How Essential Are Models/Tools for the Successful Practice of Occupational Hygiene?

Chris Money

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REACH Exposure Models

Model	Source	Comment
ECETOC Targeted Risk Assessment (TRA)	http://www.ecetoc.org/tra (english)	In English. Model most commonly used for REACH. Addresses both inhalation and dermal exposures. Incorporated into ECHA Chesar tool.
StoffenManager	https://www.stoffenmanager.nl/ (netherlands and english)	English version has more limited functionality (control banding of chemical risks; quantitative exposure assessment, and REACH worker exposure assessment)
EMKG tool	http://www.emkg.de/ (german) http://www.reach-clp-helpdesk.de/reach/en/Exposure/Exposure.html (english)	Variant of COSHH Essentials hosted by BAuA. Only addresses inhalation exposures. Links to control banding strategies.
Riskofderm	http://product-testing.eurofins.com/ and http://www.tno.nl/ (english)	Estimates dermal exposures. Limited in scope. Not supported by industry due to questions concerning the basis and reliability of the underlying algorithms
Advanced REACH Tool (ART)	http://www.advancedreachtool.com/ (english)	Part funded by industry. Based on conceptual models of exposure. Exposure predictions will vary as model uses Bayesian statistics and Monte Carlo simulations. Not extensively validated.

Outline

- What constitutes the basics of occupational hygiene?
- What types of workplace exposure models/tool are available?
- What are their limitations?
- How might hygienists usefully exploit their attributes? When are they potentially helpful?
- What does the future hold?

The Basics of Occupational Hygiene

- Occupational hygiene is about the science behind minimising the risk of ill-health due to the workplace
- It consequently demands a knowledge of the hazards of the workplace as well as the conditions under which exposures arise
  - It involves an understanding of where, why and how exposures occur
- The proper assessment of many situations can be straightforward. In other cases it can be very complex
- One key requirement in every case is an understanding of the nature, determinants and magnitude of exposure.
- Hygienists may therefore require access to suitable models and tools in order to meet these considerations

Types of Worker Exposure Model

Model Type	Primary Purpose	Scientific Grounding
Tier 0	Prioritisation of regulatory and company actions e.g. screening uses likely to be of low concern	Uncertain. Often based on combinations of 'softer' criteria of relevance for policy making e.g. tonnage, dispersivity, fugacity

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Tier 2	General application to derive realistic prediction of workplace exposures.	Various conceptual models of exposure supported by different levels of statistical manipulation. Level of inherent validation can vary widely both between and within models.
Scenario Specific	Scenario specific determinations of exposure (often for situations outside domain of other models)	Often 'best fit' equations for measured data for defined population(s). Predictive power outside a narrow domain can be very limited

