Environmental Metrology and Policy: A New Masters Degree Program

2019 Environmental Measurement Symposium

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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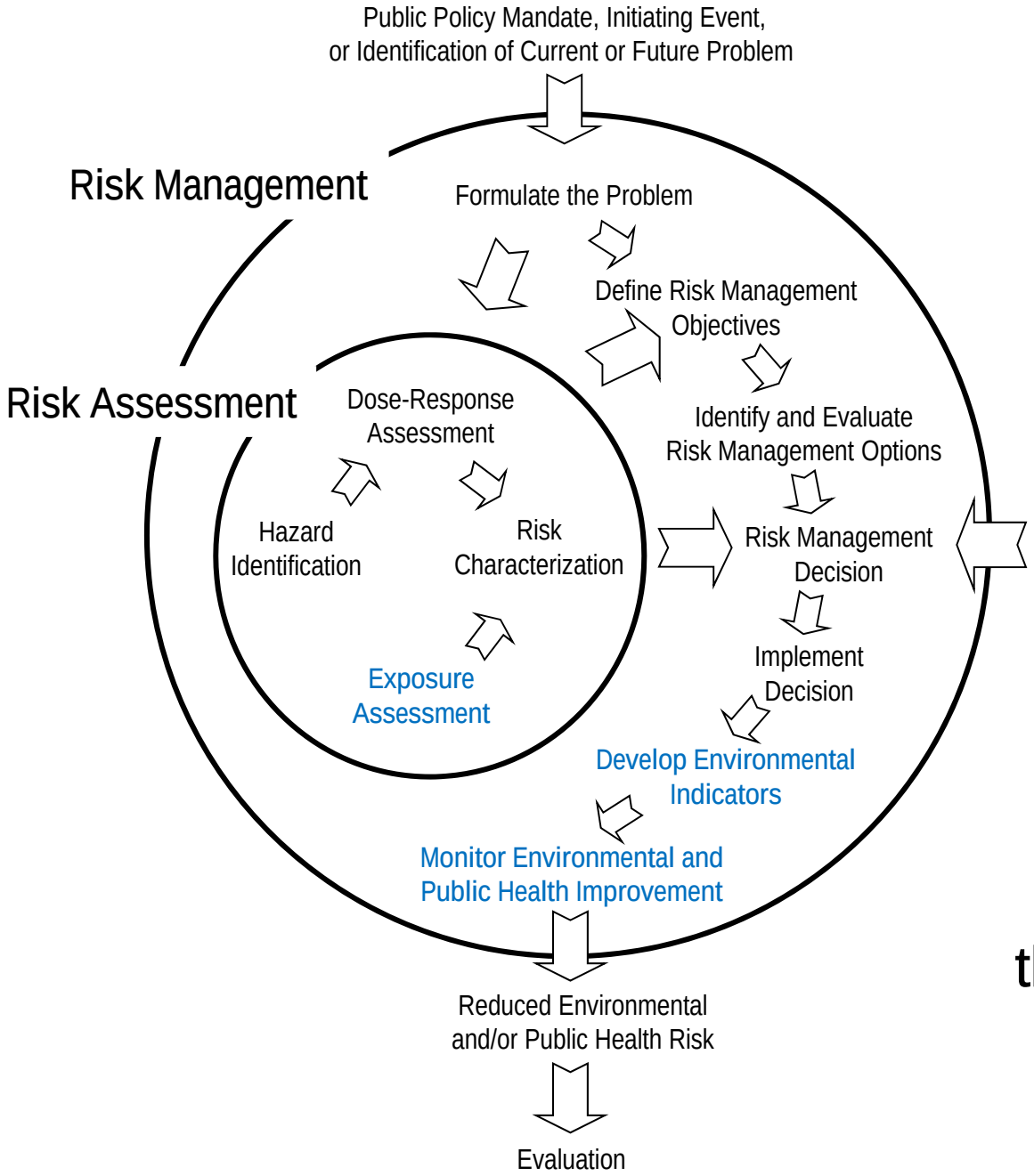
Exemplary Environmental Case Studies

