EVOLVING TOOLS IN OCCUPATIONAL RISK ASSESSMENT

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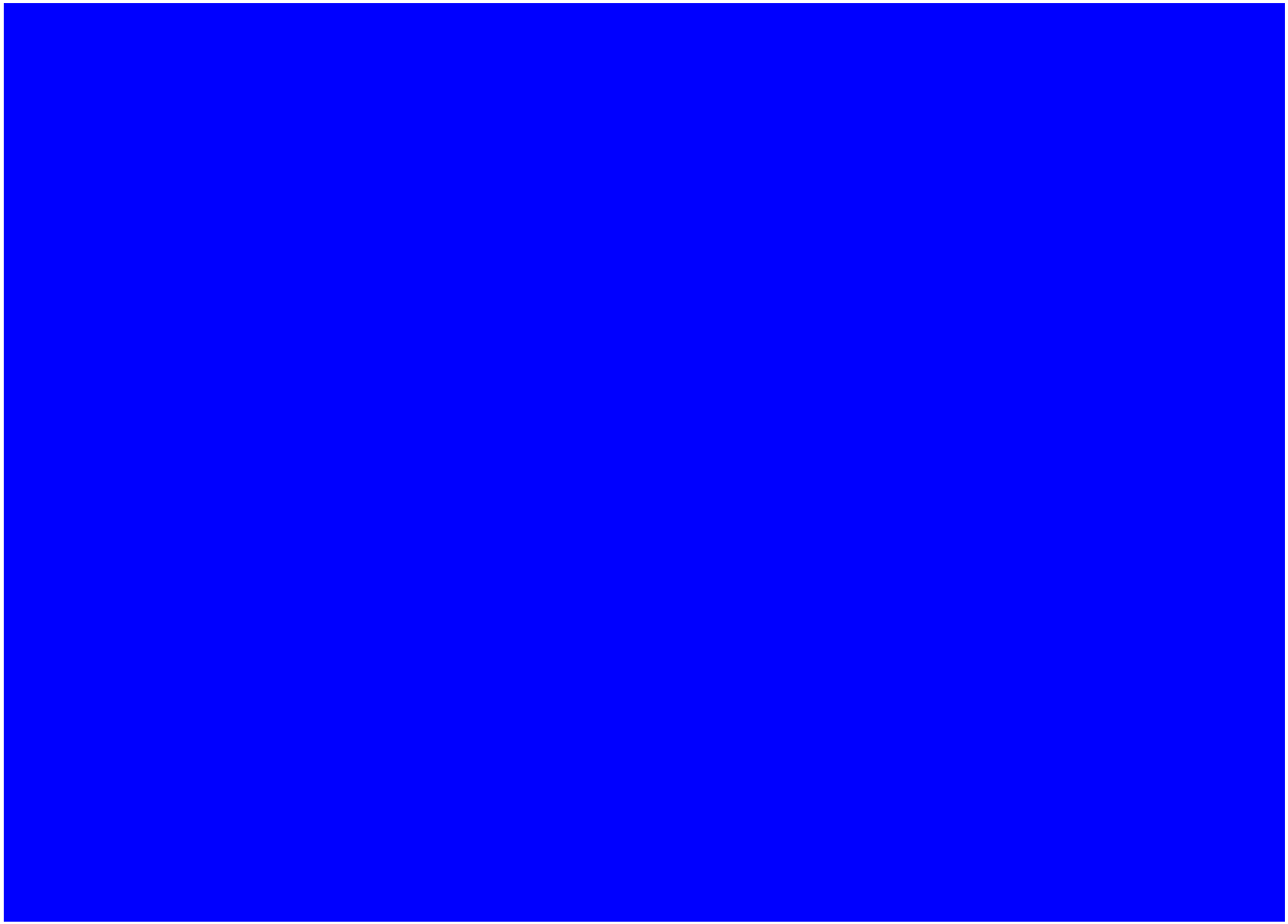
Learning Objectives

- Describe the basic approaches used for occupational health risk assessment for chemical exposures
- Recognize important areas in risk assessment that are evolving
  - New tools for traditional assignments (OEL updates)
  - Moving beyond the fence line (Cumulative Risk)
  - Who are you going to call (Emergency Response)
- Identify resources and guidance for implementation of the newest methods in occupational risk assessment



