Advisory Panel on Emerging Contaminants (APEC)

Risk Assessment 101

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Risk Assessment 101

INTRODUCTION

What is Risk?

What is Risk?

Safe vs. Risk

- What is Safe?
  - Free from harm or risk
  - Secure from threat of danger, harm, or loss
  - Zero risk
- What is Risk?
  - Possibility of loss or injury, peril
  - The chance of loss; the degree of probability of such loss
  - The probability of injury, disease, or death from exposure to a chemical agent or a mixture of chemicals

Adapted from: http://ocw.jhsph.edu/courses/EnvironmentalHealth/PDFs/Lecture1.pdf

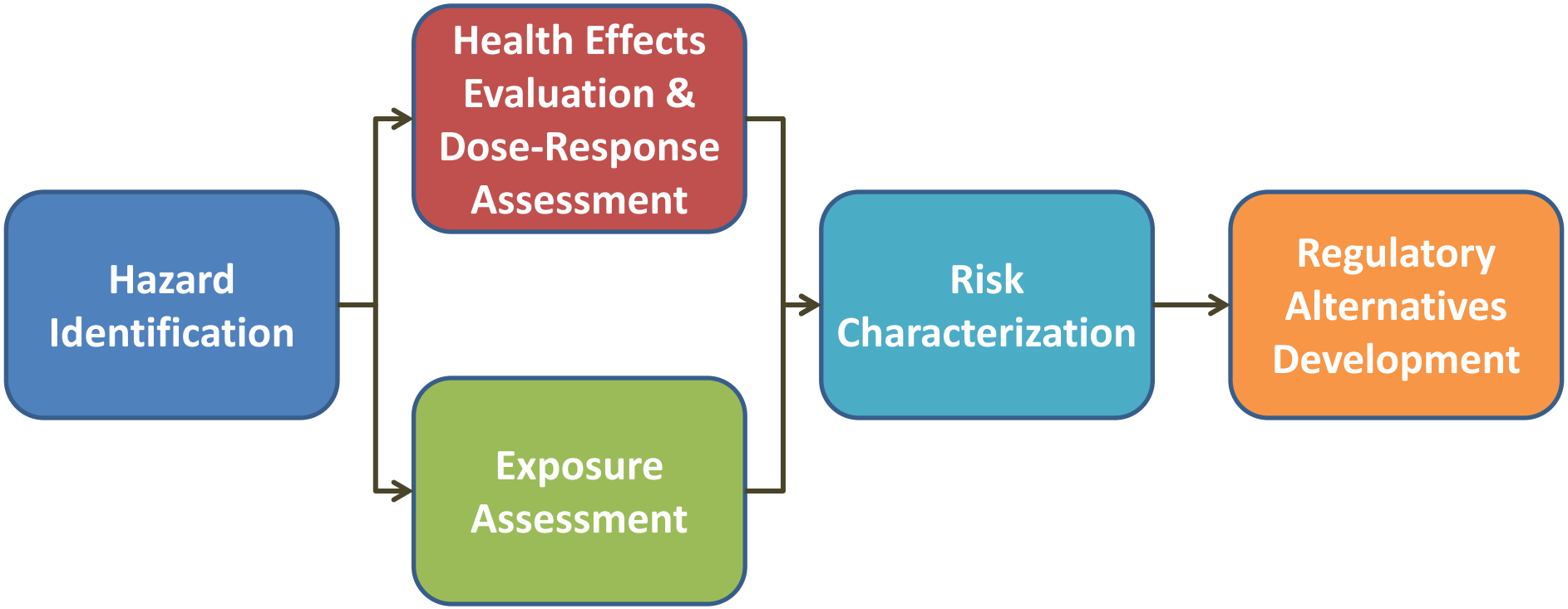
Environmental Toxicology Program

- Respond to communities where people might be exposed to hazardous substances in the environment
- Determine how hazardous a site is or has been
- Recommend actions that need to be taken to safe guard the health of community residents