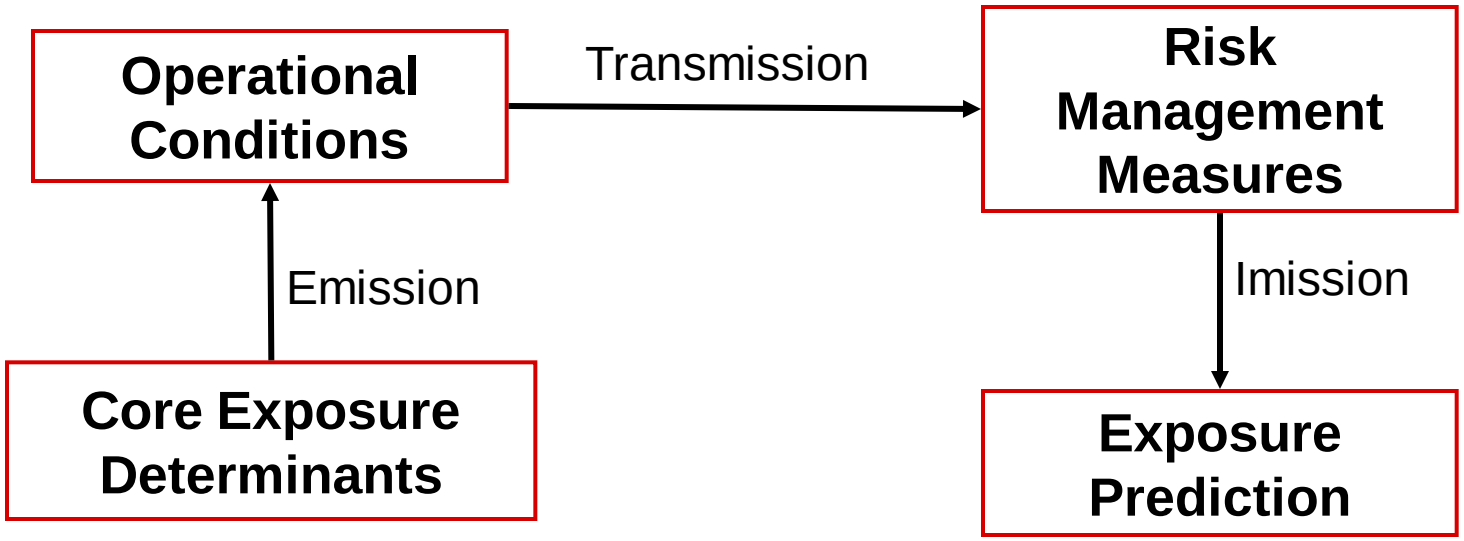
Types of Model : Tier 0

- These types of ‘model’ are unlikely to be useful for the occupational hygienist in the context of exposure assessment.

Types of Model : Tier 1

Core Characteristics	General Area of Application	Examples
• Conservative reflection of actual exposure • Broad range of application • Relevant for most workplaces • Straightforward to use • Limitations clearly described	• Preliminary screening for situations of concern • Support for Control Banding approaches • Targeting for efficient use of higher Tier tools	• ECETOC TRA • StoffenManager • COSHH Essentials • EMKG • EASE

TRA : A Simple Source Receptor Model



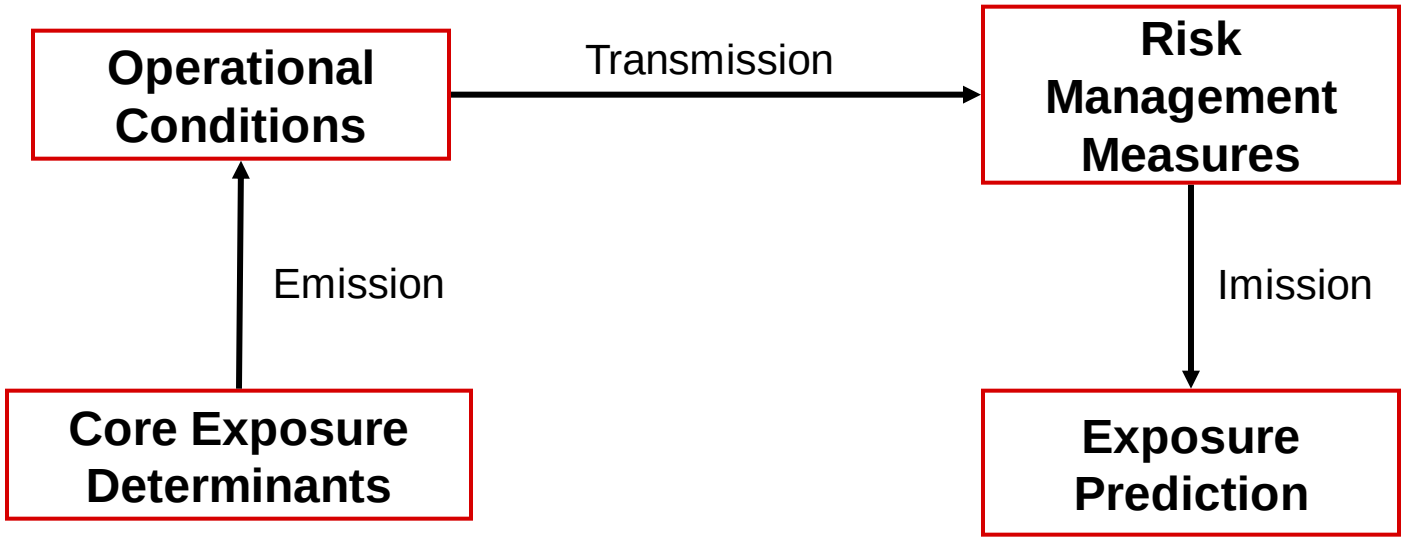
Core Determinants : vapour pressure at operating temperature; dustiness; circumstances of use; sector of use

Operating Conditions : exposure duration; percentage in a mixture

Risk Management Measures : extraction ventilation; respiratory protection

Use and Abuse of the TRA

New Determinants Suggested by Various Groups



Core Determinants : Volatility/dustiness applied to dermal estimates; exposures from UVCBs; aerosols (mists); very low VP substances