Our current practice *is* occupational risk assessment

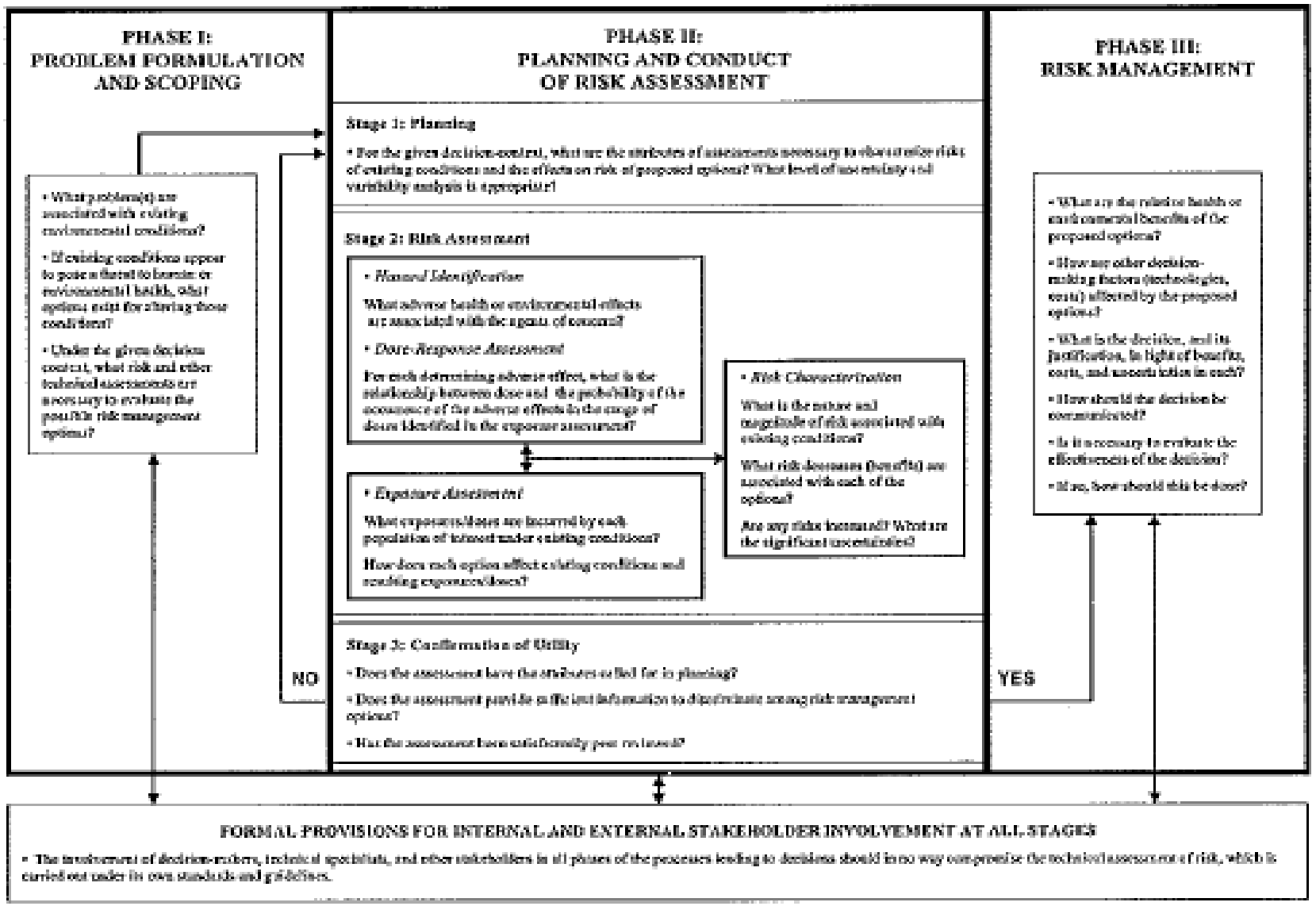


FIGURE 8-1 A framework for risk-based decision-making that maximizes the utility of risk assessment.

The NAS Risk Assessment Approach

Hazard Characterization [Recognize]: IS THIS STUFF TOXIC?

Dose-Response Assessment [Anticipate & Evaluate]: HOW TOXIC IS THIS STUFF?

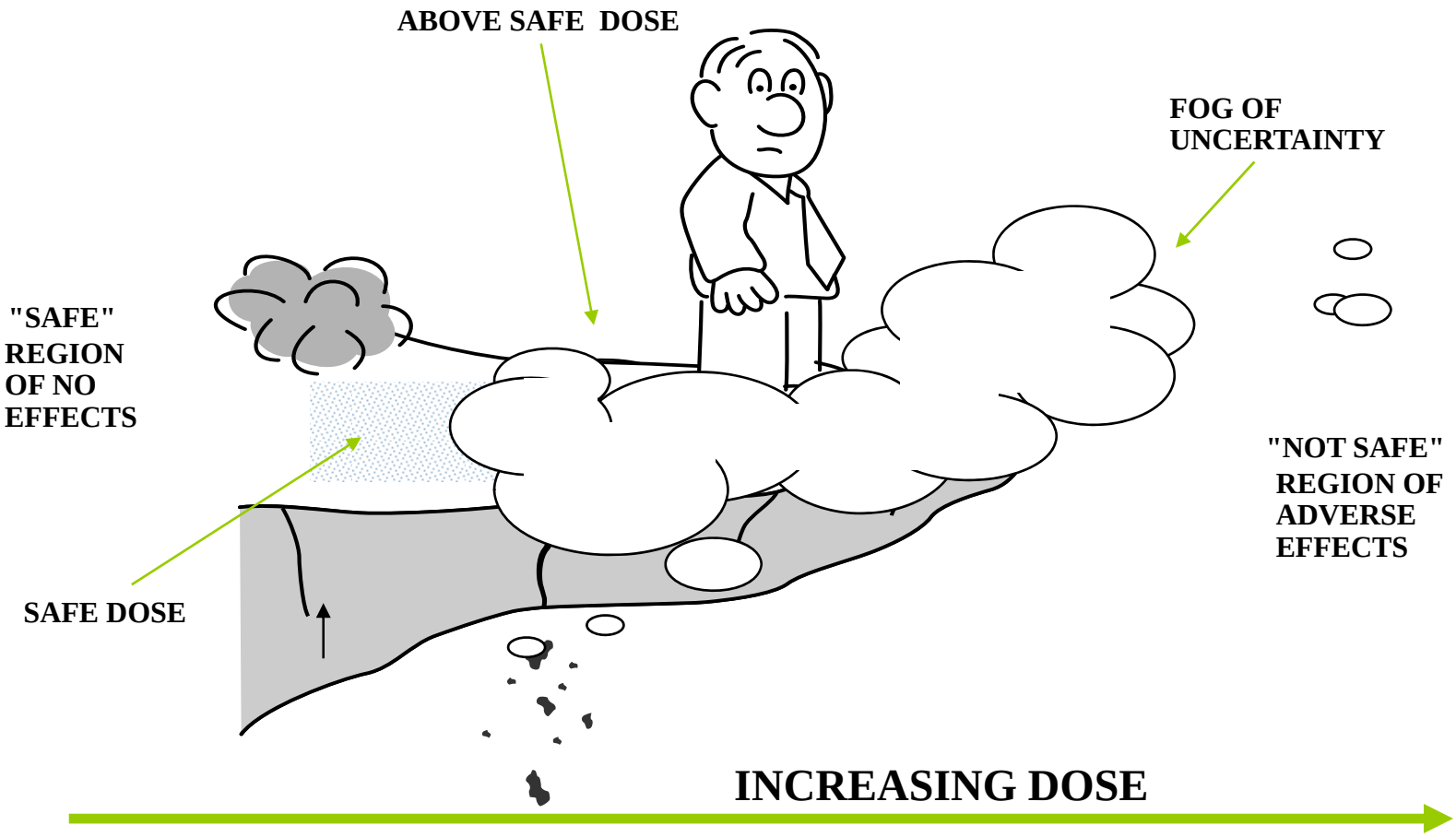
Exposure Assessment [Anticipate & Evaluate]: WHO IS EXPOSED TO THIS STUFF, HOW MUCH, HOW OFTEN, AND FOR HOW LONG EACH TIME?

