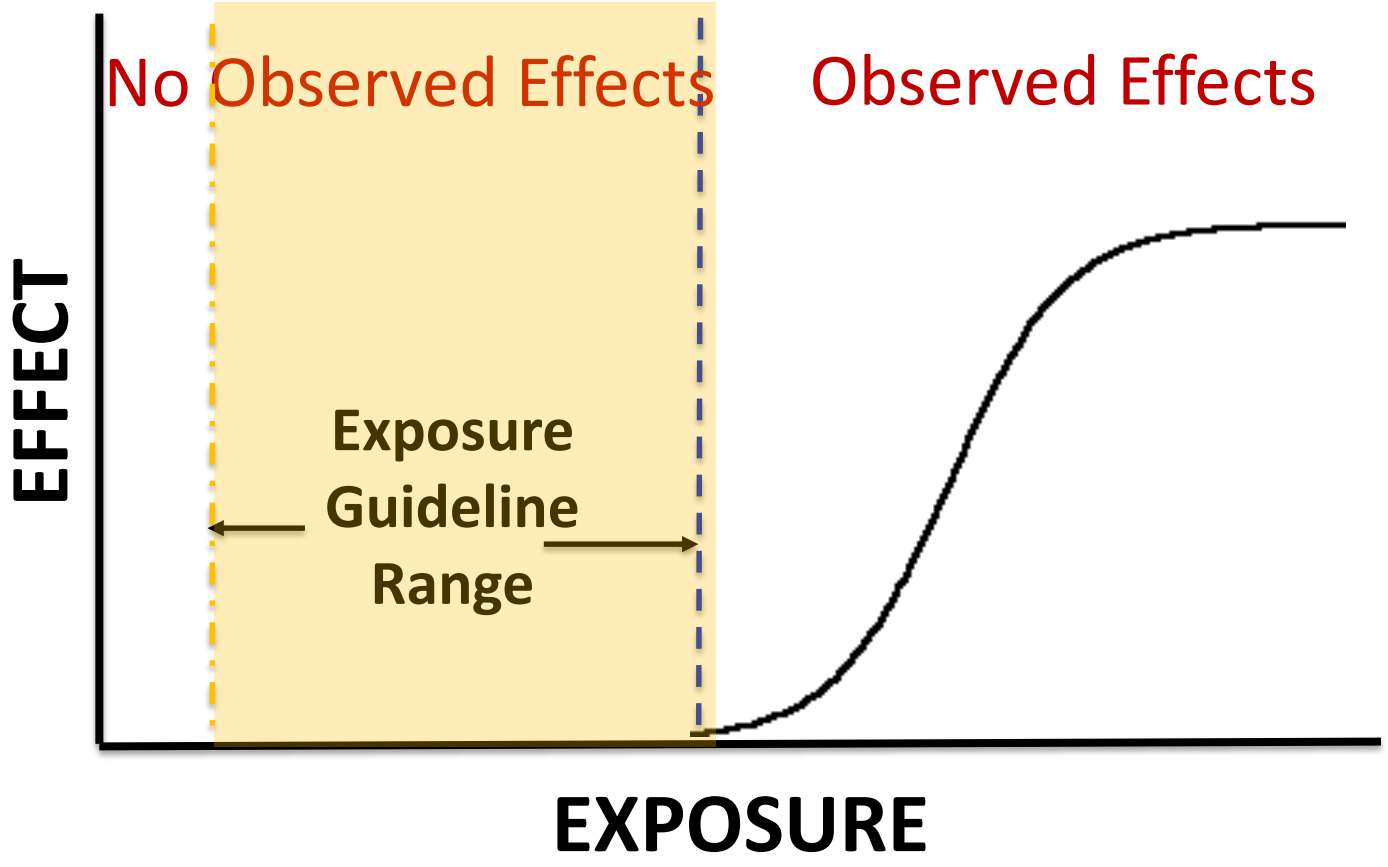
HOW ARE "SAFE" LEVELS ESTIMATED?

Just because a chemical is detected does not mean that it is "toxic" in the *amount* detected



A scientist must estimate the relationship between exposure concentration and health effects before they can make conclusions

HOW ARE "SAFE" LEVELS ESTIMATED?



100-1000 times lower than where "adverse toxicity" is observed

WHAT EXPOSURE GUIDELINES SHOULD BE USED?

Reference Concentration (RfC)

Minimal Risk Levels (MRLs)

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Acute Exposure Guideline Levels (AEGLs)

Worker Exposure Guidelines

ACGIH®

SUMMARY TABLE OF PROPOSED AEGL VALUES FOR BENZENE in ppm (mg/m³)

Classification	10-Minute	30-Minute	1-Hour	4-Hour	8-Hour	Endpoint (Reference)
AEGL-1 (Nondisabling)	130 (420)	73 (240)	52 (170)	18 (58)	9.0 (29)	Highest level available without AEGL-1 effect in humans. 110 ppm for 2h no subjective symptoms (Srbova et al., 1950)
	2000* 500)	1100 (3600)	800 (2600)	400 (1300)	200 (650)	Highest level without AEGL-2 effect (CNS depression, i.e. reduced activity in animals). 4000 ppm for 4h. Molnar et al., 1986.
	below¶	5600* (18,000)	4000* (13,000)	2000* (6500)	990 (3300)	Highest reliable NOAEL for mortality in rats. 5940 ppm for 4h. Molnar et al., 1986.