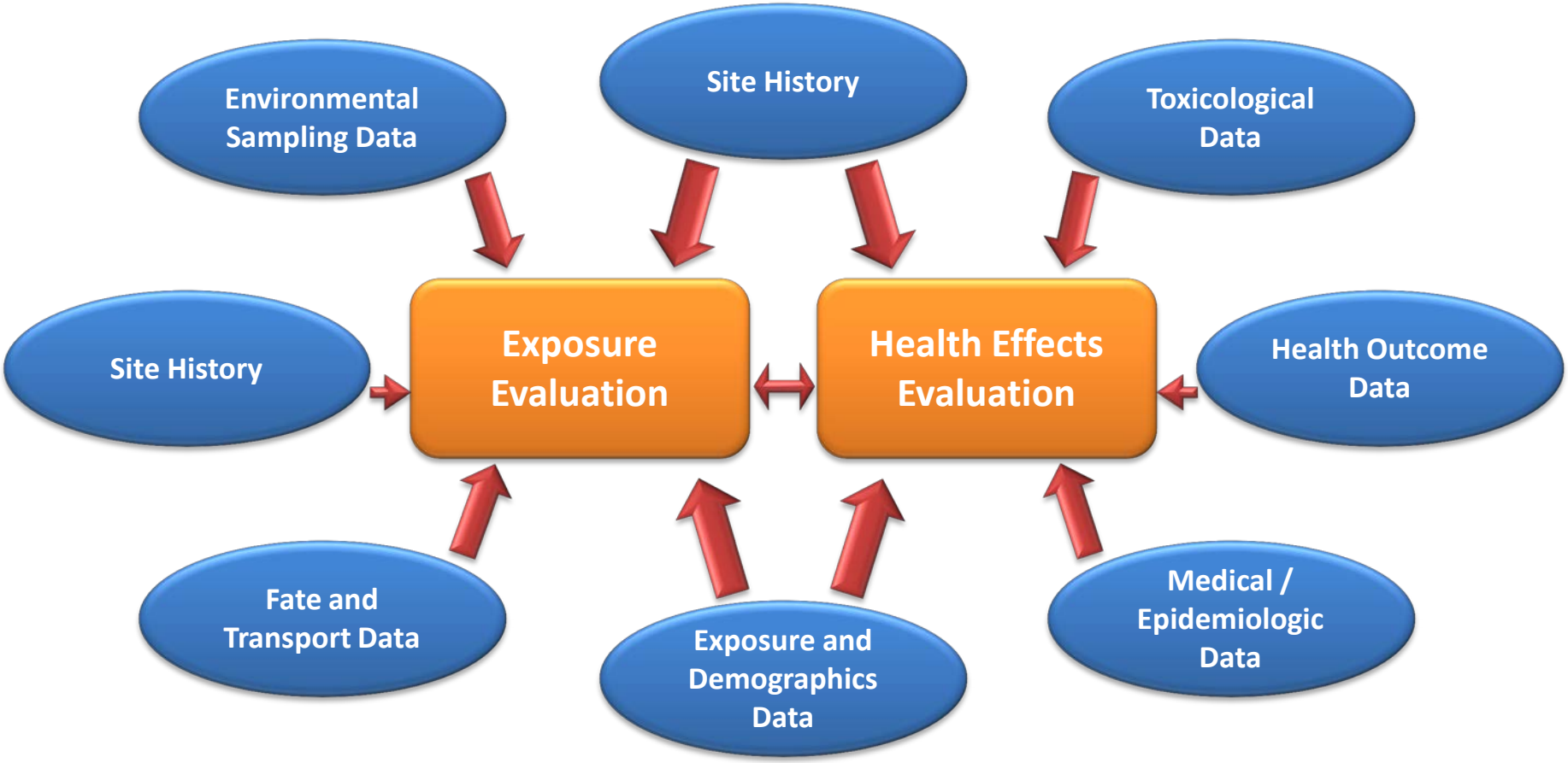
Environmental Toxicology Program (continued)