Risk Characterization [Evaluate]: SO IS THERE A PROBLEM?

Risk Management [Control]: SO WHAT ARE YOU GOING TO DO ABOUT IT?

Harmonization of Occupational Exposure Guidelines and A Suite of OEL Tools

The OEL Development Process



Dose-Response Assessment – The OEL

$$\text{Risk Value} = \frac{\text{Measure of Dose-Response}}{\text{Factors to Address Uncertainty in Extrapolation}}$$

$$\text{OEL} = \frac{\text{NOAEL or LOAEL}}{\text{UF}}$$

Exposure Guideline Disharmony?

n-Hexane Exposure Guidelines

Type of Limit	Value (ppm)	Agency
DNEL – Derived No Effect Level	4.7	REACH – European Union
IOELV - Indicative Occupational Exposure Limit Values	20	SCOEL – European Union
TLV® – Threshold Limit Value	50	ACGIH – American Conference of Governmental Industrial Hygienists
AEGL2 – Acute Exposure Guideline Level (2)	4800 (10-min) 3300 (30-min to 8-hr)	NRC – National Research Council
IDLH – Immediately Dangerous to Life and Health	1,100	NIOSH – National Institute for Occupational Health and Safety
RFC – Inhalation Reference Concentration	0.2	U.S. EPA – Environmental Protection Agency

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The International Programme on Chemical Safety (IPCS)

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IPCS Harmonization Project

Harmonization of approaches to the assessment of risk from exposure to chemicals

The International Programme on Chemical Safety (IPCS) (WHO/ILO/UNEP) is leading a project to harmonize approaches to the assessment of risk from exposure to chemicals. The goal of this project is to globally harmonize approaches to risk assessment by increasing understanding and developing basic principles and guidance on specific chemical risk assessment issues. Harmonization enables efficient use of resources and consistency among assessments.

About the Project

- Harmonization Project information brochure: A4 format [pdf 104kb]
- Harmonization Project information brochure: Trifold format [pdf 115kb]
- Strategic Plan
- Stocktake of the Project, including how the products are used
- How the work is organized
- Contact us

Project focus areas

- Aggregate/cumulative risk assessment
- Cancer risk assessment
- Non-cancer risk assessment
- Exposure assessment
- Exposure assessment and risk assessment terminology
- Mutagenicity
- PBPK Modelling
- Skin sensitization risk assessment
- Reproductive/developmental toxicity
- Chemical-Specific Adjustment Factors

RELATED PUBLICATIONS

Harmonization Project publications
Full text

Descriptions of key generic terms
Full text

Risk assessment model for insecticide treatment and subsequent use of mosquito nets
Full text

Contact us
Click here to sign up for updates to the site about selected topics of interest.

Mailing address:
IPCS
World Health Organization (WHO)
20 Avenue Appia
1211 Geneva 27
Switzerland

http://www.who.int/ipcs/methods/harmonization/en/

Key Points on Harmonization

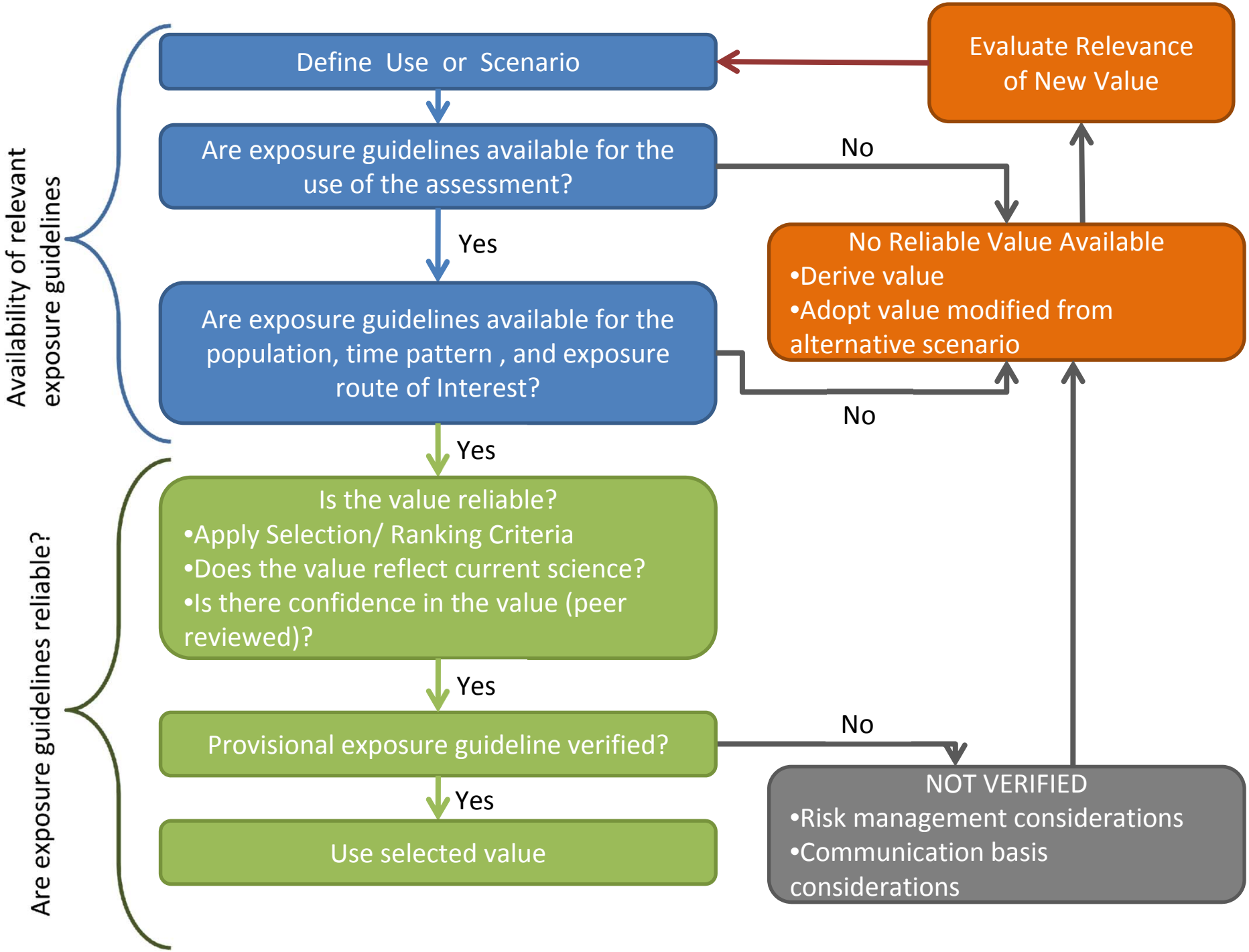
- OELs play a critical role in occupational health
- Methods and resulting OELs and other Occupational Exposure Guidelines differ among agencies
- There is growing emphasis on harmonization of methods
- Shared information facilitates harmonization
- Numerous sources of information are available, but no unified source has been compiled
- Decision guides assist to sort through the confusing landscape of guidance