-2 or AEGL-3 value is higher than 10% of the lower explosive limit of propane in air (LEL = 1.4 % ore, safety considerations against hazard of explosion must be taken into account.
n AEGL-3 value is higher than 50% of the lower explosive limit of propane in air (LEL = 1.4 % (14,000 eme safety considerations against hazard of explosion must be taken into account.
AEGL-3 value is 9700 ppm (31,000 mg/m³).

Exposure guidelines are developed for different exposure scenarios, different levels of protectiveness

MEASURING EXPOSURE

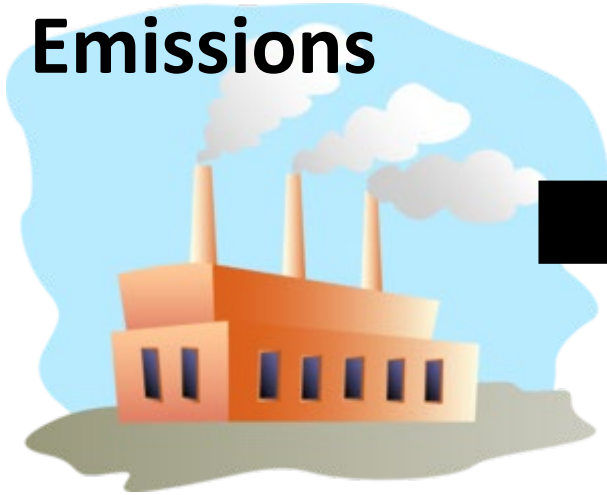
EXPOSURE FACTORS

- ✓ **Amount – how much?**
- ✓ **Duration – how long?**
  - Short-term
  - Long term
- ✓ **Frequency - how often?**
  - Once
  - Intermittent
  - Constant

EXPOSURE CONTINUUM

Source

Emissions



External

Community Air

Internal

Inhaled Amount

SOURCE DATA

Source

Emissions

Fenceline Air

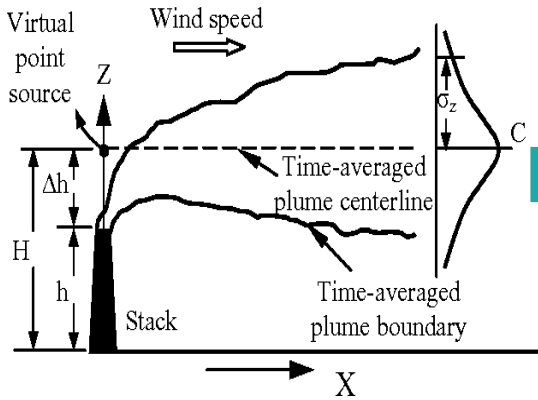
PROS

- ✓ When used with models, can predict a large range of different exposure scenarios and predictions of risks

CONS

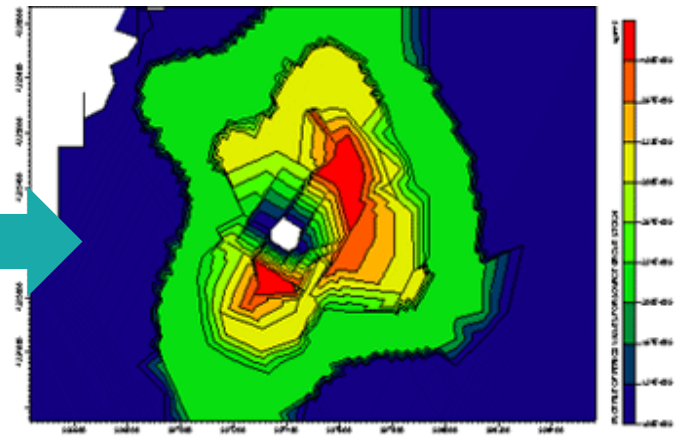
- ✓ Cannot provide direct, measured exposure data

Emission Rates
Meteorological Data



Rahman et al (2008)

Air Concentrations



http://www.aqsllc.net/services/air-dispersion-modeling

COMMUNITY AIR

External

PROS

- ✓ Provide an estimate of exposure in communities without models
- ✓ Can determine the source of exposure
- ✓ Measurements and analytical methods well established
- ✓ Can be directly compared to exposure guideline values

CONS

- ✓ **data are only as good as the study design!!!!!**

BIOMONITORING

Internal

PROS

- ✓ Direct evidence a person was exposed
- ✓ Can be useful *if* combined with other pieces of information:
  - external measurements
  - pharmacokinetic models
  - epidemiology studies
  - Cluster of health effects in a population