Operating Conditions : Control of operating temperatures; duration and concentration applied to dermal exposure

Risk Management Measures : general ventilation; use outdoors; dermal protection (gloves); specific working training; specific work procedures e.g. remote handling; specific work equipment e.g. drum pumps; enhanced RPE and extraction ventilation (beyond TRA)

Some Observations

- One drawback of ‘simple’ tools is that everyone can suddenly become an expert in their use
- It is understandable that users try to improve models or identify workarounds to their limitations
  - But often these address challenges outside the domain of the model; introduce Tier 2 considerations; or apply science of debatable veracity
- Despite the warning labels regarding limitations, users seem to be frequently guilty of a failure to read the instructions

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• Limited validation : broad reliability not yet established • Require enhanced skills for effective application e.g. correct interpretation of outputs	• Preliminary screening for situations of concern	• DREAM • RiskofDerm

Dermal Exposures to HFOs

- 2007 CONCAWE survey to assess HFO exposures during defined circumstances of manufacture and use
  - 58 situations, 13 tasks, 8 companies
- Project including validation of HFO method for dermal exposure monitoring
  - Hands, forearms and neck sample
- Experienced DREAM* assessors employed

Table 10 Potential and actual hand exposure (in DREAM units / cm^2) by facility type

Type of Facility	N	Potential exposure				Actual exposure			
		AM	Median	90th %tile	Range	AM	Median	90th %tile	Range
Oil Refinery	8	5.2	1.1	23.8	0.1 – 23.8	0.3	0.0	1.9	0.0 – 1.9
Distribution	16	5.1	2.8	24.8	0.1 – 26.8	0.4	0.3	1.4	0.0 – 2.2
Power stations	30	3.2	1.1	12.2	0.0 – 15.9	0.2	0.0	0.7	0.0 – 1.4
Ship and Power Plant Engine Building	4	0.6	0.4	1.5	0.0 – 1.5	0.0	0.0	0.0	0.0 – 0.0

N: number of DREAM assessments; AM: arithmetic mean; 90th %tile: 90th percentile of the exposure distribution.

- Actual exposures are much less than those predicted by DREAM

* Van-Wendel-de-Joode et al, Ann Occup Hyg (2003) 47 71-87

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DREAM or Reality?

- 16 DREAM assessments available where observations and measurements carried out simultaneously

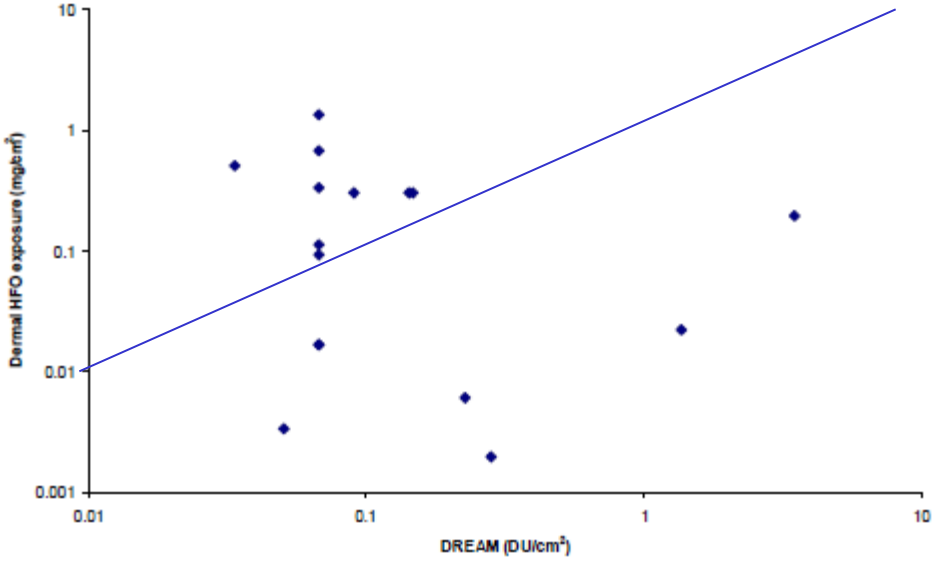

Figure 3 Dermal HFO exposure vs DREAM estimates for hand exposure (log scale)