Types of Exposure Guidance

- There are many sources and types of exposure limit information that can be applied to different scenarios:
  - Purpose of assessment
    - Priority setting, Registration, Worker exposure assessment?
  - Exposure duration
    - Acute versus chronic?
  - Exposure population
    - Responders, workers, general population?
  - Exposure frequency
    - Routine or infrequent?
- How do you find these and select one for your scenario?

Selecting Among Resources

- How to decide which value among many?
- Mandated regulatory hierarchy in-place?
- Other considerations to weigh in decision:
  - Relevance of the guide value to the scenario or use of interest
  - The degree to which the exposure guidance includes current literature and methods
  - Confidence in the value
    - Screening vs. full assessment
    - Robustness of limit setting process (e.g., authoritative agency, peer review, etc)


Availability of relevant exposure guidelines
Are exposure guidelines reliable?
Define Use or Scenario
Are exposure guidelines available for the use of the assessment?
Yes
No
Are exposure guidelines available for the population, time pattern , and exposure route of Interest?
Yes
No
Is the value reliable?
•Apply Selection/ Ranking Criteria
•Does the value reflect current science?
•Is there confidence in the value (peer reviewed)?
Yes
Provisional exposure guideline verified?
Yes
No
Use selected value
Evaluate Relevance of New Value
No Reliable Value Available
•Derive value
•Adopt value modified from alternative scenario
NOT VERIFIED
•Risk management considerations
•Communication basis considerations

Progression in Occupational Risk Guideline Development Tools

- Normal progression in risk assessment is from reliance on qualitative hazard-based approaches to quantitative risk-based assessments as data increases
- Hazard approach,
  - Advantage: rapid assessment allows for action to be taken quickly to address most likely health concerns
  - Disadvantage: absence of an objective measure of likelihood for health concern can lead to: 1) inadequate protection, 2) less confidence in the assessment, 3) difficulty in communicating risks
- The preferred IH practice is to use hazard-based approaches as an interim procedure until an OEL can be developed

