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## Chapter 3 - Drinking Water Intake

## 3. DRINKING WATER INTAKE

### 3.1. BACKGROUND

Drinking water is a potential source of human exposure to toxic substances. Contamination of drinking water may occur by, for example, percolation of toxics through the soil to ground water that is used as a source of drinking water; runoff or discharge to surface water that is used as a source of drinking water; intentional or unintentional addition of substances to treat water (e.g., chlorination); and leaching of materials from plumbing systems (e.g., lead). Estimating the magnitude of the potential dose of toxics from drinking water requires information on the quantity of water consumed. The purpose of this section is to describe key published studies that provide information on drinking water consumption (Section 3.2) and to provide recommendations of consumption rate values that should be used in exposure assessments (Section 3.6).

Currently, the U.S. EPA uses the quantity of 2 L per day for adults and 1 L per day for infants (individuals of 10 kg body mass or less) as default drinking water intake rates (U.S. EPA, 1980). These rates include drinking water consumed in the form of juices and other beverages containing tapwater (e.g., coffee). The National A cademy of Sciences (NAS, 1977) estimated that daily consumption of water may vary with levels of physical activity and fluctuations in temperature and humidity. It is reasonable to assume that some individuals in physically-demanding occupations or living in warmer regions may have high levels of water intake.

Numerous studies cited in this chapter have generated data on drinking water intake rates. In general, these sources support EPA's use of 2 L /day for adults and $1 \mathrm{~L} /$ day for children as upper-percentile tapwater intake rates. M any of the studies have reported fluid intake rates for both total fluids and tapwater. Total fluid intake is defined as consumption of all types of fluids including tapwater, milk, soft drinks, alcoholic beverages, and water intrinsic to purchased foods. Total tapwater is defined as water consumed directly from the tap as a beverage or used in the preparation of foods and beverages (i.e., coffee, tea, frozen juices, soups, etc.). Data for both consumption categories are presented in the sections that follow. However, for the purposes of exposure assessments involving source-specific contaminated drinking water, intake rates based on total tapwater are more representative of source-specific tapwater intake. Given the assumption that purchased foods and beverages are widely distributed and less likely
to contain source-specific water, the use of total fluid intake rates may overestimate the potential exposure to toxic substances present only in local water supplies; therefore tapwater intake, rather than total fluid intake, is emphasized in this section.

All studies on drinking water intake that are currently available are based on short-term survey data. Although short-term data may be suitable for obtaining mean intake values that are representative of both shortand long-term consumption patterns, upper-percentile values may be different for short-term and long-term data because more variability generally occurs in short-term surveys. It should also be noted that most drinking water surveys currently available are based on recall. This may be a source of uncertainty in the estimated intake rates because of the subjective nature of this type of survey technique.

The distribution of water intakes is usually, but not always, lognormal. Instead of presenting only the lognormal parameters, the actual percentile distributions are presented in this handbook, usually with a comment on whether or not it is lognormal. To facilitate comparisons between studies, the mean and the 90th percentiles are given for all studies where the distribution data are available. With these two parameters, along with information about which distribution is being followed, one can calculate, using standard formulas, the geometric mean and geometric standard deviation and hence any desired percentile of the distribution. Before doing such a calculation one must be sure that one of these distributions adequately fits the data.

The available studies on drinking water consumption are summarized in the following sections. They have been classified as either key studies or relevant studies based on the applicability of their survey designs to exposure assessment of the entire United States population. Recommended intake rates are based on the results of key studies, but relevant studies are also presented to provide the reader with added perspective on the current state-of-knowledge pertaining to drinking water intake.

