

3. Ingestion of Water and Other Select Liquids

3.1 Introduction

Water ingestion can be a pathway of exposure to environmental chemicals. Contamination of water may occur at the water supply source (ground water or surface water); during treatment (e.g., toxic by-products may be formed during chlorination); or post-treatment (e.g., leaching of lead or other materials from plumbing systems). People may be exposed to contaminants in water when consuming water directly as a beverage, indirectly from foods and drinks made with water, or incidentally while swimming. Estimating the magnitude of the potential dose of environmental contaminants from water ingestion requires information on the quantity of water consumed. Chapter 3 of the *Exposure Factors Handbook* provides information on ingestion of water consumed as a beverage, ingestion of other select liquids, and ingestion of water while swimming. Highlights of these data are provided here.

3.2 Recommended Exposure Factors

Drinking Water Ingestion Rates: The recommended drinking water ingestion rates for general population children <3 years of age are based on an analysis of data from the U.S. Department of Agriculture's 1994-1996 and 1998 Continuing Survey of Food Intakes by Individuals (CSFII) (Kahn and Stralka, 2008a; Kahn, 2008). The recommended drinking water ingestion rates for individuals ≥ 3 years of age are based on the U.S. EPA analysis of 2003-2006 data from the National Health and Nutrition Examination Survey (NHANES). The CSFII data set includes survey response data for more than 20,000 people nationwide. The NHANES data set includes survey responses from more than 18,000 people nationwide. These recommended rates represent both consumption of water as a beverage (direct intake) and water used in preparing foods and beverages (indirect intake). The recommended intake rates for pregnant and lactating women are also based on an analysis of data from CSFII (Kahn and Stralka, 2008b). The recommended data represent intake from community (site-specific) water supplies and do not include intake from bottled water or water intrinsic in purchased foods that may be widely distributed. Table 3-1 provides the recommended per capita

and consumer-only drinking water ingestion rates. Per capita rates include all survey participants whether or not they ingested any water from the source during the survey period. Consumer-only rates exclude individuals who did not ingest water from the source during the survey period. Overall, the confidence rating for the recommendations for drinking water ingestion rates is medium to high.

Water Ingestion Rates While Swimming: The recommended values for water ingestion rates during swimming for children and adults are presented in Table 3-2. These values are based on a study by Dufour et al. (2006), which estimated water ingestion of 53 swimmers (12 adults and 41 children under 18 years of age) during a 45-minute swimming period at an outdoor pool. The overall confidence in the recommendations for ingestion of water while swimming is low. Data on the amount of time spent swimming are provided in Chapter 16 of the *Exposure Factors Handbook*.



Table 3-1. Recommended Values for Drinking Water Ingestion Rates^a

Age Group	Mean		95 th Percentile		Mean		95 th Percentile	
	mL/day	mL/kg-day	mL/day	mL/kg-day	mL/day	mL/kg-day	mL/day	mL/kg-day
	Per Capita^b				Consumers Only^d			
Birth to <1 month	184	52	839 ^c	232 ^c	470 ^c	137 ^c	858 ^c	238 ^c
1 to <3 months	227	48	896 ^c	205 ^c	552	119	1,053 ^c	285 ^c
3 to <6 months	362	52	1,056	159	556	80	1,171 ^c	173 ^c
6 to <12 months	360	41	1,055	126	467	53	1,147	129
1 to <2 years	271	23	837	71	308	27	893	75
2 to <3 years	317	23	877	60	356	26	912	62
3 to <6 years	327	18	959	51	382	21	999	52
6 to <11 years	414	14	1,316	43	511	17	1,404	47
11 to <16 years	520	10	1,821	32	637	12	1,976	35
16 to <18 years	573	9	1,783	28	702	10	1,883	30
18 to <21 years	681	9	2,368	35	816	11	2,818	36
≥21 years	1,043	13	2,958	40	1,227	16	3,092	42
>65 years	1,046	14	2,730	40	1,288	18	2,960	43
All ages	869	14	2,717	42	1,033	16	2,881	44
Pregnant women	819 ^c	13 ^c	2,503 ^c	43 ^c	872 ^c	14 ^c	2,589 ^c	43 ^c
Lactating women	1,379 ^c	21 ^c	3,434 ^c	55 ^c	1,665 ^c	26 ^c	3,588 ^c	55 ^c

^a Ingestion rates for combined direct and indirect water from community water supply. For multiple percentiles, see Chapter 3 of the *Exposure Factors Handbook*.

^b Per capita intake rates are generated by averaging consumer-only intakes over the entire population (including those individuals that reported no intake).

^c Estimates are less statistically reliable based on guidance published in the *Joint Policy on Variance Estimation and Statistical Reporting Standards on NHANES III and CSFII Reports: NHIS/NCHS Analytical Working Group Recommendations* (NCHS, 1993).

^d Consumer-only intake represents the quantity of water consumed only by individuals that reported consuming water during the survey period.

The source of data for children <3 years is the 1994-1996 and 1998 CSFII (Kahn and Stralka, 2008a; Kahn, 2008); for individuals ≥3 years and all ages, the source of data is the U.S. EPA analysis of 2003-2006 NHANES data. The source of data for pregnant and lactating women is the 1994-1996 and 1998 CSFII (Kahn and Stralka, 2008b).

Table 3-2. Recommended Values for Water Ingestion While Swimming

Age Group	Mean		Upper Percentile	
	mL/event ^a	mL/hour	mL/event ^a	mL/hour
Children	37	49	90 ^b	120 ^b
Adults	16	21	53 ^c	71 ^c

^a Participants swam for 45 minutes.

^b 97th percentile.

^c Maximum value.

Source: Dufour et al., 2006.

For more information about the key studies used to derive the recommended water ingestion rate values, refer to **Chapter 3 of the *Exposure Factors Handbook*** at <http://www.epa.gov/ncea/efh/pdfs/efh-chapter03.pdf>. Detailed information on water ingestion studies among the general population is included in Section 3.3, and studies regarding pregnant and lactating women can be found in Section 3.4. Section 3.5 presents relevant studies on water intake among individuals located in hot climates or engaging in high activity levels. Section 3.6 presents information on ingestion of water while swimming or diving. Limited information on the ingestion of select liquids is also provided in Section 3.3.