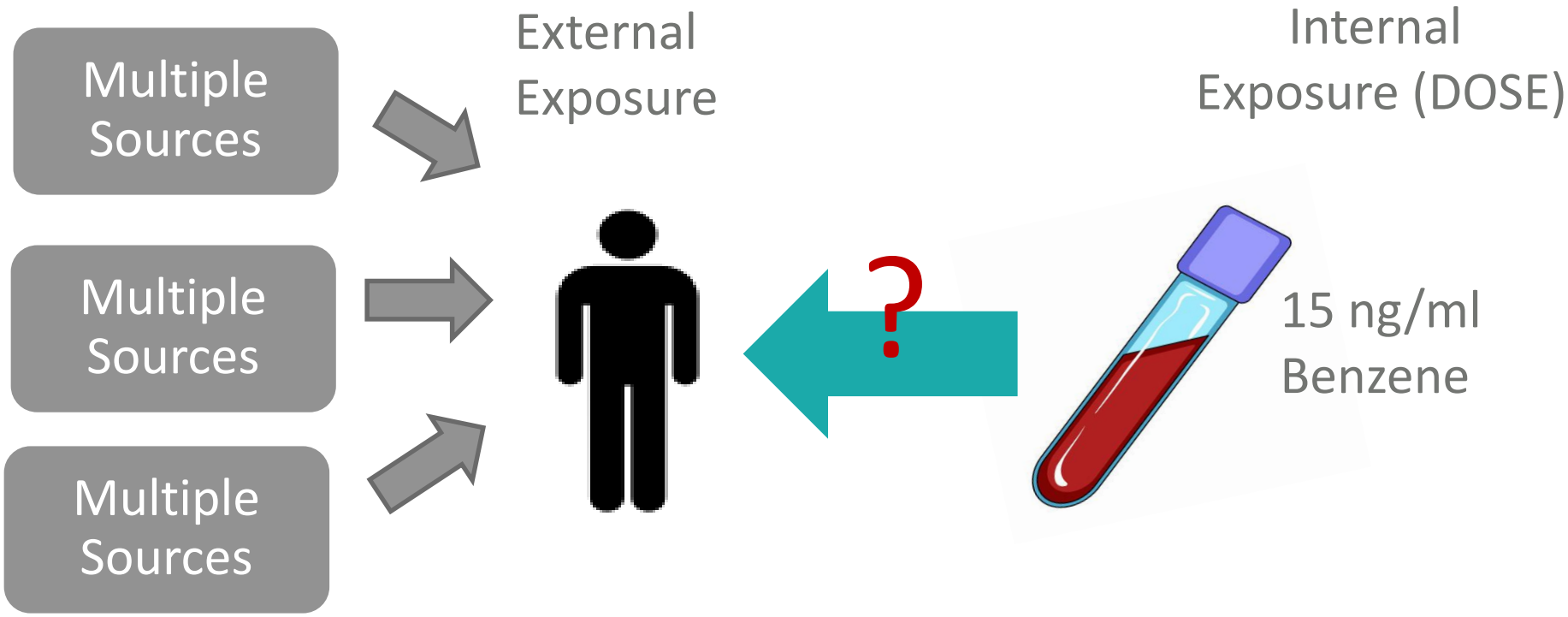
CONS

- ✓ Cannot directly provide information on
  - source
  - exposure
  - health risks
- ✓ Feasibility (cost, time, sufficient # people, invasive, methods)
- ✓ Risk communication

BIOMONITORING CHALLENGES

✓ Interpreting data to characterize exposure

- Sources?
- Activities?
- Weather?
- Timing?



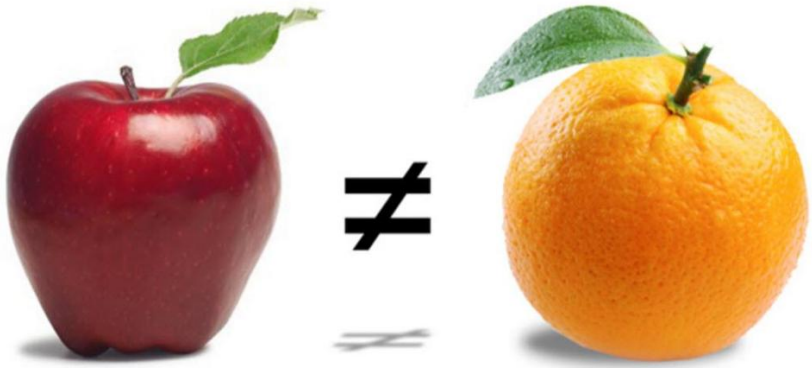
Difficult to identify and control exposure if you can't answer these questions