- Educate communities statewide about hazardous chemicals and substances
- Involve communities when responding to their environmental public health concerns

Components of Risk Assessment in Rulemaking



Information Needed to Evaluate Exposures and Health Effects



Exposure Pathways

2a. Release & Migration (volatilization)

2b. Environmental Media (air)

3. Exposure Point (ambient air)

4. Exposure Route (ingestion)

5. Potentially Exposed Population (residents)

1. Source (drums)

4. Exposure Route (inhalation)

3. Exposure Point (Private wells)

2a. Release Mechanism (leaching)

2b. Environmental Media (groundwater)

Health Effects Evaluation

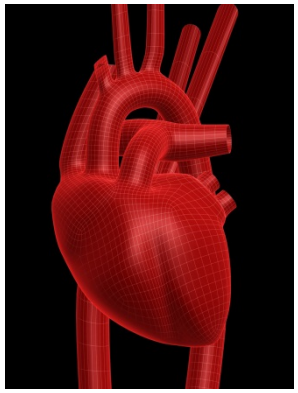
- End Points
- Dose – Response
- Comparison to Health Based Guidelines

Gastrointestinal

Hepatic

Respiratory

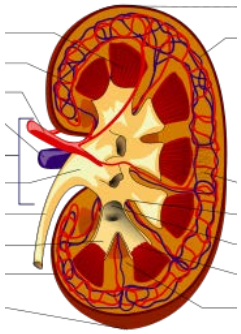
Dermatological



Cardiovascular & Hematological

Neurological

Reproductive & Developmental



Renal

Exposure Assessment

- Acute Exposure – Short term exposure
- Chronic Exposure – Long term exposure
- Critical Periods – Period when an organ/system is most vulnerable
- Route of exposure – inhalation, ingestion, dermal
- Carcinogenicity

Solving the problem

- Risk Assessment
  1. Define the problem
  2. Measure its determinants – Dose calculations
     - Determinant = any factor or variable that can affect the frequency with which a disease occurs in a population
- Risk Management
  3. Develop intervention/prevention strategies
  4. Set policy/priorities
  5. Implement and evaluate

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DEVELOPING NPDWR'S

(NATIONAL PRIMARY DRINKING WATER REGULATIONS)

Introduction to Safe Drinking Water Regulation

- Risk Assessment in the Safe Drinking Water Act (SDWA)
  - Establishing public health protection **goals**
    - Maximum Contaminant Level Goal (**MSLG**)
  - Estimating and comparing the benefits of risk reduction for **regulatory** options
    - Maximum Contaminant Levels (**MCLs**)
    - Treatment Technique (**TT**)

Maximum Contaminant Level Goals (MCLG)

- Definition:
  - Maximum level of a contaminant in drinking water at which no known or anticipated adverse health effect would occur, and which allows an adequate margin of safety
- Do not consider cost and technology.
- Considerations in setting an MCLG:
  - End-Point – cancer or non-cancer
  - Acute or chronic exposure concerns
  - Sensitive populations
- Data obtained from epidemiological and toxicological studies

Maximum Contaminant Level (MCL)

- Is enforceable
- Set as close to the MCLG as feasible
- "Feasible" is the level that may be achieved:
  - Best available technology (BAT), treatment technique
  - Examination for efficiency under field conditions and not solely under laboratory conditions
  - Taking cost into consideration
- Requires a determination as to whether the benefits justify the costs

Treatment Technique (TT)

- Alternative to an MCL when it is not economically and technologically feasible to ascertain the level of the contaminant
  - Common for microbiological contaminants
- A TT is also an enforceable standard involving a measurable procedure or level of technological performance (e.g. “Action Level”)
  - Surface Water Treatment Rule
  - Lead and Copper Rule

National Primary Drinking Water Regulations (NPDWRs)