- Arsenic
- Asbestos
- Climate Change
- Dioxin
- Formaldehyde
- Hydraulic Fracturing
- Lead
- Mercury
- Mobile Sources
- Ozone
- Particulate Matter
- PCBs
- Radon

If You Were The EPA Administrator



Risk Management Options

- Prescriptive standards
- Performance-based standards
- Non-regulatory approaches
  - Action levels
  - Health advisories
  - Labelling
  - Consumer and other information
  - Voluntary consensus standards
  - Industry recommended practices
  - Third-party certification

Considerations

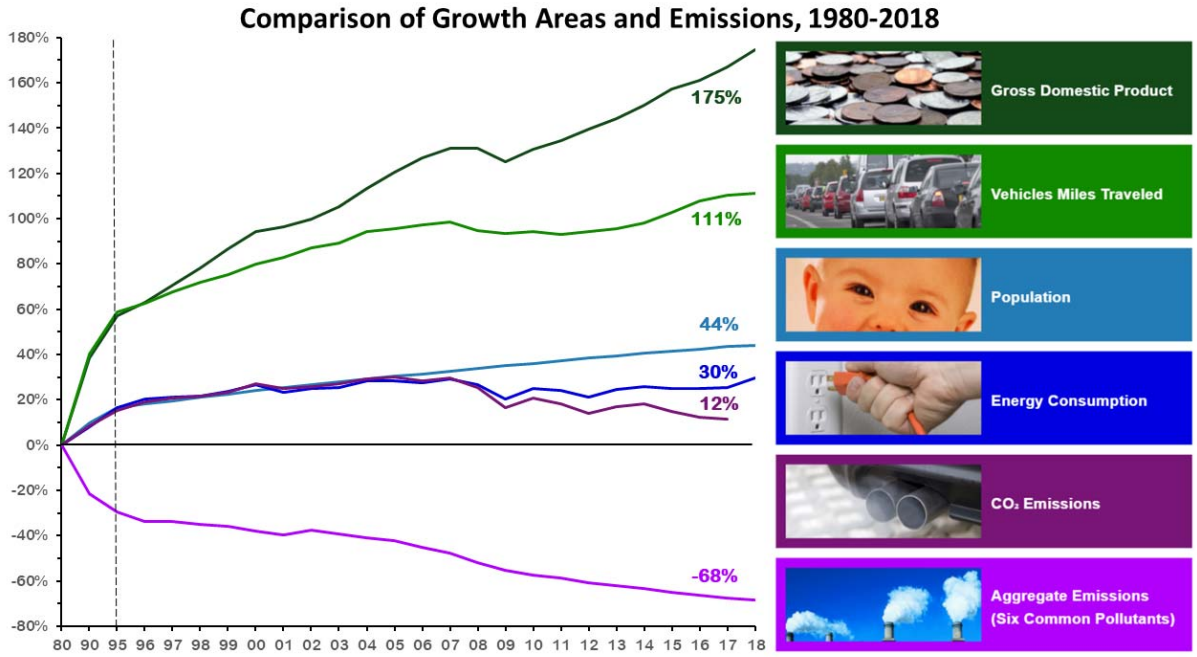
- Statutory and Legal
- Policy
- Enforcement
- Political
- Social
- Economic
- Public Health
- Environmental

If you were
the EPA Administrator

Particulate Matter NAAQS:
Our Nation's Most Expensive and Beneficial Regulation

“Criteria Air Pollutants”

- Particulate matter (PM)
- Ozone (O_3)
- Nitrogen dioxide (NO_2)
- Sulfur dioxide (SO_2)
- Carbon monoxide (CO)
- Lead (Pb)



Benefits and Costs of EPA Rules

- EPA rules account for 61 - 80 % of the monetized benefits and 44 - 55 % of the monetized costs of Federal regulations.
- The benefits from the PM NAAQS alone range from $3B - $7.5B and the costs from $45M - $300M (2001$).
- Benefit-to-Cost Ratio
  - Central estimate: 30:1
  - Range: 10-172:1