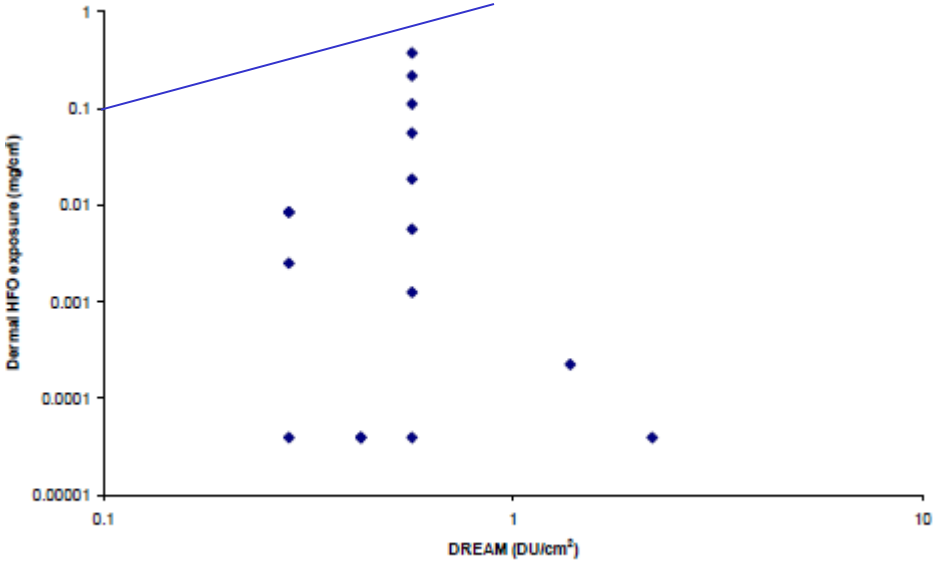

Figure 4 Dermal HFO exposure vs DREAM estimates for forearm exposure (log scale).

- No obvious correlation between the DREAM estimates and the results of dermal exposure measurements

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Some Observations

- Findings do not undermine the potential utility of DREAM. Rather, they serve to emphasise the need for work on describing (and extending) the boundary of reliable application.
- Many models (perhaps unfairly) are showcased before they are ‘market ready’

Types of Model : Tier 2

Core Characteristics	General Area of Application	Examples
• Often a complex underlying basis for model • Broad range of application within a defined sector i.e. relevant for many (but not all) workplaces • 'Accurate' exposure estimates • Expertise in use required • Limitations clearly described	• Refining understanding of exposures • Targeted application for higher Tier evaluations e.g. monitoring • Improved confidence in exposure predictions	• ART • BEAT • MEASE

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• Integrity of model not validated. Not publicly available	• Polymer production and processing	• PESTool

Some Observations

- These models are not ‘complete’ insofar as their boundaries of application is by definition a function of the rigour of their validation
- Process of validation is often ‘constrained’
  - No or little characterisation of inter- and intra- individual variation or expert/non-expert user
  - Calibration populations often ‘clustered’ around activities supported by historic measurement data
- It is straightforward to develop a model. It is much more of a challenge to maintain and sustain it.
  - Sustainability into the future?
- Predictive power outside a narrow domain can still be very uncertain

Types of Model : Scenario Specific

Core Characteristics	General Area of Application	Examples
• Narrow range of application • Only relevant to few substances or workplaces • Technical expertise in understanding and use of model often required • Limitations clearly described	• Refining understanding of specific exposures • Targeted application for higher Tier evaluations e.g. monitoring	• Bitumen pavers • Benzene (petroleum distribution workers) • Welders • Printers (rotogravure) • Painters

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• Limited basis for validation • Reliability domains not well-described • Limited range of exposure determinants	• Exposure re-construction (epidemiology) • Hypothesis development • Local (site/sector specific) application • Preliminary screening for situations of concern	• Grain dust • Asbestos • Aluminium smelting • EtOx sterilisation • Butadiene and SBR manufacture