- Microorganisms
  - 7 standards addressing microorganisms
    - 3 bacteria, viruses, 4 indicators (i.e. turbidity)
- Disinfection Byproducts
  - 4 standards
- Disinfectants
  - 3 standards
- Inorganic Chemicals
  - 16 standards
- Organic Chemicals
  - 53 standards
- Radionuclides
  - 4 standards

Currently there are 87 legally enforceable standards

Key Steps for Developing NPDWRs

- Setting the MCLG (Maximum Contaminant Level Goal)
  - **Health effects information**
  - **Exposure information**
  - **Relevant information and procedures developed by EPA for risk assessment and characterization**
- Assess whether an MCL (Maximum Contaminant Level) or TT(Treatment Technique) is more appropriate
- Identify and evaluate costs and effectiveness of treatment alternatives
- Specify Best Available Technology (BAT)

Key Steps for Developing NPDWRs

- Evaluate contaminant occurrence
  - Number or systems affected
  - To what degree are they affected
- Evaluate contaminant exposure
  - Number of people affected
  - To what degree are they affected
- Characterize compliance choices for regulatory alternatives

Key Steps for Developing NPDWRs

- Develop multiple MCL (or TT) alternatives
  - Compare benefits and costs; address uncertainty
  - Document the underlying data and analyses to support the proposed or final rule
    - Economic Analysis
    - Health Criteria Document
    - Occurrence and Exposure Document
    - Cost and Technology Document

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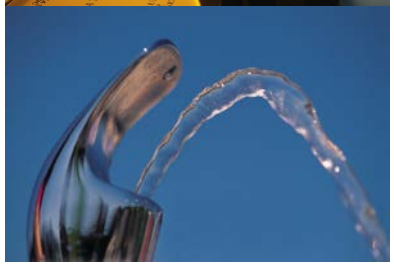
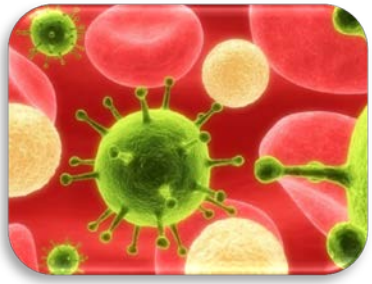
HEALTH HAZARDS



Types of Contaminants



- Microbiological
  - Waterborne pathogens
- Biological toxins
- Chemicals
  - Naturally occurring
  - Man-made
  - Used in commerce, pesticides
- Disinfection products and byproducts

Sensitive Populations

- Infants and children
- Pregnant women & fetuses
- Elderly people
- Immunocompromised individuals
- Highly exposed individuals

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SETTING MCLG'S

Identifying Adverse Health Effects

- Different adverse effects can occur with different magnitude, frequency, route, and duration of exposure
- Two broad categories of health effects:
  - Cancer
  - Non-cancer

Toxicological Studies

- Toxicology – the study of poisons and their actions
- Toxicological experiments often
  - Involve non-human experiments
  - Involve small numbers of animals
  - High exposure doses
  - Use mathematical models to determine the concentration of the chemical that would cause disease in people
    - EPA uses the studies with the greatest ***margin of safety*** (overestimation of risk)

Toxicological Study Methods

- Some animals subjected to high doses of chemicals
  - Necessary to observe statistically significant rates of disease
- Other animals exposed to lower doses of chemicals
  - Necessary to provide data inputs for a dose-response curve
- Long-term carcinogenicity studies
- Use these studies together to develop a dose-response curve