Office of Management and Budget
The Executive Office of the President

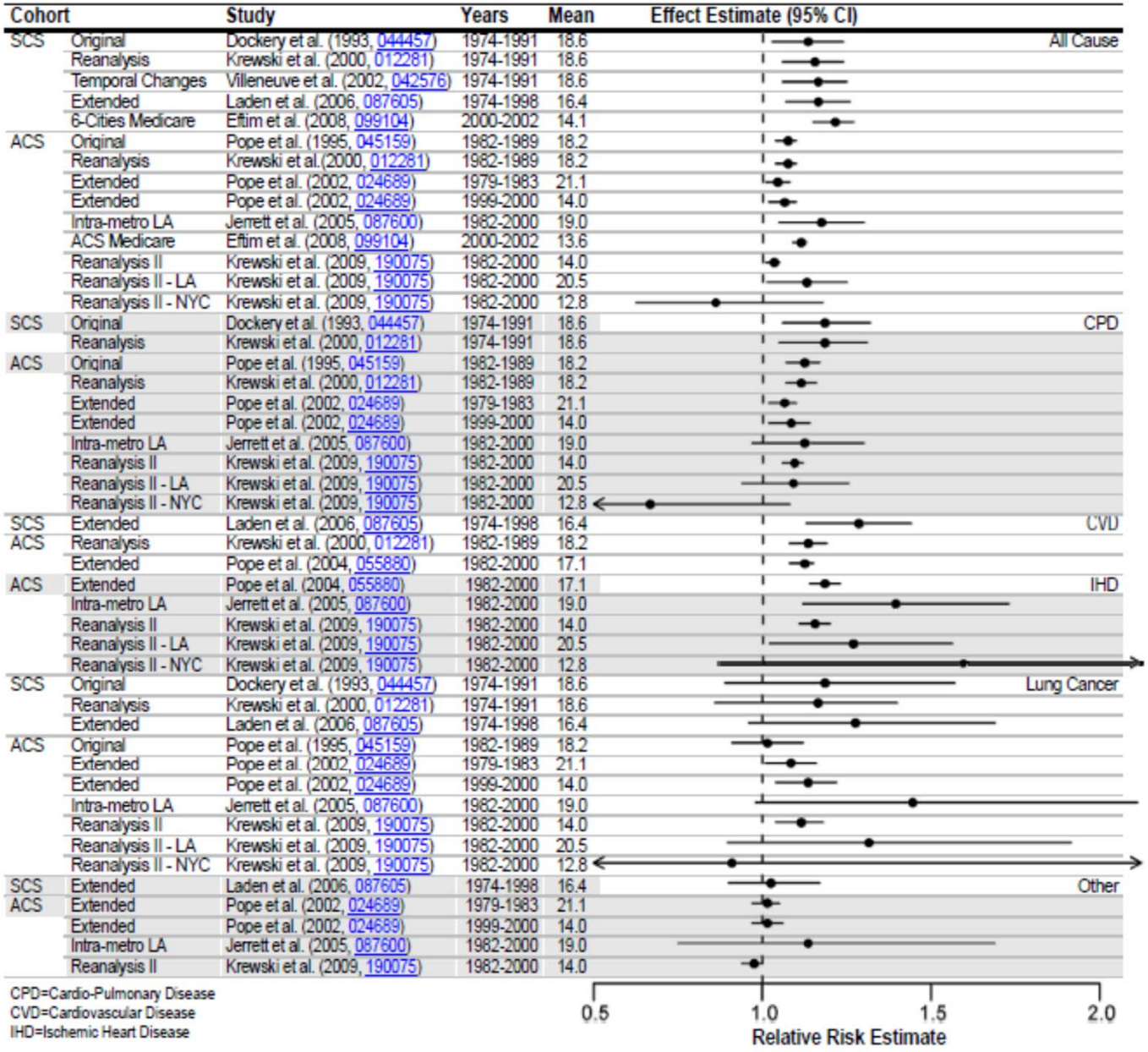


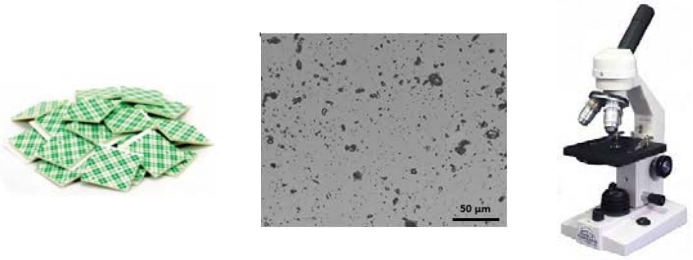
Figure 7-6. Mortality risk estimates associated with long-term exposure to $PM_{2.5}$ from the Harvard Six Cities Study (SCS) and the American Cancer Society Study (ACS).

Abridged PM NAAQS Chronology

Year	Primary / Secondary	Indicator	Averaging Time	Level (ug/m3)	Form
1971	Primary	TSP	24-hour	260	Not to be exceeded more than once per year
	Primary	TSP	Annual	75	Annual geometric mean
	Secondary	TSP	24-hour	150	Not to be exceeded more than once per year
	Secondary	TSP	Annual	60	Annual geometric mean
2013	Primary	$PM_{2.5}$	Annual	12.0	Annual arithmetic mean averaged over 3 years
