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335 Evolving Tools in Occupational Health Risk Assessment

Andrew Maier, CIH, DABT

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Ohio | Bureau of Workers' Compensation

EVOLVING TOOLS IN OCCUPATIONAL RISK ASSESSMENT

ANDREW MAIER, PHD, DABT, CIH
TOXICOLOGY EXCELLENCE FOR RISK ASSESSMENT (TERA)

maier@tera.org or 513-542-7475 x16

OSC12

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

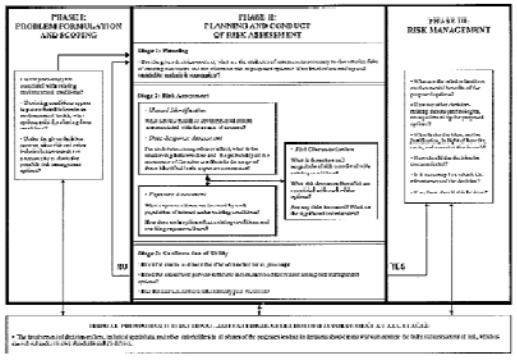


FIGURE 8-1 A framework for risk-based decision-making that maximizes the utility of risk assessment.

The NAS Risk Assessment Approach

Hazard Characterization [Recognize]: IS THIS STUFF TOXIC?

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

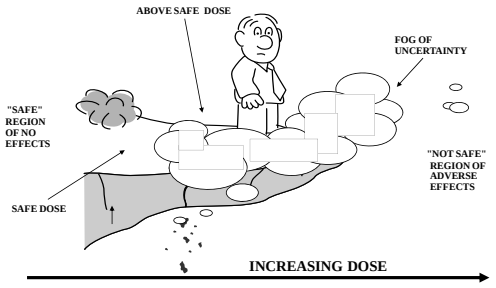
Exposure Assessment [Anticipate & Evaluate]: WHO IS EXPOSED TO THIS STUFF, HOW MUCH, HOW OFTEN, AND FOR HOW LONG EACH TIME?

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

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

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

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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

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

Key Points on Harmonization

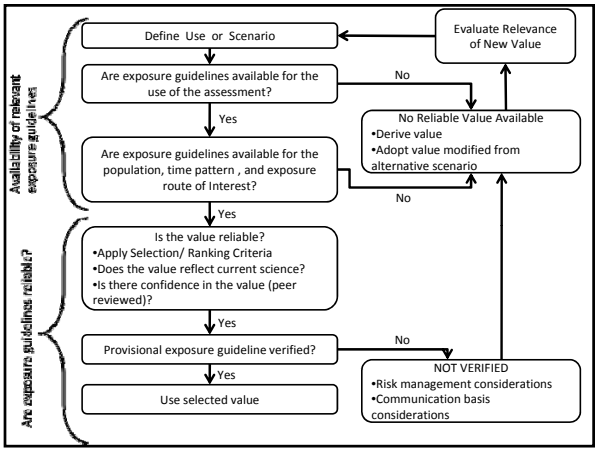
- OELs play a critical role in occupational health
- Methods and resulting OELs and other Occupational Exposure Guidelines differ among agencies
- There is growing emphasis on harmonization of methods
- Shared information facilitates harmonization
- Numerous sources of information are available, but 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)



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

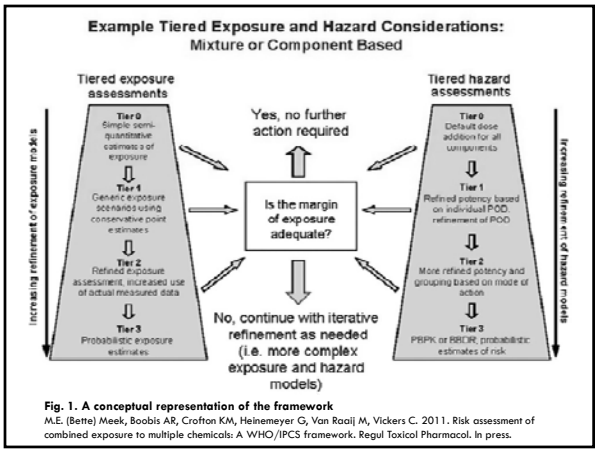
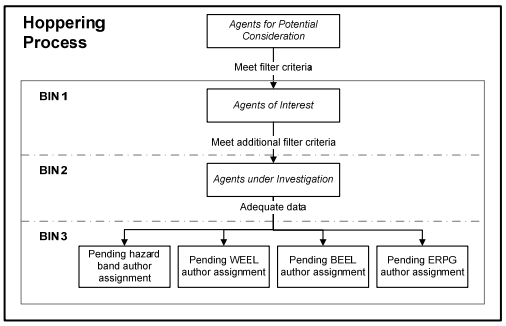


Fig. 1. A conceptual representation of the framework
M.E. (Bette) Meek, Boobis AR, Crofton KM, Heinemeyer G, Van Raaij M, Vickers C. 2011. Risk assessment of combined exposure to multiple chemicals: A WHO/IPCS framework. Regul Toxicol Pharmacol. In press.