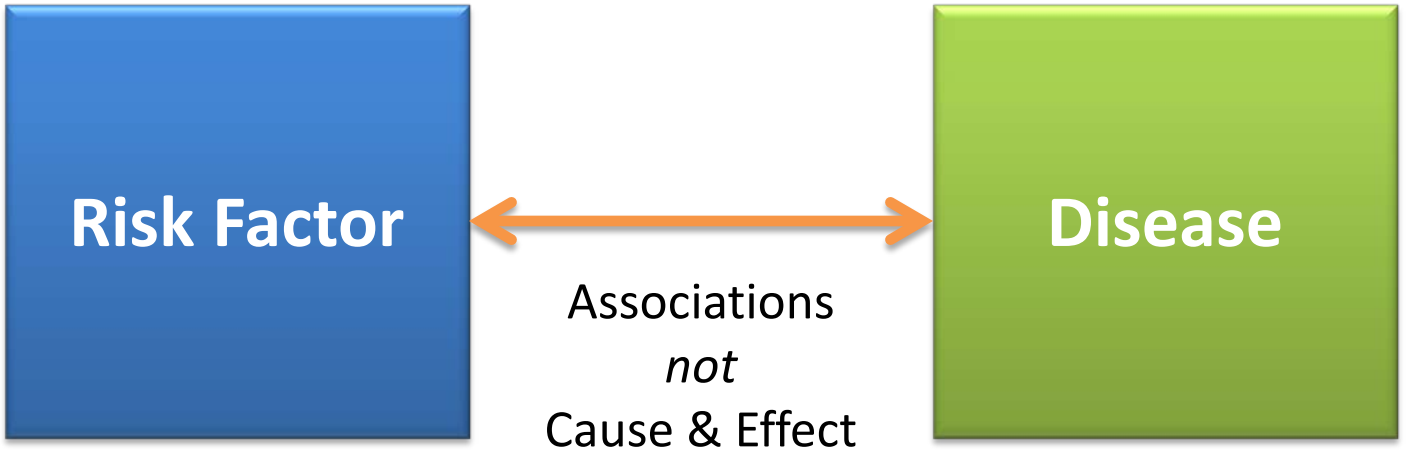
Strengths and Limitations of Toxicology Studies

- Environmental factors can be controlled
  - Contaminant under study
  - Other exposures
  - Facilitates interpretation of results
- Uncertainty associated with extrapolations
  - From high doses tested to environmentally relevant doses
  - From effects on animals to effects on humans

Epidemiological Studies

- **Epidemiology** – the study of how, when, and where diseases occur in populations of humans, and the application of study results to control a public health problem
- Studies based on human exposure
- Epidemiologists seek to identify:
  - **Risk factors** associated with the occurrence of disease
  - Protective factors that reduce the risk of disease