BIOMONITORING CHALLENGES

✓ Interpreting Data for Health Risk

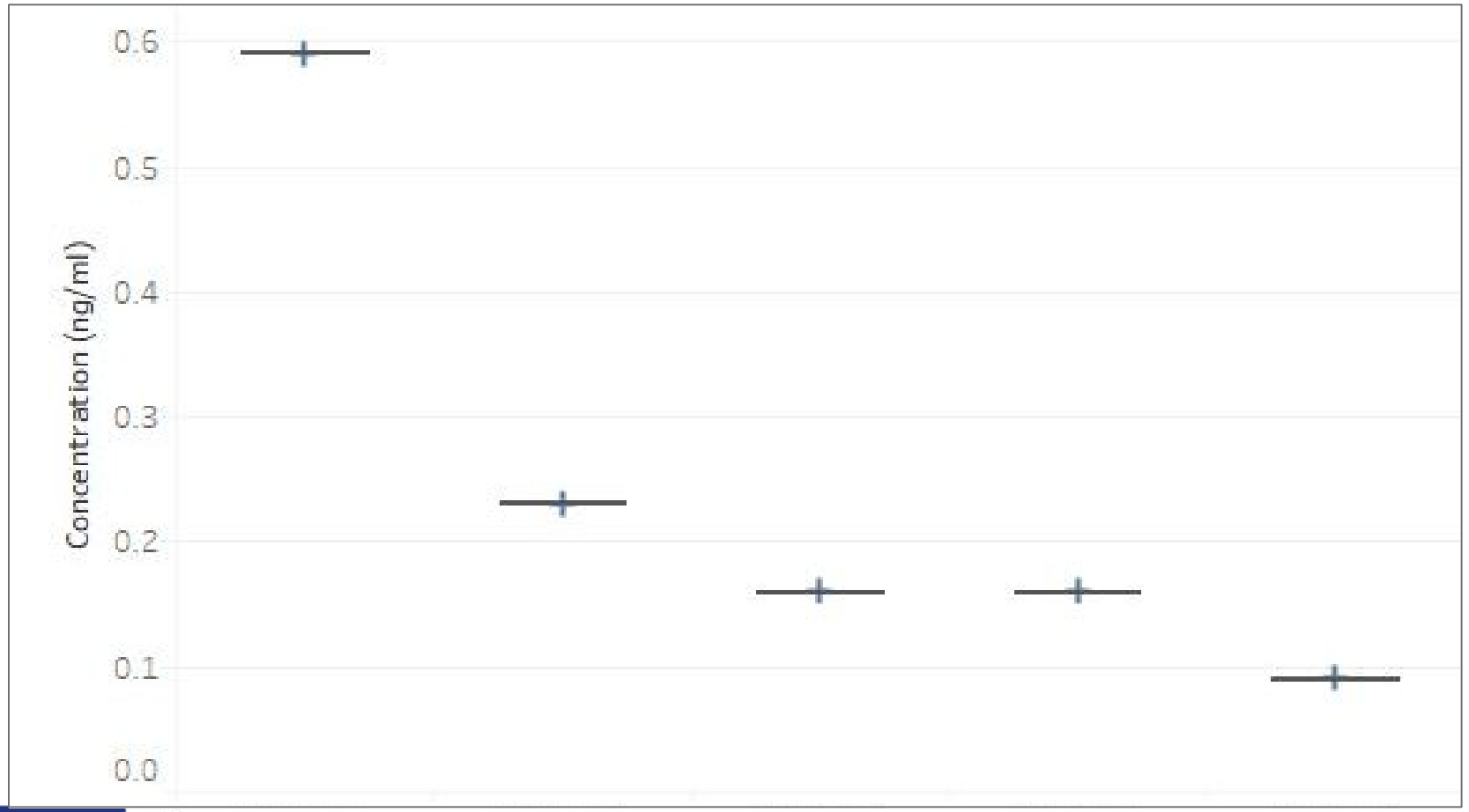
$$\frac{\text{MEASURED ENVIRONMENTAL EXPOSURE}}{\text{EXPOSURE GUIDELINE VALUE}}$$

Most exposure guideline values are derived to compare to measured external exposure levels, not internal