	Secondary	$PM_{2.5}$	Annual	15.0	Annual arithmetic mean averaged over 3 years
	Both	$PM_{2.5}$	24-hour	35	98th percentile averaged over 3 years
	Both	PM_{10}	24-hour	150	Not to be exceeded more than once a year on average over a 3-year period

How is particulate matter measured?

- EPA's Ambient Monitoring Technology Information Center
  - Maintains the list of designated reference and equivalent methods and Federal regulations related to ambient air quality monitoring
  - Provides information on ambient air quality monitoring networks, monitoring methods, and air quality trends
  - https://www.epa.gov/amtic



Metrology Meets Policy

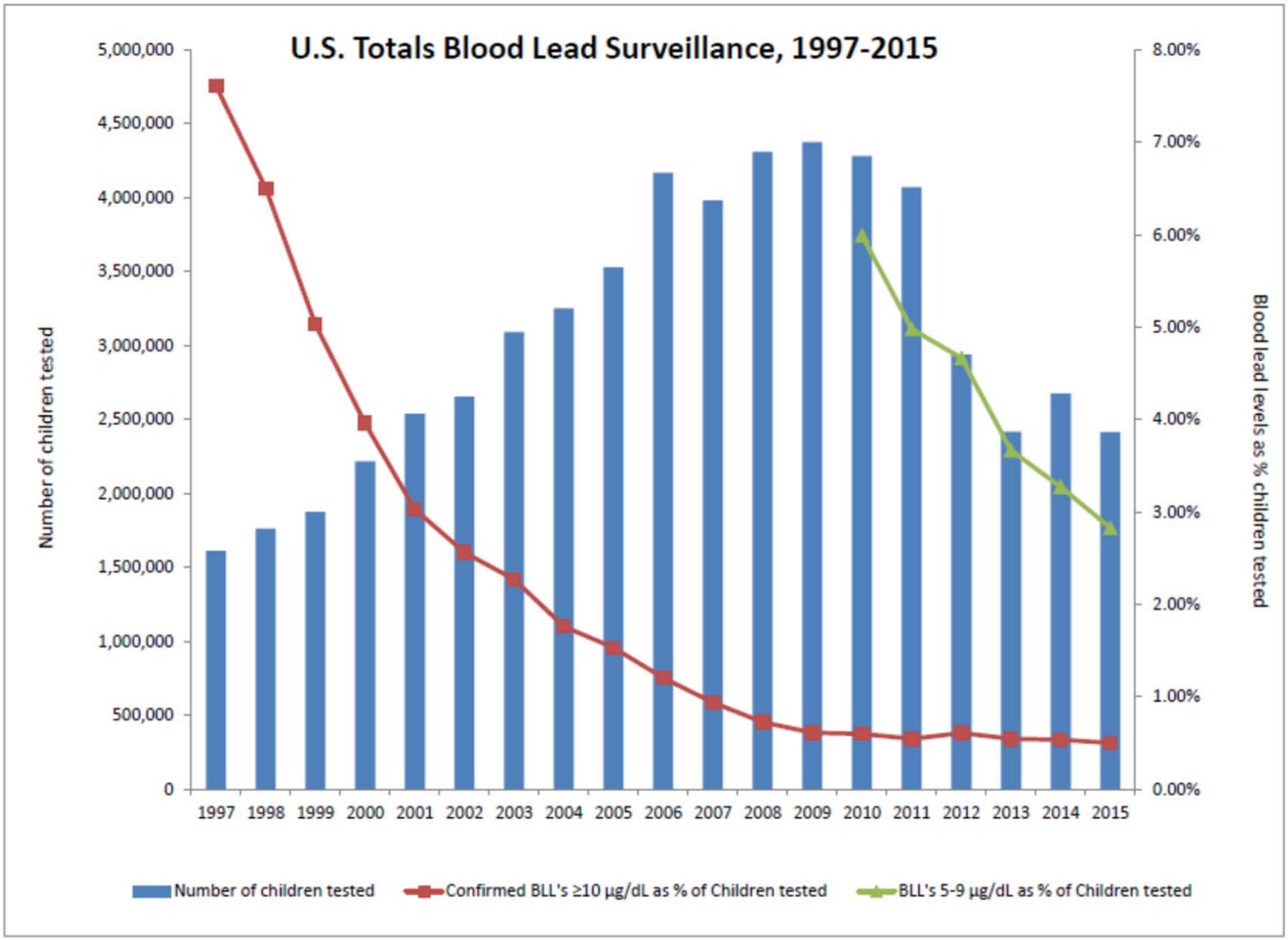
- How?
- Why?
- What?