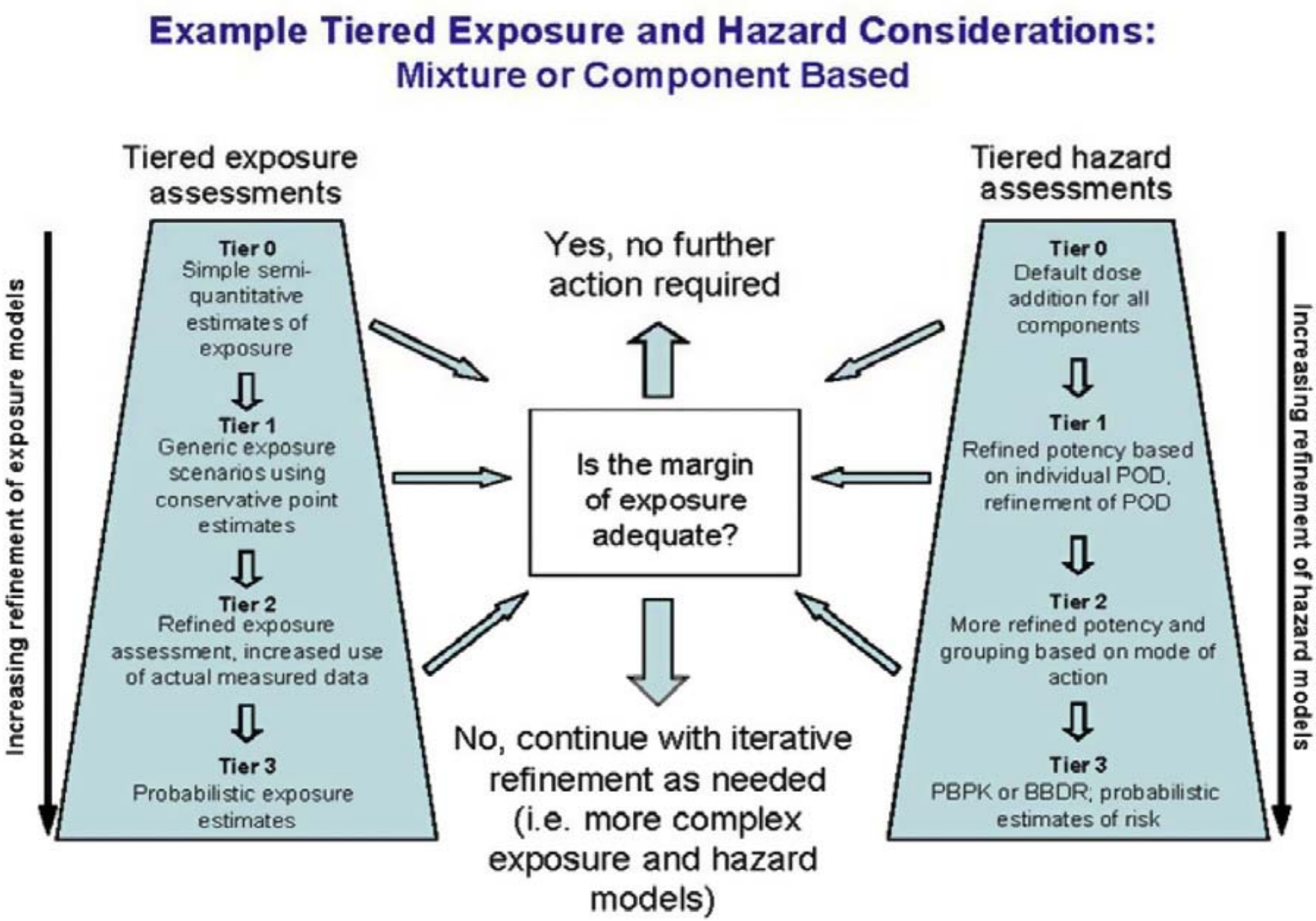
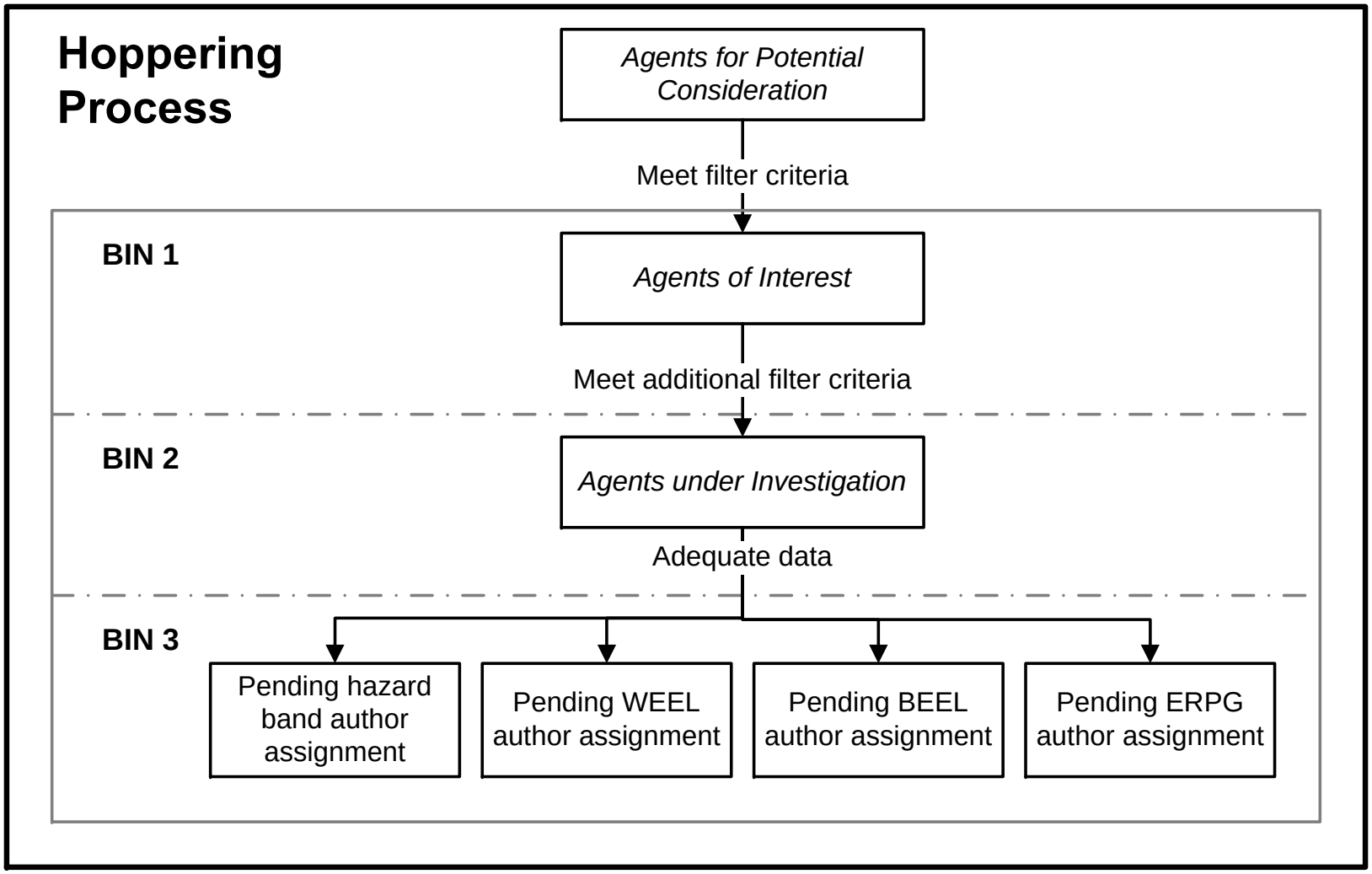


Fig. 1. A conceptual representation of the framework

M.E. (Bette) Meek, Boobis AR, Crofton KM, Heinemeyer G, Van Raaij M, Vickers C. 2011. Risk assessment of combined exposure to multiple chemicals: A WHO/IPCS framework. Regul Toxicol Pharmacol. In press.

WEEL "Hoppering Process"



Hazard Banding

- Array existing data for a series of key end points
- Establish criteria for categorizing each end point
- Typically assign hazard band based on worst of the identified hazard categories
- Preliminary OEL ranges often associated with each hazard band
- Many systems exist, but there are moves toward harmonizing criteria, including validation exercises – see NIOSH initiatives

REACH DNELs and DMELs

- DNEL:
  - The Derived No-Effect Level (DNEL) is defined in Annex 1 of REACH as the level of exposure above which humans should not be exposed
  - Develop separate DNELs for populations, durations, and routes based on exposure assessment
  - Manufacturers and importers are required to calculate DNELs as part of their Chemical Safety Assessment (CSA) for any chemicals used in quantities of 10 tons or more per year
  - Will be reported in eSDS

Worker-DNEL$_{long\text{-}term}$ for *dermal route*

Study	13-week Rats (dermal)
NOEL/NOEC	880 mg/kg bw
Conversion	not needed
LOEL	n.a.
AF (overall)	100
Interspecies (allometric factor)*	4
Interspecies (remaining differences)**	2.5
Intra-species (worker)	5
Exposure duration (sub-acute to chronic)	n.a.
Exposure duration (sub-chronic to chronic)	2
LOAEL to NOAEL	n.a.
DNEL (long-term)	8.8 mg/kg bw/d

Correlation Approaches

- No toxicology data, some physicochemical property (P) or relative potency data
  - $OEL_a = (P_a/P_b) \times OEL_b$
- Irritancy
  - Acidity (pKa) for organic acids
  - RD50 values
- Lethality
  - Acute Lethality (LD50 and LC50)
- Systemic Toxicity
  - Subchronic NOAELs or LOAELs

Exposure Assessment Evolving Too!