CASE STUDY

Measurements of benzene in blood

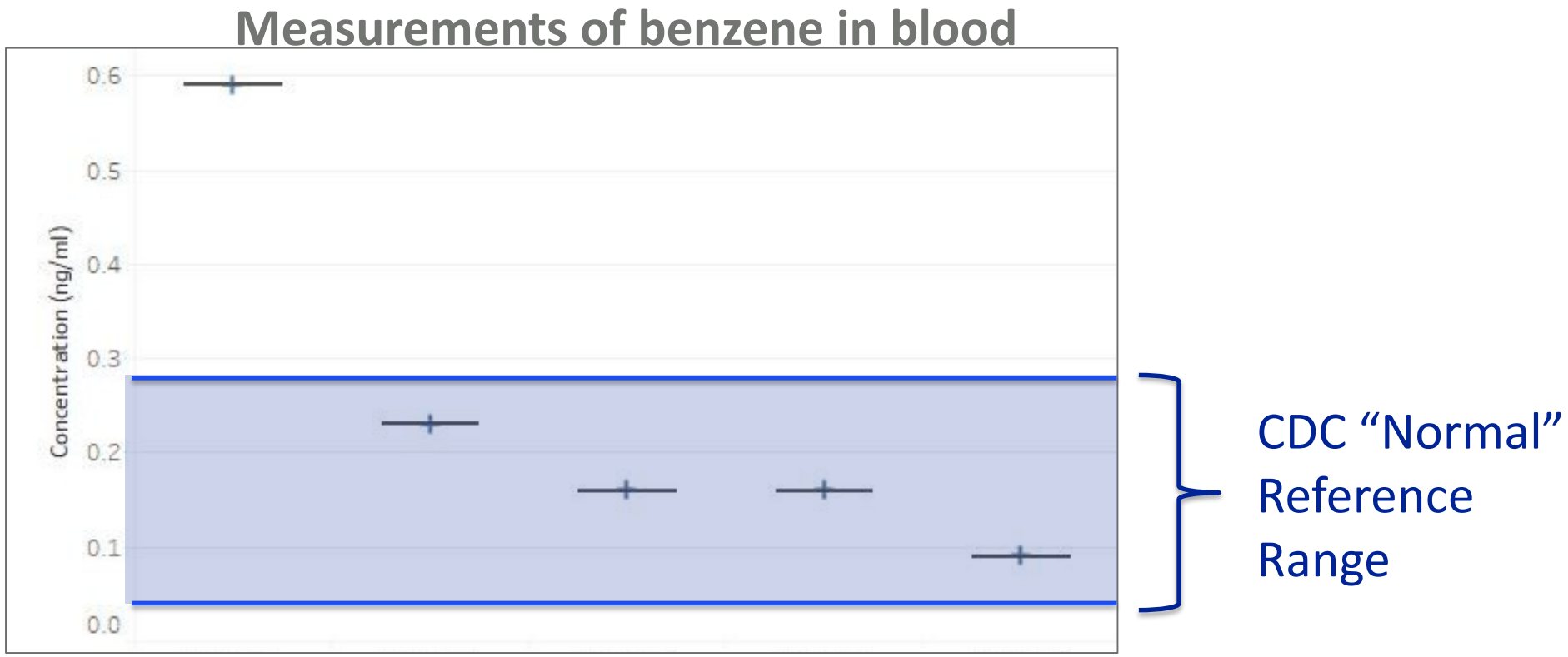


- *Why is there benzene in my blood?*
- *What is my health risk?*
- *Where did it come from?*

CASE STUDY

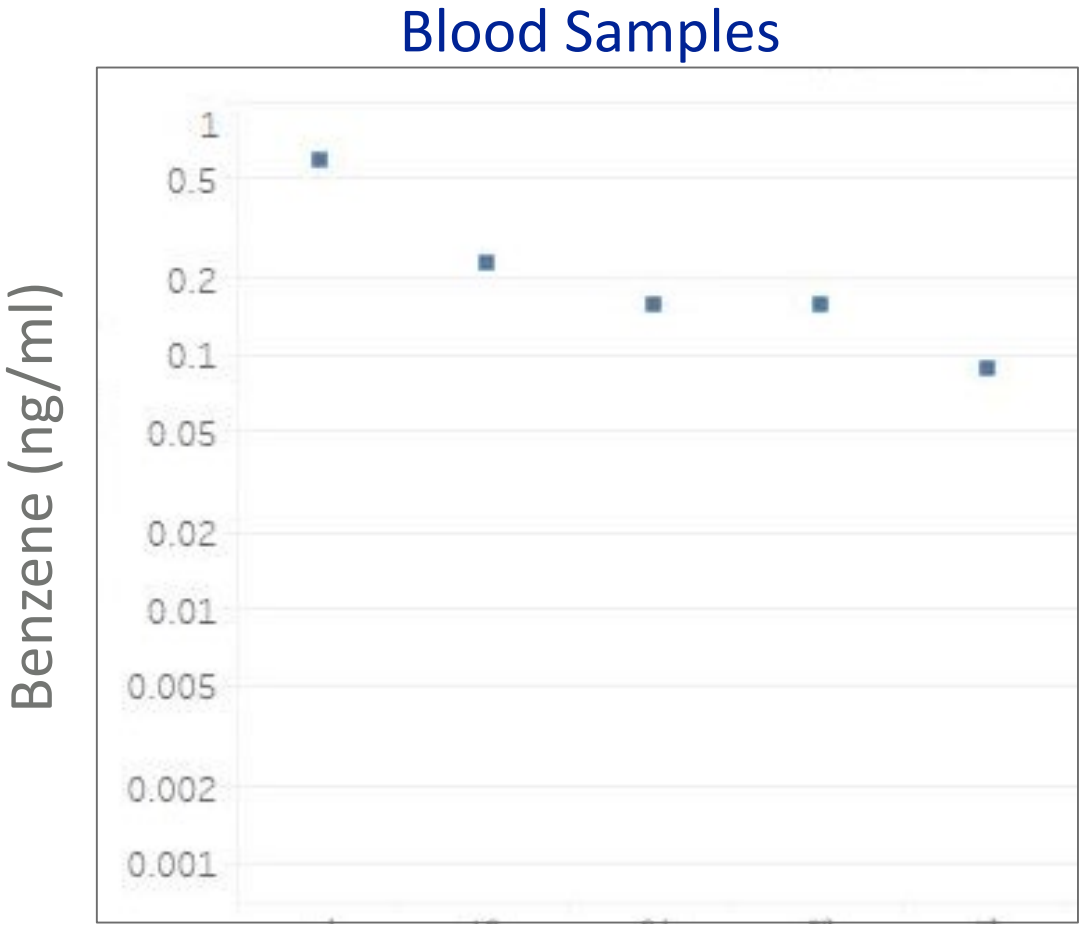
Why is there benzene in my blood?