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

$$\text{Endpoint-specific DNEL} = \frac{NOAEL_{-exp}}{AF_1 \times AF_2 \times \ldots \times AF_n} = \frac{NOAEL_{-exp}}{\text{Overall AF}}$$

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

RCR (for simultanous 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)

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

  - RSC adjusted OEL

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

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…

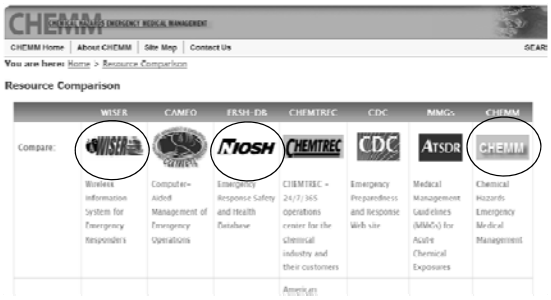
Man-made Threats

- 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

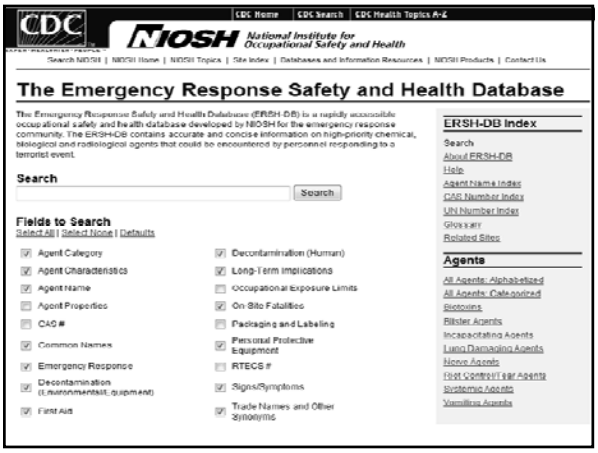
Resources and Tools (continued)



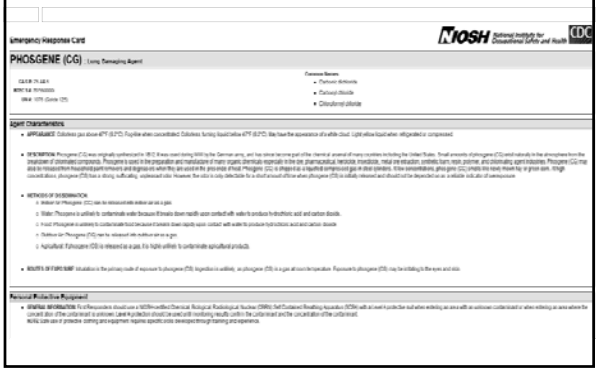
http://chemm.nlm.nih.gov/toolcomparator.htm

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

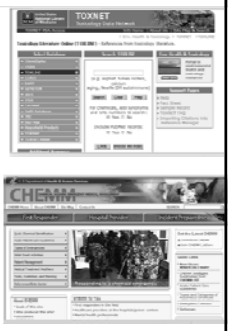


ERSH-DB Example: Phosgene



NLM

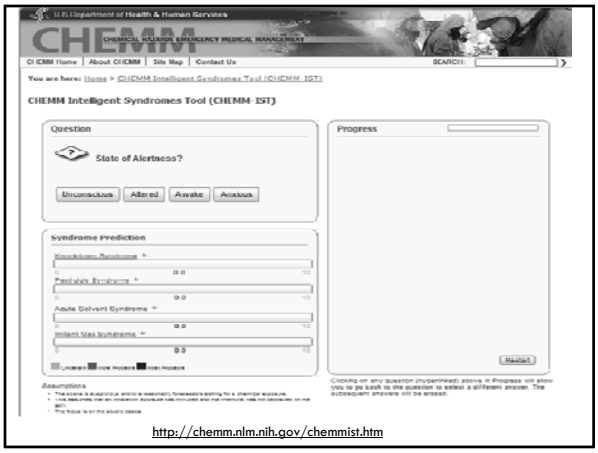
- Broad spectrum of resources/tools
- Hazard and Toxicology Information Sources for:
  - Rapid response activities
  - Planning or ongoing management
  - Other integrated resources
    - CHEMM*
    - WISER*



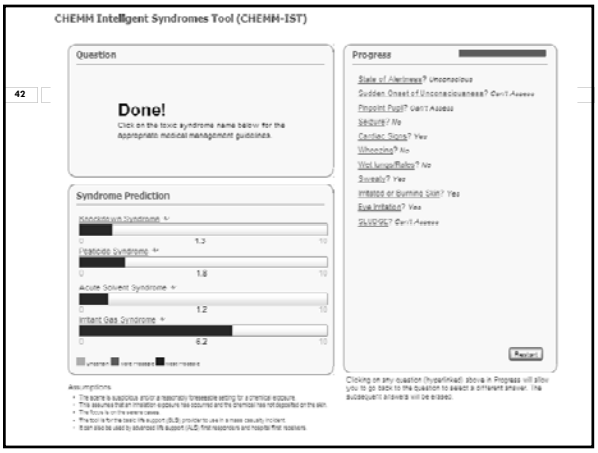
CHEMM

- 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



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



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

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Dr. Bert Hakkinen - NLM

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