Key Trends Include:

- Increased Exposure *Estimation*
  - Scenario-based approaches: e.g. EPA and EU REACH
  - Increased access to software-based exposure estimation tools
- Exposure Measurement
  - Tools for deciding on sampling strategies (e.g. Bayesian statistics approach)
  - Increased focus on task-based approaches
  - More use of biomarkers of effect and exposure
  - Focus on “total” exposure

Assessing Impacts of Total Exposure – Cumulative Risk

Area of Change – Cumulative Risk

- We are clearly moving to more systematic evaluation of "real-life" exposures
  - Multiple routes of exposure
  - Mixtures of chemicals
  - Total exposure (occupational plus non-occupational)
  - Combined effects of chemicals plus non-chemical stresses
- We need "OELs" and exposure assessment tools to address these new perspectives

Key Definitions

- Aggregate exposure = one chemical, multiple routes
- Mixture = exposure to more than one chemical
- Cumulative risk = exposure to single or multiple chemicals and nonchemical stressors by all routes

Risk Integration

- EPA Pathways Approach for Site Risk Assessment
- Calculates exposure from multiple pathway

Model Equation for Developing Acceptable Risk-Based Concentrations in Soil.
Acceptable Soil Cleanup Target Levels for Non-Carcinogens

$$SCTL = \frac{THI \times BW \times AT \times RBA}{EF \times ED \times FC \times \left[\left(\frac{1}{RfD_o} \times IR_o \times 10^{-6}\,kg/mg\right) + \left(\frac{1}{RfD_d} \times SA \times AF \times DA \times 10^{-6}\,kg/mg\right) + \left(\frac{1}{RfD_i} \times IR_i \times \left(\frac{1}{VF} + \frac{1}{PEF}\right)\right)\right]}$$

SCTL = Soil Cleanup Target Level
THI = target hazard index (unitless)
BW = body weight (kg)
AT = averaging time (days)
EF = exposure frequency (days/yr)
ED = exposure duration (years)
RBA = relative bioavailability factor (unitless)

FC = fraction from contaminated source (unitless)
IR_O = ingestion rate, oral (mg/day)
SA = surface area of skin exposed (cm^2/day)
AF = adherence factor (mg/cm^2)
DA = dermal absorption (unitless)
IR_i = inhalation rate (m^3/day)
VF = volatilization factor (m^3/kg)

PEF = particulate emission factor (m^3/kg)
RfD = reference dose (mg/kg-day)
RfD_O = oral
RfD_d = dermal
RfD_i = inhalation

Risk Characterisaton Step

$$\text{Endpoint-specific DNEL} = \frac{\text{NOAEL}_{\text{corr}}}{\text{AF}_1 \times \text{AF}_2 \times \ldots \times \text{AF}_n} = \frac{\text{NOAEL}_{\text{corr}}}{\text{Overall AF}}$$

$$\text{RCR} = \frac{\text{Exposure}}{\text{DNEL}}$$

RCR (for simulatanous exposure via three routes) = RCR (oral) + RCR (dermal) + RCR (inhalation)

ECETOC (European Centre for Ecotoxicology and Toxicology of Chemicals). 2010. *Guidance on Assessment Factors to Derive a DNEL*. ECETOC TR No. 110.

Exposome

"… the measure of all the exposures of an individual in a lifetime and how those exposures relate to disease."

Source: http://www.cdc.gov/niosh/topics/exposome/

Relative Source Contribution

- Use of RSC in Calculations for Water Criteria and OEL
  - Maximum Contaminant Level Goal (MCLG)

$$MCLG = \frac{(RfD\ x\ BW\ x\ RSC)}{(water\ intake\ )}$$

  - RSC adjusted OEL

$$OEL = \frac{(NOAEL\ x\ RSC)}{(UF\ )}$$

BW = body weight; NOAEL = no observed adverse effect level; UF = uncertainty factor

EPA's Pesticide Approach

1) Identify Common Mechanism Group (CMG);
2) Identify Potential Exposures;
3) Characterize and Select Common Mechanism Endpoint(s);
4) Determine The Need For a Dosimetry-Based Cumulative Risk Assessment;
5) Determine Candidate Cumulative Assessment Group
6) Conduct Dose- Response Analyses and Determine Relative Potency and Points of Departure;
7) Develop Detailed Exposure Scenarios All Routes and Durations;
8) Establish Exposure Input Parameters;
9) Conduct Final Cumulative Risk Assessment;
10) Conduct Characterization of Cumulative Risk.

U.S. EPA. 2002. Guidance on Cumulative Risk Assessment of Pesticide Chemicals That Have a Common Mechanism of Toxicity. Office of Pesticide Programs. Washington, DC.

OSH and Emergency Response

Natural Disasters

- Earthquakes, Fires, Floods, Hurricanes, Tornadoes…

Epidemics

- Measles, Yellow Fever, Flu, Small Pox…

Man-made Threats

- Industrial and Transport Accidents; Terrorism events…

Role of the Industrial Hygienist

- Common Role:
  - Advisor to Onsite Incident Commander
    - Health effects of Concern and Relevant Exposure Limits
      - Exposure assessment strategy
      - Entry and control procedures
- Toxicology information supports decision making!
- Needs and resources differ based on response phase:
  - Planning
  - Initial Incident Response
  - Ongoing Response
  - Recovery and Clean-up

Resources and Tools (continued)

http://chemm.nlm.nih.gov/toolcomparator.htm

Emergency Response Safety & Health Database (ERSH-DB)

- Developed by NIOSH in response to the needs of emergency response community
  - FBI,DHS,HHS
- Rapidly accessible OSH database
- Contains concise information on high priority chemical, biological &radiological agents
  - ~200 entries (40 on-line at this time)
- http://www.cdc.gov/niosh/ershdb/about.html

The Emergency Response Safety and Health Database

The Emergency Response Safety and Health Database (ERSH-DB) is a rapidly accessible occupational safety and health database developed by NIOSH for the emergency response community. The ERSH-DB contains accurate and concise information on high-priority chemical, biological and radiological agents that could be encountered by personnel responding to a terrorist event.