- *Benzene can come from many non oil and gas sources*
- *Can be detected in the general population*



CASE STUDY

What is my health risk?



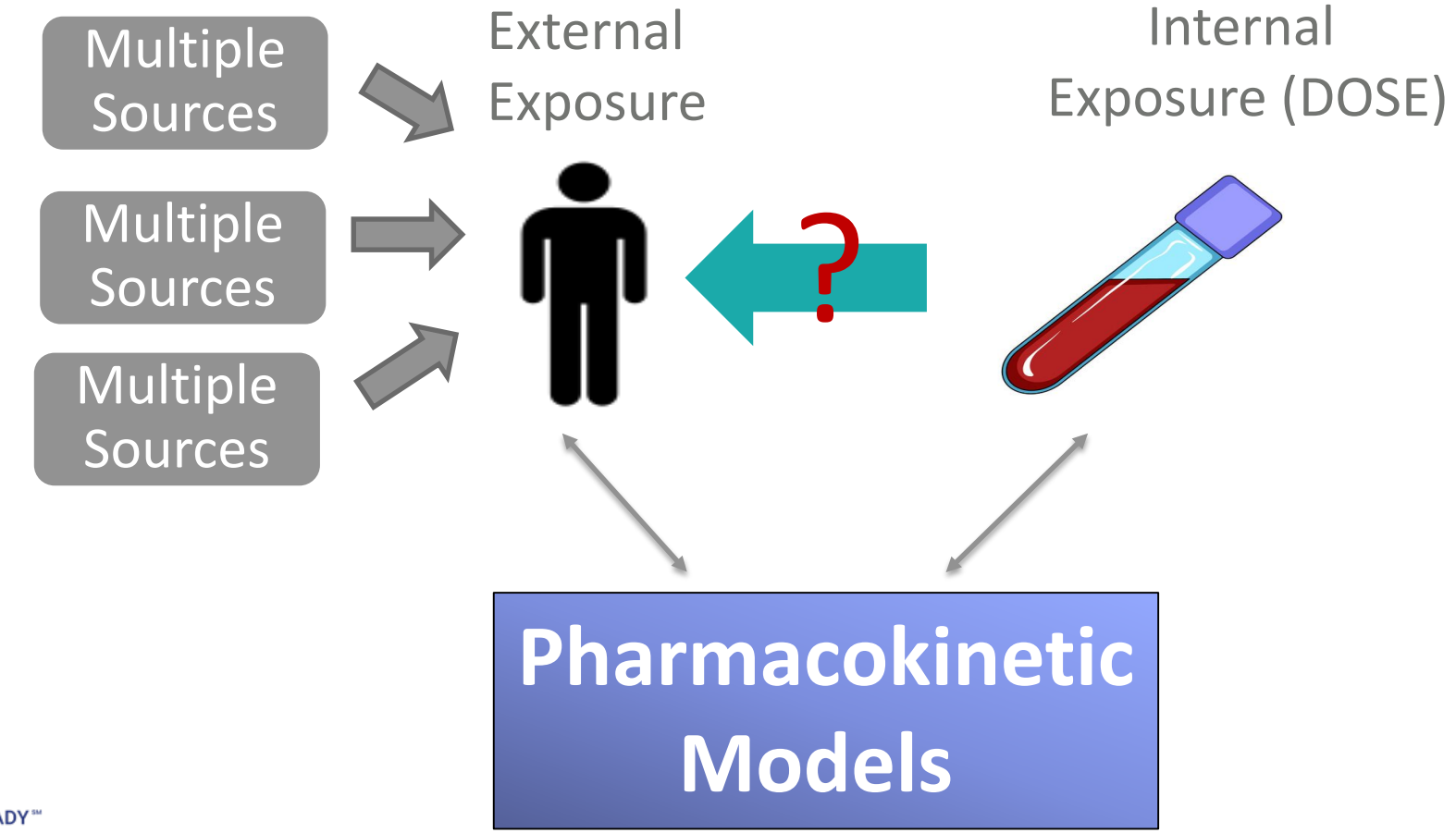
$$\text{RISK} = \frac{\text{MEASURED ENVIRONMENTAL EXPOSURE}}{\text{EXPOSURE GUIDELINE VALUE}}$$

- What's the environmental exposure?
- What exposure guideline value do you use if you don't know the exposure scenario?