- Who?
- Where?
- When?

- Indicator
- Averaging time
- Level
- Form

What is lead (Pb), and where is it found?

- Lead is a naturally occurring element found in small amounts in the Earth's crust.
- While it has some beneficial uses, it can be toxic to humans and animals.
- Lead is found in all parts of our environment – air, soil, water, and inside our homes (e.g., lead-based paint).
- Much of our exposure comes from past use of leaded gasoline, former lead smelters, pipes and plumbing materials, batteries, ammunition, and cosmetics.


U.S. Totals Blood Lead Surveillance, 1997-2015
Number of children tested
Blood lead levels as % children tested
5,000,000
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
8.00%
7.00%
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Number of children tested
Confirmed BLL's ≥10 µg/dL as % of Children tested
BLL's 5-9 µg/dL as % of Children tested

Lead in Drinking Water

- Lead enters drinking water through the corrosion of plumbing materials.
- A number of factors determine how much lead enters water including:
  - the chemistry of the water (its acidity)
  - the amount of lead the water comes in contact with
  - the length of time the water is in contact with lead
  - the presence of protective scales or coatings inside the plumbing materials.
- Homes built before 1986 are more likely to have lead pipes, fixtures, and solder.
- However new homes are also at risk, as even legally “lead-free” plumbing can contain up to 8% lead.

Lead and Copper Rule (LCR) Chronology

1991	EPA sets a 15 ppb limit for lead measured at customer taps, and establishes a MCLG of zero for lead in drinking water.
2000	EPA updates analytic methods; provides for the demonstration of corrosion control; and includes requirements for lead monitoring, service line replacements, and recordkeeping.
2007	EPA clarifies monitoring requirements and requires sampling results to be provided to consumers.
Today	EPA is considering revisions to the 1991 LCR, which may include a health-based benchmark, point-of-use filters, and ban partial service line replacements.

Lead and Copper Rule (LCR)

- Applies to the 68,000 public water systems, which serve ~ 300M people
- Requires public water systems to…
  - Sample taps *in homes* and to take actions to treat water to make it less corrosive to plumbing containing lead and copper;
  - If the results exceed the Pb action level (15 ppb) after installing corrosion control, replace (at least) 7% of lead service lines per year;
  - Replace the portion of the lead service line owned by the system;
  - Offer to replace the customer-owned portion at cost.