Search

Search

Fields to Search

Select All | Select None | Defaults

- [x] Agent Category
- [x] Agent Characteristics
- [x] Agent Name
- [ ] Agent Properties
- [ ] CAS #
- [x] Common Names
- [x] Emergency Response
- [x] Decontamination (Environmental/Equipment)
- [x] First Aid
- [x] Decontamination (Human)
- [x] Long-Term Implications
- [ ] Occupational Exposure Limits
- [x] On-Site Fatalities
- [ ] Packaging and Labeling
- [x] Personal Protective Equipment
- [ ] RTECS #
- [x] Signs/Symptoms
- [x] Trade Names and Other Synonyms

ERSH-DB Index

Agents

ERSH-DB Example: Phosgene

Emergency Response Card

NIOSH National Institute for Occupational Safety and Health CDC

PHOSGENE (CG) :: Lung Damaging Agent

CAS #: 75-44-5
RTECS #: SY560000
UN #: 1076 (Guide 125)

Common Names:

- Carbonic dichloride
- Carbonyl chloride
- Chloroformyl chloride

Agent Characteristics

- **APPEARANCE**: Colorless gas above 47°F (8.2°C). Fog-like when concentrated. Colorless, fuming liquid below 47°F (8.2°C). May have the appearance of a white cloud. Light yellow liquid when refrigerated or compressed.

- **DESCRIPTION**: Phosgene (CG) was originally synthesized in 1812. It was used during WWI by the German army, and has since become part of the chemical arsenal of many countries including the United States. Small amounts of phosgene (CG) exist naturally in the atmosphere from the breakdown of chlorinated compounds. Phosgene is used in the preparation and manufacture of many organic chemicals especially in the dye, pharmaceutical, herbicide, insecticide, metal ore extraction, synthetic foam, resin, polymer, and chlorinating agent industries. Phosgene (CG) may also be released from household paint removers and degreasers when they are used in the presence of heat. Phosgene (CG) is shipped as a liquefied compressed gas in steel cylinders. At low concentrations, phosgene (CG) smells like newly mown hay or green corn. At high concentrations, phosgene (CG) has a strong, suffocating, unpleasant odor. However, the odor is only detectable for a short amount of time when phosgene (CG) is initially released and should not be depended on as a reliable indicator of overexposure.

- **METHODS OF DISSEMINATION**:
  - Indoor Air: Phosgene (CG) can be released into indoor air as a gas.
  - Water: Phosgene is unlikely to contaminate water because it breaks down rapidly upon contact with water to produce hydrochloric acid and carbon dioxide.
  - Food: Phosgene is unlikely to contaminate food because it breaks down rapidly upon contact with water to produce hydrochloric acid and carbon dioxide.
  - Outdoor Air: Phosgene (CG) can be released into outdoor air as a gas.
  - Agricultural: If phosgene (CG) is released as a gas, it is highly unlikely to contaminate agricultural products.

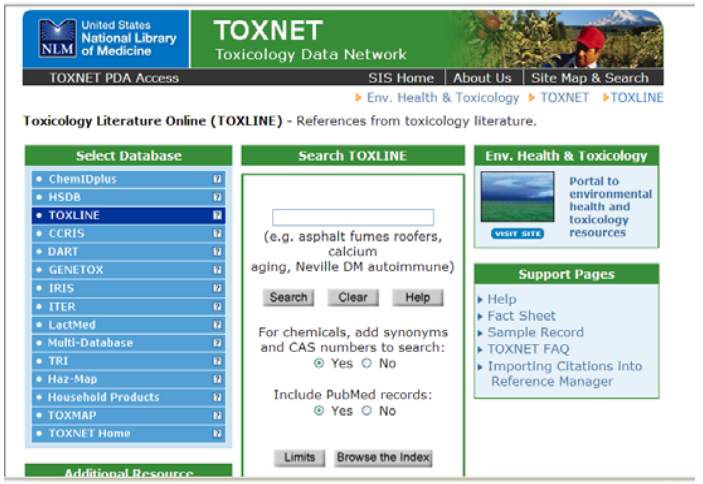
- **ROUTES OF EXPOSURE**: Inhalation is the primary route of exposure to phosgene (CG). Ingestion is unlikely, as phosgene (CG) is a gas at room temperature. Exposure to phosgene (CG) may be irritating to the eyes and skin.

Personal Protective Equipment

- **GENERAL INFORMATION**: First Responders should use a NIOSH-certified Chemical, Biological, Radiological, Nuclear (CBRN) Self Contained Breathing Apparatus (SCBA) with a Level A protective suit when entering an area with an unknown contaminant or when entering an area where the concentration of the contaminant is unknown. Level A protection should be used until monitoring results confirm the contaminant and the concentration of the contaminant.
  NOTE: Safe use of protective clothing and equipment requires specific skills developed through training and experience.