CASE STUDY

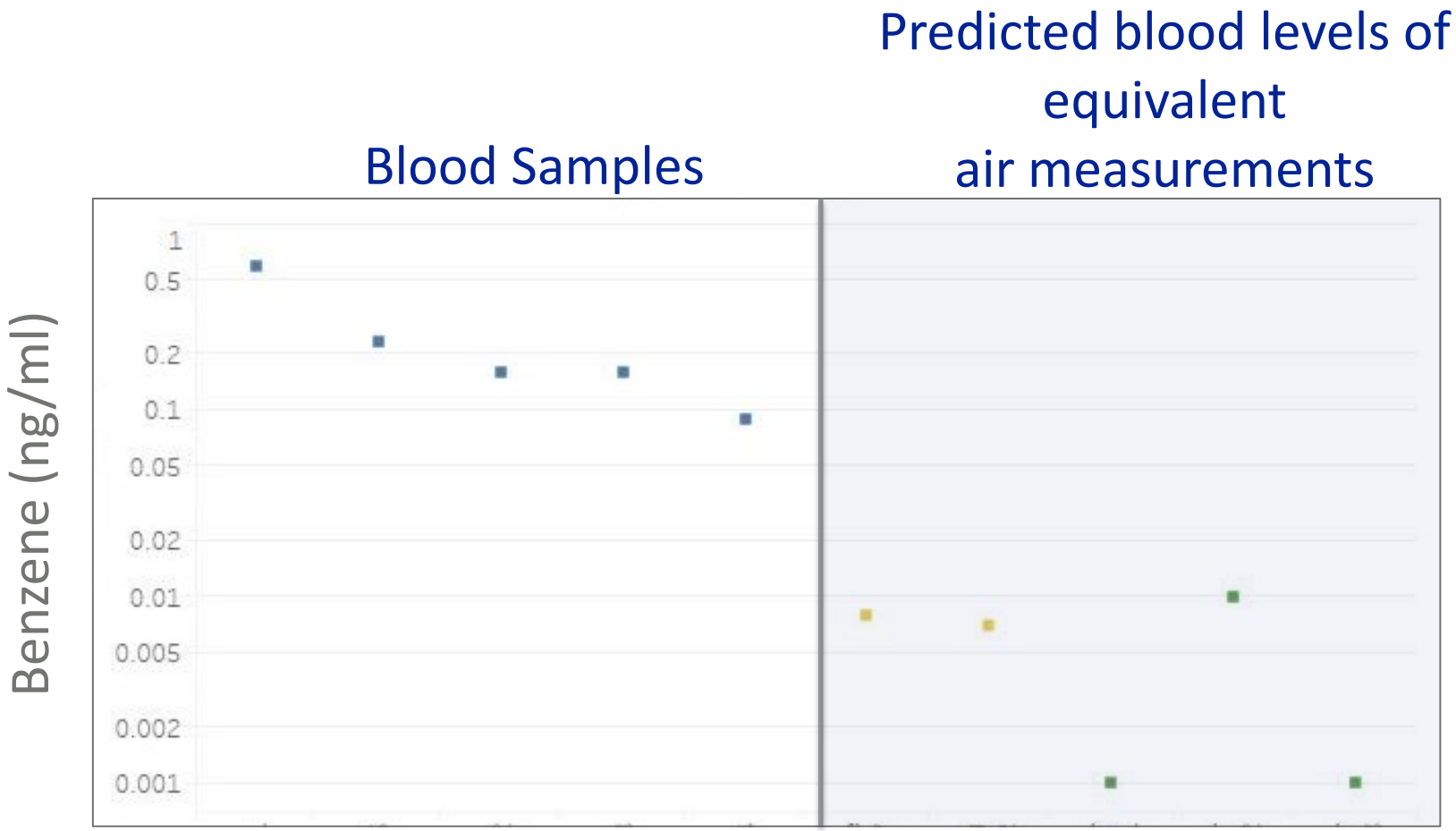
Where did it come from?

No clue! You have to collect environmental data!



CASE STUDY

Compare apples to apples



CASE STUDY

Where do you go from here?

Biomonitoring uncertainty at all levels

- Methods used to collect the samples
- Analytical methods
- Exposure history
- Sources of exposure
- Extrapolating from an internal dose to an external exposure

Can become a risk communication and public health decision making nightmare!

NOT ALL EXPOSURES ARE CREATED EQUAL

"Compared with measures of contaminants in air, water, or food, biomonitoring results are intrinsically associated with a person and thereby *have far greater potential to generate concern and action*, for good or ill"

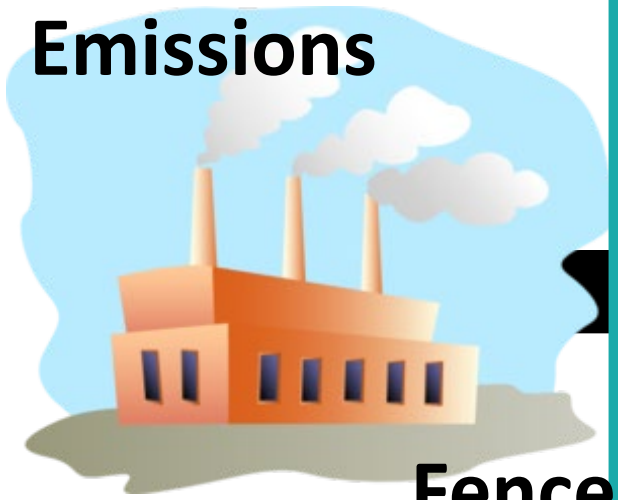
"The social and political climate in which the new technology of biomonitoring has emerged is itself volatile; contentious and potentially fractious policy debates and litigation surround the field and *render it likely that studies will be conducted or interpreted to meet the agendas of specific parties* unless great care is taken to establish uniformly agreed on scientific standards against which any study can be transparently judged. "

National Academy of Science, Biomonitoring Report (2006)

WHAT SHOULD YOU MEASURE?

