Evaluation of Swimmer Exposures Using the SWIMODEL Algorithms and Assumptions

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Lane Designations

1) Introduction to the SWIMODEL

2) General Exposure Assumptions

3) Calculation Methods
   - Incidental Oral Exposure
   - Dermal Exposure
   - Buccal, Aural, Nasal Orbital Exposures
   - Inhalation Exposures

4) Toxicological Endpoint Considerations

5) Comparison of Exposure Routes

The Swimmer Exposure Assessment Model (SWIMODEL) Introduction

- Used to develop screening exposure estimates for swimmers exposed to pool chemicals and breakdown products in swimming pools/spas.

- Modification of a study used by Beech (1980) for estimating exposure to trihalomethanes (THMs) in swimming pools.

- Computerized as the SWIMODEL program. Last updated in 2003. Can only be run on Windows XP. Not compatible with Windows 7 or higher.

SWIMODEL Assumptions for Competitive Swimmers

Age	Body Weight	Exposure Duration (hours/day)	
		Short Term	Intermediate/ Long Term
Adult	80 kg	3	1.83
11 to <16	57 kg	2	1.65
6 to <11	32 kg	1	1

- The competitive exposure durations in the SWIMODEL are derived from ACC's swim coach survey.
- The body weights are updates from the 2011 EFH.

SWIMODEL Assumptions for Non-Competitive Swimmers

Age	Body Weight	Exposure Duration (hours/day)	
		Short Term	Intermediate
Adult	80 kg	1	0.5
11 to <16	57 kg	1	0.5
6 to <11	32 kg	1	0.5

The durations have been revised to reflect the time spent in the water swimming rather than just being at the pool (e.g., pool deck).

Incidental Oral Exposure Algorithm

Dose (mg/kg/day) = (CW x IGR x ED)/BW

CW = Chemical Concentration in Water (mg/liter)

IGR = Water Ingestion Rate (liters/hour)

ED = Exposure Duration (Hours/Day)

BW = Body Weight (Kg)

Water Ingestion Rate

Age	Water Ingestion Rate (liters/hour)	
	Competitive	Non-Competitive
Adult	0.0125	0.025
11 to <16	0.025	0.05
6 to <11	0.050	0.05

- These values are from SWIMODEL (EPA, 2003)
- Research published after 2003 has confirmed these values and ingestion rates are included in the 2011 EFH.

Dermal Exposure Algorithm

$$\text{Dose} = \frac{CW \times Kp \times SA \times ET \times CF}{BW}$$

Where:

CW = Chemical Concentration in Water (mg/liter)

Kp = Permeability Constant (cm/hr)

SA = Surface Area (cm^2)

ET = Exposure Time (hours/day)

CF = Conversion Factor (0.001 Liter/cm^3)

BW = Body Weight (Kg)

Calculation of the Permeability Constant (Kp)

$$\log Kp = -2.72 + [0.71 \times \text{Log}(Kow)] - 0.0061 \times MW$$

$$Kp = 10^{\log Kp}$$

Where:

Kow = Octanol/water partition coefficient (unitless)

MW = Molecular Weight (g/mole)

Note 1- The Kp algorithm is only valid for organic chemicals
Note 2 -The default Kp is 0.001 cm/hour (US EPA, 1992)

Kp Example (Cyanuric Acid)

Where:

Kow = 89.1 (unitless)

MW = 129 grams/mole

$$\log Kp = -2.72 + [0.71 \times \text{Log}(89.1)] - 0.0061 \times 129$$

$$\log Kp = -2.72 + [0.71 \times 1.95] - 0.787$$

$$\text{Log}Kp = -2.12$$

$$Kp = 10^{-2.12} = 0.0076 \text{ cm/hour}$$

Dermal Exposure Surface Area

Age	Surface Area (cm^2)
Adult	19,500
Child 11 to <16	15,900
Child 6 to <11	10,800

- These are updated values from the 2011 EFH.

SWIMODEL Supplemental Exposure Routes

- Buccal/Sublingual - Water taken into the mouth but not ingested (spit out)
- Orbital/Nasal - Eye and nose exposure
- Aural - Ear exposure
- Inhalation Exposure

At this time, EPA/OPP/AD is not including these routes of exposure in our swimming assessments (inhalation on a case-by-case basis).

Buccal / Sublingual Exposures

Exposure (mg/event) = CW x WI x AR x ET

Where:

CW = Chemical Concentration in Water (mg/liter)
WI = Water Intake Rate that is not ingested (liters/hour)
AR = Absorption factor (0.01 based on nitroglycerin)
ET = Exposure Time (hours/event assuming 1 event/day)

Buccal/Sublingual Water Intake Rate

Age	Water Intake Rate (liters/hour)	
	Competitive	Non-Competitive
Adult	1.25	2.5
11 to <16	2.5	5.0
6 to <11	2.5	5.0

- The water intake rate represents water that enters the mouth but is not swallowed.

Orbital/Nasal Exposures

- Non-Competitive Orbital/Nasal exposures calculated the same way as buccal/sublingual exposures.
- Competitive Nasal Exposure assumed to be the same as Buccal/Sublingual Exposures.
- Competitive Orbital Exposures assumed to eliminated by the use of swim goggles, thus only Nasal exposures would be assessed for these swimmers.

Aural (Ear) Exposure Algorithm

$$\text{Dose} = \frac{CW \times OW \times Kp \times SA \times ET \times CF}{BW}$$

Where:

CW = Chemical Concentration in Water (mg/liter)

OW = Octanol/Water coefficient

Kp = Permeability Constant (cm/hr)

SA = Surface Area (4 cm^2)

ET = Exposure Time (hours/day)

CF = Conversion Factor (0.001 Liter/cm^3)

BW = Body Weight (Kg)

Inhalation (Air Concentration) Algorithm

$$Cvc = Cw \times HLC \times 1000 \text{ liter}/m^3$$

Where:

Cvc = Chemical vapor concentration (mg/m^3)

Cw = Chemical concentration in water

HLC = Henry's Law Constant (unitless)

Toxicological Endpoint Considerations

- Dermal exposures are assessed using oral endpoints.
- Exposures primarily short to intermediate term duration for recreational swimmers and long term for competitive swimmer.

Percent Dose by Route of Exposure

	Competitive Swimmer		Non-Competitive Swimmer	
Exposure Route	Dose (mg/kg/day)	%	Dose (mg/kg/day)	%
Ingestion	0.014	30	0.0094	29
Dermal	0.011	24	0.0037	12
Buccal/Sublingual	0.014	30	0.0094	29
Nasal/Orbital	0.0071	15	0.0094	29
Aural	4.5E-06	<0.1	1.5E-06	<0.1
Combined	0.046	100	0.032	100

References

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