Some Observations

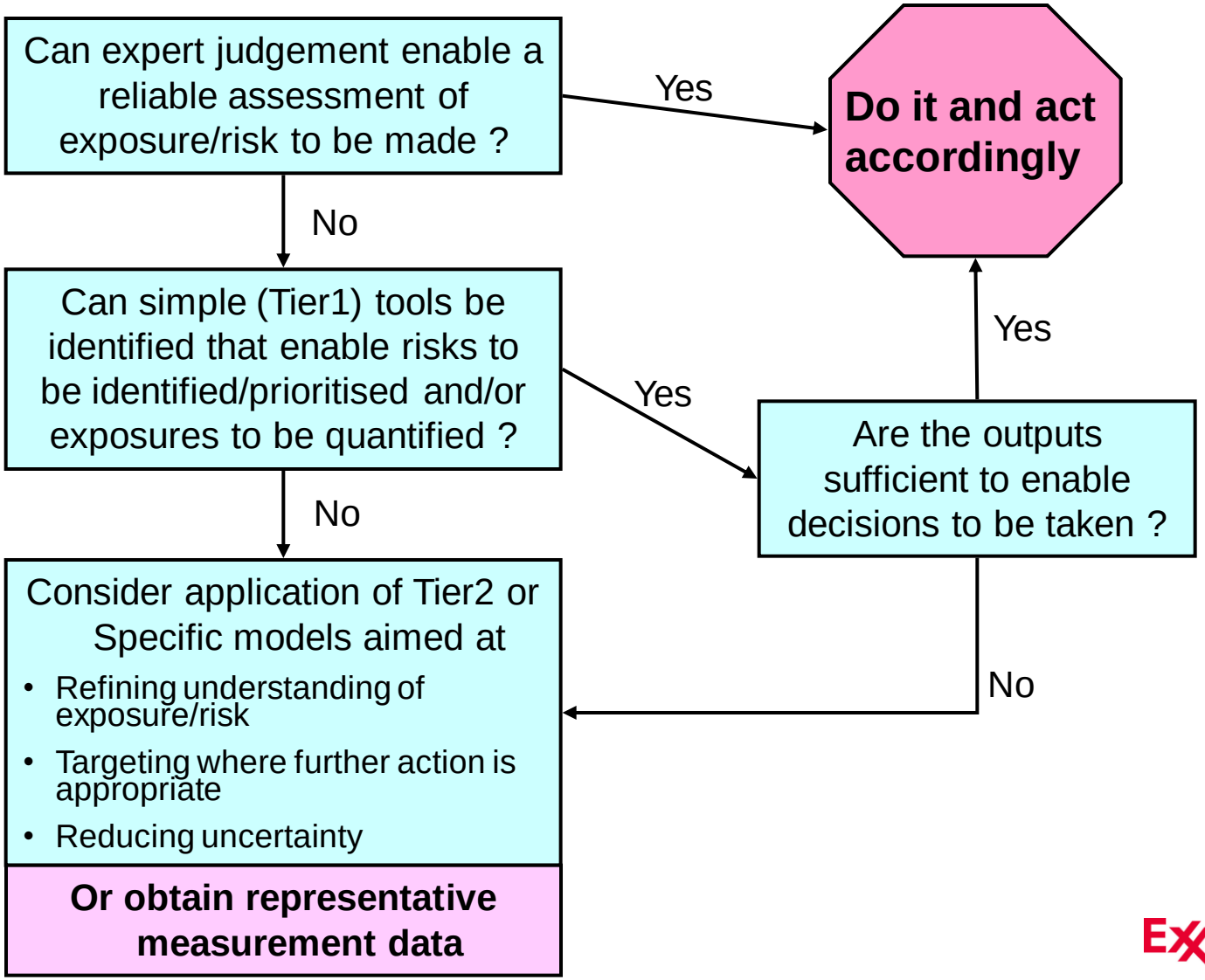
- The most common type of model
  - Possibly because they are the most straightforward to develop
- Are often ‘best fit’ equations derived from limited measured data for defined population(s).
- Predictive power outside a narrow domain can be very restrictive

Considerations for Effectively Exploiting Exposure Models

- When is a model going to help me? Where it might help, then what type should be applied?