NLM

- Broad spectrum of resources/tools
- Hazard and Toxicology Information Sources for:
  - Rapid response activities
  - Planning or ongoing management
  - Other integrated resources
    - CHEMM*
    - WISER*



CHEMM

- Chemical Hazards Emergency Medical Management (CHEMM) (http://chemm.nlm.nih.gov/)

- In short, CHEMM is a complete resource containing information on **planning, preparing for, and responding to, chemical emergencies,** such as terrorist attacks, chemical spills, industrial explosions, building collapse, and natural disasters

U.S.Department of **Health & Human Services**

CHEMM

CHEMICAL HAZARDS EMERGENCY MEDICAL MANAGEMENT

Get the Latest CHEMM

- Download CHEMM
- Join CHEMM ListServ

Quick Links

- CHEMM Intelligent Syndrome Tool: **CHEMM-IST**
- Acute Patient Care Guidelines
- Types and Categories of Hazardous Chemicals
- Emergency Contacts
- Dictionary

About CHEMM

- Goals of this site
- Who produced this site?
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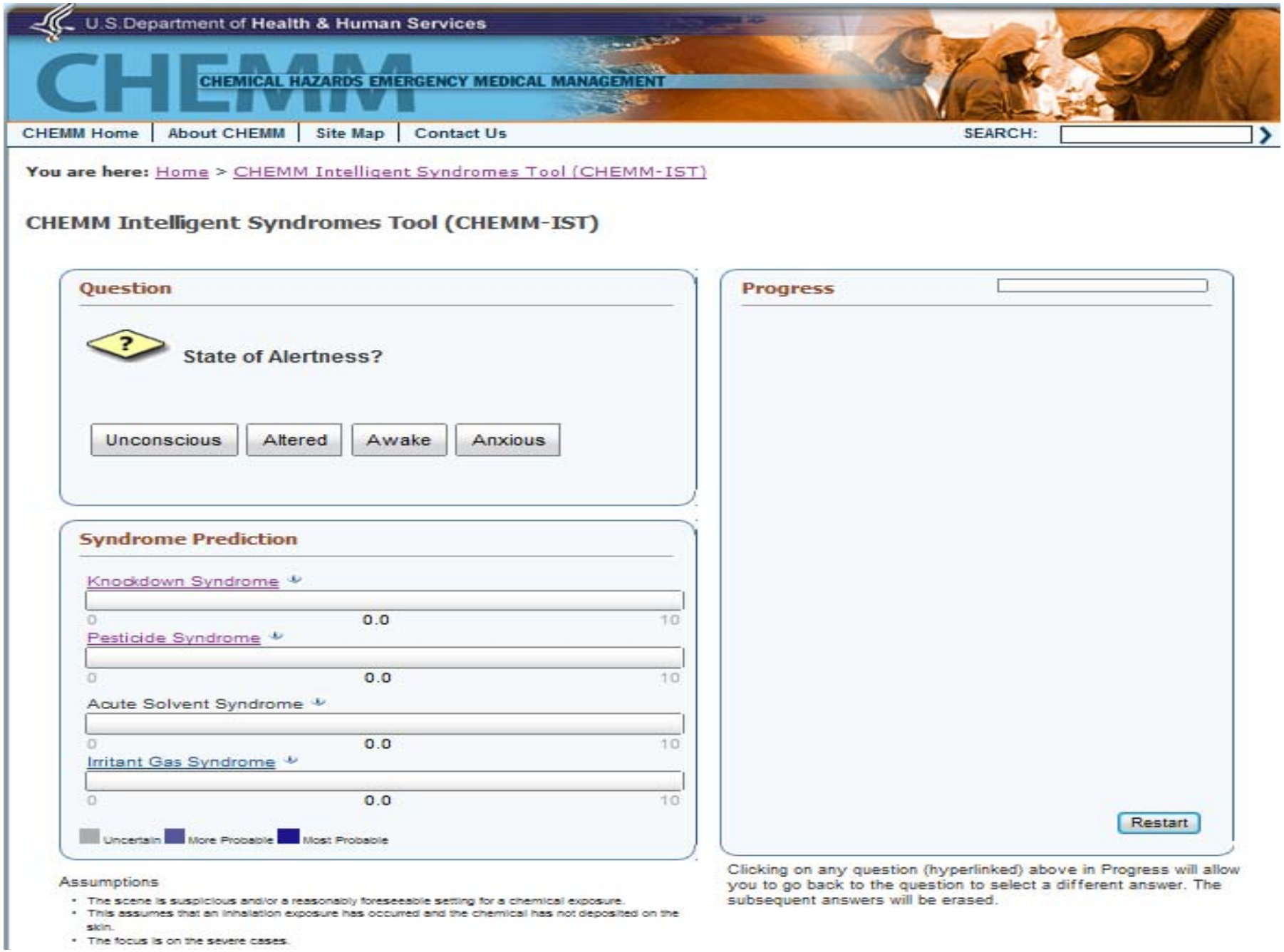
CHEMM for You

- First responders in the field
- Healthcare providers at the hospitals/poison centers
- Mental health professionals
- Public information officers
- Industrial hygienists/toxicologists
- Response planners
- Trainers
- The public

Other Resources

- CDC
- CHEMTREC
- DHS
- DOD
- EPA
- FBI
- FDA
- FEMA
- HHS
- NOAA
- NRC
- AAPCC



http://chemm.nlm.nih.gov/chemmist.htm

CHEMM Intelligent Syndromes Tool (CHEMM-IST)

Question

Done!

Click on the toxic syndrome name below for the appropriate medical management guidelines.

Syndrome Prediction

Knockdown Syndrome
0 1.3 10

Pesticide Syndrome
0 1.8 10

Acute Solvent Syndrome
0 1.2 10

Irritant Gas Syndrome
0 6.2 10

Uncertain More Probable Most Probable

Progress

State of Alertness? *Unconscious*
Sudden Onset of Unconsciousness? *Can't Assess*
Pinpoint Pupil? *Can't Assess*
Seizure? *No*
Cardiac Signs? *Yes*
Wheezing? *No*
Wet lungs/Rales? *No*
Sweaty? *Yes*
Irritated or Burning Skin? *Yes*
Eye Irritation? *Yes*
SLUDGE? *Can't Assess*

Restart

Clicking on any question (hyperlinked) above in Progress will allow you to go back to the question to select a different answer. The subsequent answers will be erased.

Assumptions

- The scene is suspicious and/or a reasonably foreseeable setting for a chemical exposure.
- This assumes that an inhalation exposure has occurred and the chemical has not deposited on the skin.
- The focus is on the severe cases.
- The tool is for the basic life support (BLS) provider to use in a mass casualty incident.
- It can also be used by advanced life support (ALS) first responders and hospital first receivers.

Additional Resource Links

For links to all the free on-line resources and full citations to guidance documents mentioned in this presentation see the links page at:

www.tera.org/OARS/resources

Acknowledgement: Dr. Scott Dotson – CDC/NIOSH
Dr. Bert Hakkinen - NLM