Lead: Using Flint to Reignite a Legacy Issue

Flint, MI Water Crisis Chronology

April 2014	To reduce costs, the city of Flint switches its water source from the Detroit River to the Flint River without consideration of needed corrosion inhibitors.
October 2014	General Motors' truck assembly plant discontinues using Flint tap water due to corroding engine parts.
January 2015	Flint residents complain of health issues caused by city water.
February 2015	Miquel Del Toral of EPA detects lead levels in water at the home of a Flint resident 7x greater than EPA's acceptable limit.
March 2015	Flint City Council members vote to reconnect to Detroit water. The emergency manager overrules the vote.

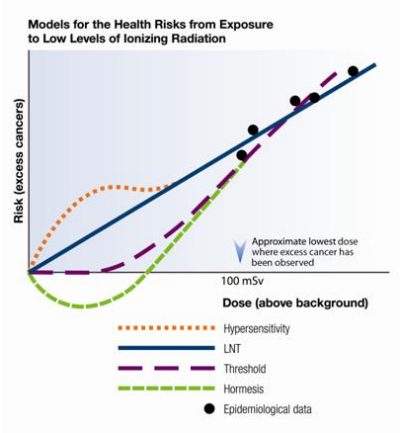
Flint, MI Water Crisis Chronology

September 2015	Virginia Tech's water study team reports that 40% of Flint homes have elevated levels of lead.
	Pediatrician Mona Hanna-Attisha releases a study showing increased number of children with high lead-blood levels after the water switch.
October 2015	MI Governor Rick Snyder signs a bill to reconnect Flint to Detroit water. The switch is made the next day.
November 2016	MI and the City of Flint are ordered to deliver bottled water to homes where filters have yet to be determined to be working properly.
March 2017	A Federal judge approves a settlement in which MI agrees to replace lead or galvanized steel water lines for at least 18,000 Flint households by 2020.

Flint, MI Water Crisis Chronology

August 2017	Federal and state aid to Flint exceeds $370M for water infrastructure upgrades and a registry of those exposed to lead-contaminated water.
Today	Flint residents continue to be instructed to use bottled or filtered water until all lead pipes have been replaced (2020).

Challenges/Opportunities



- Extrapolation from…
  - Occupational exposures to environmental exposures
  - Animal toxicology studies to human health effects
  - In vitro and in silico toxicology to human health effects
- Harmonization of…
  - Cancer and non-cancer risks
  - Ecological and public health risks

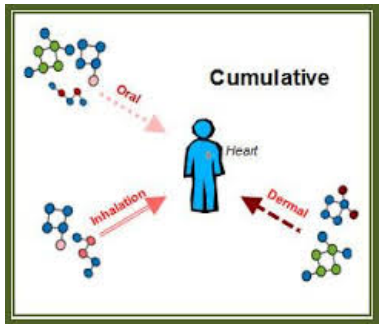
Inhalation Unit Risk
Oral Slope Factor

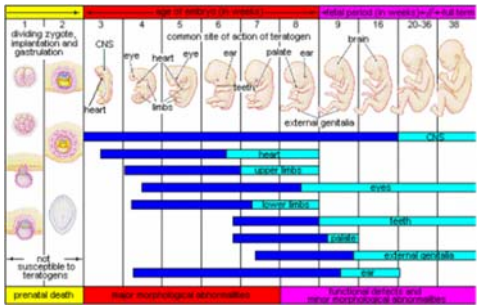
?

Reference Concentration
Reference Dose

Challenges/Opportunities

- Chemical Mixtures and Cumulative Risk Assessment
  - Including non-chemical stressors
- Exposure Guidelines
  - Exposure is a function of concentration and time.
  - Windows of susceptibility
- Leading vs. Lagging Indicators of Environmental Conditions
- Citizen Science
- Data Mining, AI / Machine Learning
- Approaches to Cost-Benefit Analysis
- Finishing this presentation before you fall asleep.





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