Linking Risk Factors and Disease

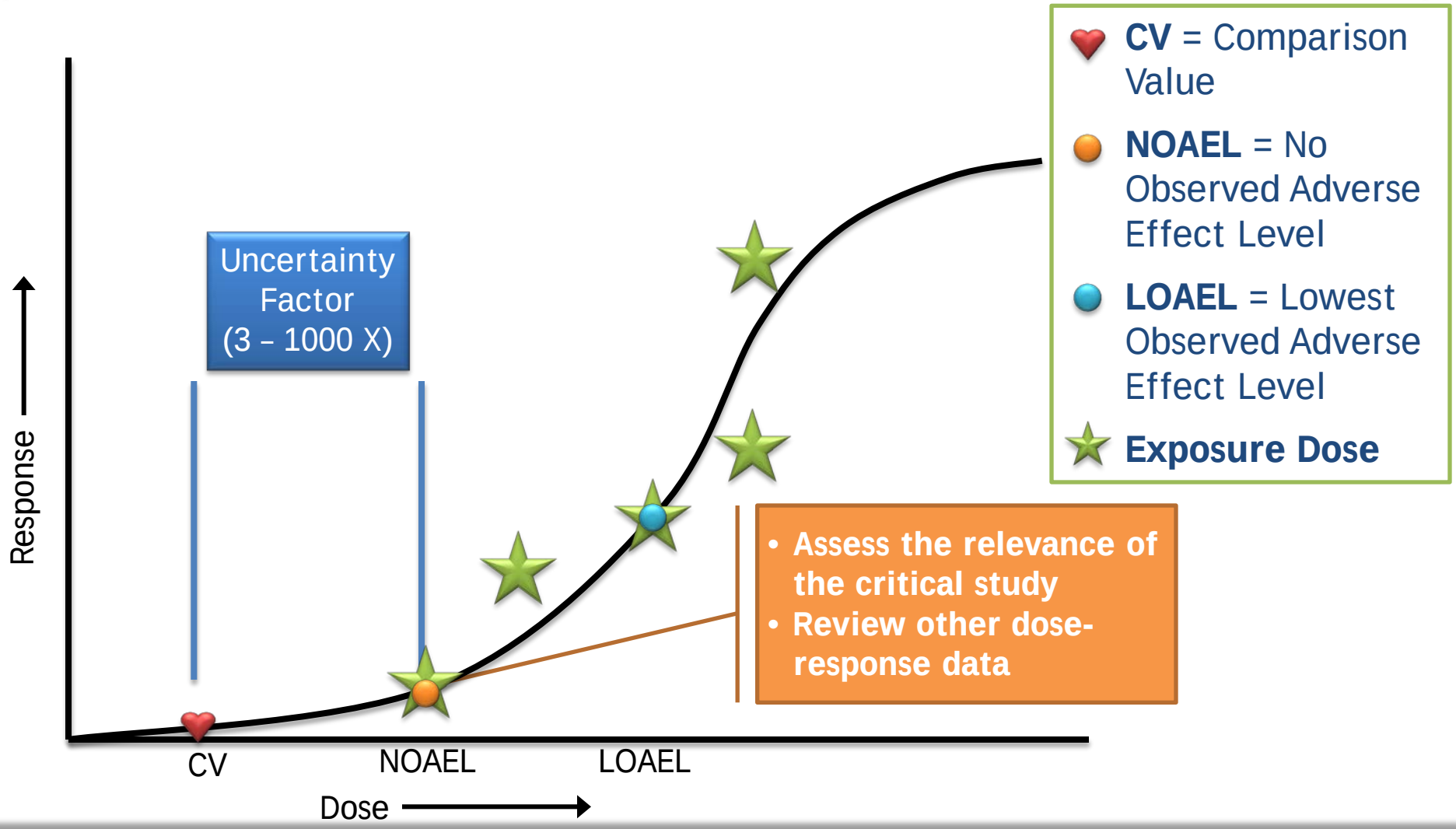


Strengths and Limitations of Epidemiological Studies

- Especially useful where high rates of rare diseases occur in small populations
- Provide data on the actual incidence of disease
- Dose-responses and exposure estimates are not needed

- Less effective in determining the causes of common diseases in large populations
- Difficulties in correlating data across geographic areas
- Cannot definitively prove cause and effect
- Often involve occupational exposures or case studies

Dose-Response Relationships



Non-carcinogens

Reference Dose (RfD)

$$\text{RfD} = \frac{NOAEL}{UF \times MF} \text{ or } \frac{LOAEL}{UF \times MF}$$

UF = Uncertainty Factor

- ex. interspecies

MF = Modifying Factor

- ex. Completeness of overall data

The daily exposure level which, during an entire lifetime of a human, appears to be without appreciable risk – mg/kg/day

Non-carcinogens

- Threshold type:
  - RfD (mg/kg-day) is determined from toxicological or epidemiological data
  - The Drinking Water Equivalent Level (DWEL) (mg/L) is computed from the RfD assuming 2 L/day consumption and 70 kg body weight
  - RSC is applied to DWEL to get MCLG

$$\text{MCLG} = DWEL \times RSC$$

MCL = Maximum Contaminant Level

DWEL = Drinking Water Equivalent Level

RSC = Relative Source Contribution

Non-carcinogens

- Non-threshold type
  - Lead
    - Neurological and cognitive effects in young children
  - Microorganisms
    - *Cryptosporidium*, *Giardia*, *Legionella*, total coliforms, viruses
- MCLG = 0