Source

Emissions



Fenceline Air

External

Community Air

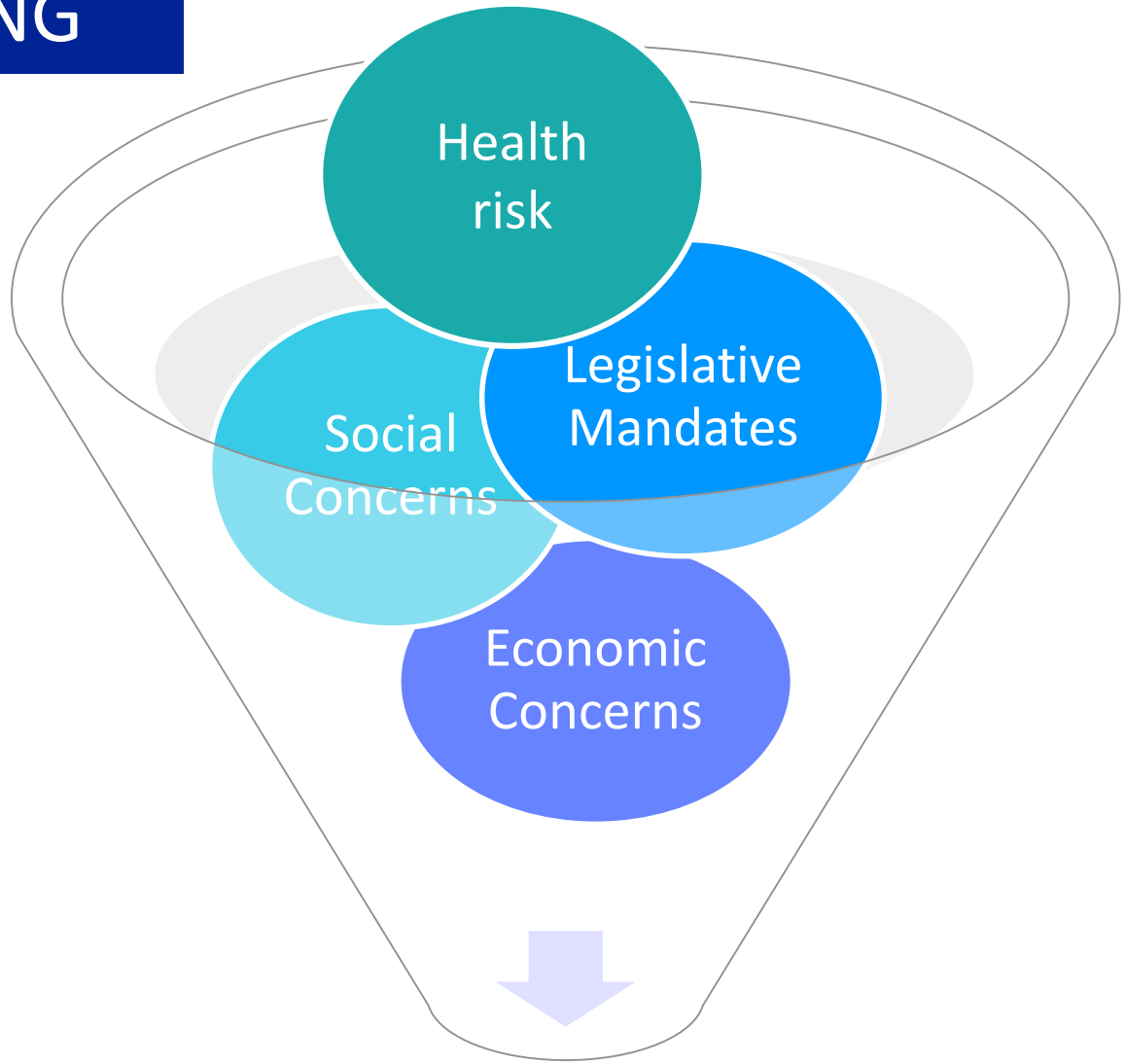
Internal

Inhaled Amount

HEALTH RISK FOR DECISION MAKING

Health ? Risk

Vs.



PUBLIC HEALTH DECISION MAKING

CONCLUSIONS

- Health risks do not need to be unknown, they can be measured
- Start with why: assessing risk should be fit for purpose
- Just because a chemical is detected does not mean that it is “toxic” in the *amount* detected
- Not all data are created equal!

Addressing health risk concerns can be a “boom”, not a “bust”

Thank you!
Questions?

KEY CONCEPTS OF RISK ASSESSMENT

There is no risk if there is no exposure

Detecting a chemical in the air or in the body does not equate to risk

Risk is a function of exposure and the chemical hazard

A scientist must know or estimate the relationship between exposure concentration and health effects before they can make conclusions