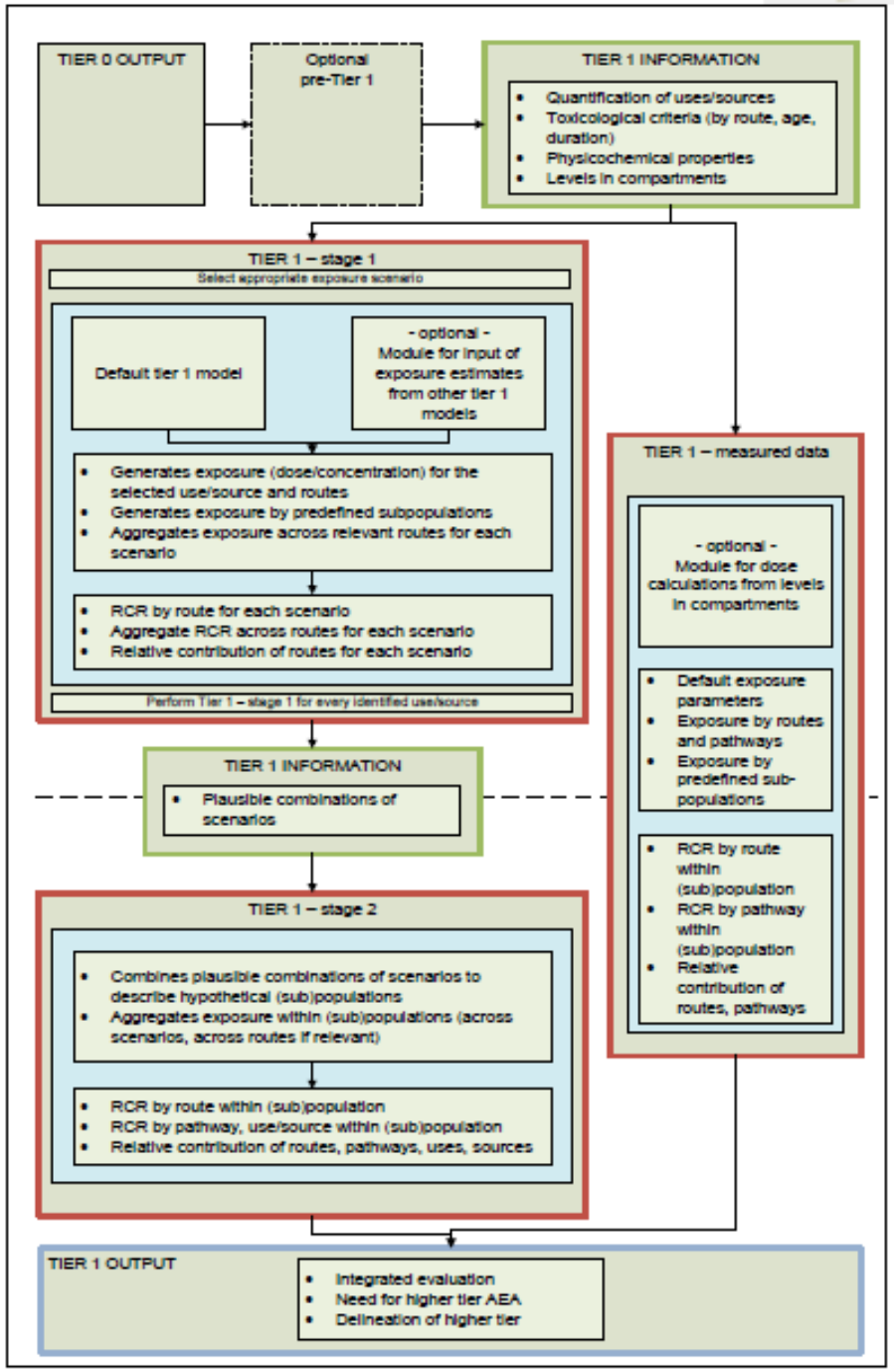
- Targeting those situations where the use of models can help
- Tiering the application of models to reduce uncertainty
- Working within the boundary of reliability (application domain) of the model
- Exploiting the value that a structured use of models can bring to yield resource efficiencies
- Providing practically relevant outputs
- Identifying areas of uncertainty e.g. for refined model development

Strategies for the Effective Application of Models in Occupational Hygiene



Further Observations

- Occupational hygiene is a practical discipline that is rooted in science
  - It is about delivering practical solutions based on an understanding of how exposures/risks present
- Model developers appear less keen to discuss their shortcomings than their attributes
- Not enough models appear to reflect the interests of (less expert) users
  - You do not require 6 decimal place accuracy to make 2 decimal place decisions
- Too many models fail to carry a clear warning label regarding their limitations
  - And users are also often guilty of failing to read the instructions



The Future ?

Are the models that are currently available likely to answer the questions that will be asked next year?

None of the current exposure models effectively address

- Biomonitoring (internal dose)
- Changing dose metrics e.g. exposome and effective exposure
- Additive/aggregate exposures (multiple sources)
- Cumulative exposures (multiple sources to multiple hazards)

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Summary

- Tools can be useful but they are not always necessary
- Tools add value where they are intelligently applied
  - All tools have their limitations but do we always know these?
  - And when we do, do we respect them?
- Sophisticated tools are not always required
- Tools are only as good as their users
  - Can we all drive high speed cars? Or do we even need them?
- No single tool is a panacea
- Tools will fail to deliver their potential if these simple ‘rules’ are not applied
  - **Without the professional knowledge and critical eye of an IH with field experience, models could actually be more harmful than helpful in some situations..**