Carcinogens

- The MCLG is traditionally set at zero for all carcinogens
  - Assumed to be genotoxic (affects the cell's genetic material)
  - No threshold

Cancer Risk Assessment

- EPA applies a model to the available dataset to calculate the "cancer slope factor"
- Cancer Risk is calculated using
  - Exposure calculations
  - Cancer slope factor

$$Risk = C \times \frac{IR \times EF \times ED}{BW \times AT} \times SF \times ADAF$$

C = Concentration
IR = Intake rate
BW = Body weight
Ef = Exposure frequency

ED =Exposure duration
AT =Averaging time
SF = Cancer slope factor
ADAF = Age-dependent adjustment factor

Cancer Risk

- Example of cancer risk
  - 2.4×10^{-05}
  - This means that the risk calculation estimates that there will be 2.4 extra cases of cancer per 100,000 people over a lifetime of exposure.
    - $10^{-05} = 1/100{,}000$

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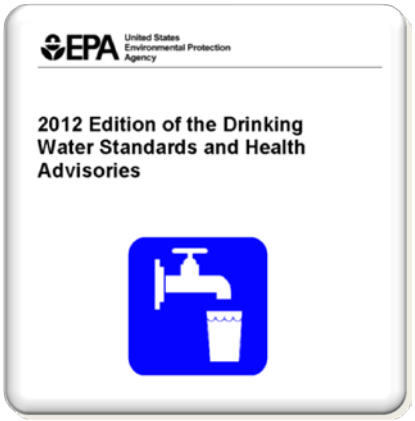
HEALTH ADVISORIES & OTHER SOURCES OF HEALTH EFFECTS INFORMATION

EPA's Health Advisories

- Serve as a technical guidance for federal, state, and local officials
  - Health effects
  - Analytical methodologies
  - Treatment technologies
  - MCLG, MCL



http://water.epa.gov/action/advisories/drinking/upload/dwstandards2012.pdf

Chemicals	CASRN Number	Standards			Status HA Document	Health Advisories						Cancer Descriptor[1]
		Status Reg.	MCLG (mg/L)	MCL (mg/L)		10-kg Child						
						One-day (mg/L)	Ten-day (mg/L)	RfD (mg/kg/day)	DWEL (mg/L)	Life-time (mg/L)	mg/L at 10^{-4} Cancer Risk	
ORGANICS												
Acenaphthene	83-32-9	-	-	-	-	-	-	0.06	2	-	-	-
Acifluorfen (sodium)	62476-59-9		-	-	F '88	2	2	0.01	0.4	-	0.1	*L/N*
Acrylamide	79-06-1	F	zero	TT[2]	F '87	1.5	0.3	**0.002**	0.07	-	-	L
Acrylonitrile	107-13-1		-	-	-	-	-	-	-	-	0.006	B1
Alachlor	15972-60-8	F	zero	0.002	F '88	0.1	0.1	0.01	0.4	-	*0.04*	*B2*

Other Sources of Health Effects Information

- Scientific Literature
- IRIS – Integrated Risk In formation System (EPA)
  - IRIS database is web accessible and contains human health information on more than 550 chemical substances, http://www.epa.gov/IRIS/
- CDC – Centers for Disease Control and Prevention www.CDC.gov
  - Maintains information on diseases, etiologies, and treatments
  - Morbidity and Mortality Weekly Report www.cdc.gov/MMWR/
  - Surveillance Summaries for Waterborne Disease Outbreaks – US www.cdc.gov/healthywater/statistics/wbdoss/surveillance.html
- ATSDR – Agency for Toxic Substances and Disease Registry
  - Toxicological profiles, www.atsdr.cdc.gov/toxprofiles/index.asp
- The World Health Organization
  - Guidelines for Drinking Water Quality www.who.int/water_sanitation_health/dwq/gdwq3rev/en/
- EPA SDWA Regulation Development
  - http://water.epa.gov/lawsregs/rulesregs/regulatingcontaminants/index.cfm

Contact Information

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