### 3.2. KEY GENERAL POPULATION STUDIES ON DRINKING WATER INTAKE

Canada Department of Health and Welfare Tapwater Consumption in Canada - In a study conducted by the C anadian Department of Health and W elfare, 970 individuals from 295 households were surveyed to determine the per capita total tapwater intake rates for various age/sex groups during winter and summer seasons
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(Canadian Ministry of National Health and Welfare, 1981). Intake rate was also evaluated as a function of physical activity. The population that was surveyed matched the Canadian 1976 census with respect to the proportion in different age, regional, community size and dwelling type groups. Participants monitored water intake for a 2 -day period (1 weekday, and 1 weekend day) in both late summer of 1977 and winter of 1978. All 970 individuals participated in both the summer and winter surveys. The amount of tapwater consumed was estimated based on the respondents' identification of the type and size of beverage container used, compared to standard sized vessels. The survey questionnaires included a pictorial guide to help participants in classifying the sizes of the vessels. For example, a small glass of
water was assumed to be equivalent to 4.0 ounces of water, and a large glass was assumed to contain 9.0 ounces of water. The study also accounted for water derived from ice cubes and popsicles, and water in soups, infant formula, and juices. The survey did not attempt to differentiate between tapwater consumed at home and tapwater consumed away from home. The survey also did not attempt to estimate intake rates for fluids other than tapwater. Consequently, no intake rates for total fluids were reported.

Daily consumption distribution patterns for various age groups are presented in Table 3-1. For adults (over 18 years of age) only, the average total tapwater intake rate was $1.38 \mathrm{~L} /$ day, and the 90th percentile rate was 2.41 L/day as determined by graphical interpolation. These


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data follow a lognormal distribution. The intake data for males, females, and both sexes combined as a function of age and expressed in the units of milliliters (grams) per kilogram body weight are presented in Table 3-2. The tapwater survey did not include body weights of the participants, but the body weight information was taken from a Canadian health survey dated 1981; it averaged 65.1 kg for males and 55.6 kg for females. Intake rates for specific age groups and seasons are presented in Table 3-3. The average daily total tapwater intake rates for all ages and seasons combined was $1.34 \mathrm{~L} /$ day, and the 90th percentile rate was 2.36 L /day. The summer intake rates are nearly the same as the winter intake rates. The authors speculate that the reason for the small seasonal variation here is that in Canada, even in the summer, the ambient temperature seldom exceeded 20 degrees $C$ and marked increase in water consumption with high activity levels has been observed in other studies only when the ambient temperature has been higher than 20 degrees. A verage daily total tapwater intake rates as a function of the level of physical activity, as estimated subjectively, are presented in Table 3-4. The amounts of tapwater consumed that are derived from various foods and beverages are presented in Table 3-5. Note that the consumption of direct "raw" tapwater is almost constant across all age groups from school-age children through the oldest ages. The increase in total tapwater consumption beyond school age is due to coffee and tea consumption.

| Table 3-2. A verage Daily Tapwater Intake of Canadians (expressed as milliliters per kilogram body weight) |  |  |  |
| :---: | :---: | :---: | :---: |
|  | A verage D aily Intake (mL/kg) |  |  |
| A ge Group (years) | Fema les | M ales | Both Sexes |
| < 3 | 53 | 35 | 45 |
| 3-5 | 49 | 48 | 48 |
| 6-17 | 24 | 27 | 26 |
| 18-34 | 23 | 19 | 21 |
| 35-54 | 25 | 19 | 22 |
| 55+ | 24 | 21 | 22 |
| Total Population | 24 | 21 | 22 |
| Source: Canadian M inistry of National Health and W elfare, 1981. |  |  |  |

Data concerning the source of tapwater (municipal, well, or lake) was presented in one table of the study. This categorization is not appropriate for making conclusions about consumption of ground versus surface water.

This survey may be more representative of total tapwater consumption than some other less comprehensive surveys because it included data for some tapwatercontaining items not covered by other studies (i.e., ice cubes, popsicles, and infant formula). One potential source of error in the study is that estimated intake rates were based on identification of standard vessel sizes; the accuracy of this type of survey data is not known. The cooler climate of Canada may have reduced the importance of large tapwater intakes resulting from high activity levels, therefore making the study less applicable to the United States. The authors were not able to explain the surprisingly large variations between regional tapwater intakes; the largest regional difference was between Ontario (1.18 liters/day) and Quebec ( 1.55 liters/day).

Ershow and Cantor - Total Water and Tapwater Intake - Ershow and Cantor (1989) estimated water intake rates based on data collected by the USDA 1977-1978 Nationwide Food Consumption Survey (NFCS). Daily intake rates for tapwater and total water were calculated for various age groups for males, females, and both sexes combined. Tapwater was defined as "all water from the household tap consumed directly as a beverage or used to prepare foods and beverages." Total water was defined as tapwater plus "water intrinsic to foods and beverages" (i.e., water contained in purchased food and beverages). The authors showed that the age, sex, and racial distribution of the surveyed population closely matched the estimated 1977 U. S. population.

Daily total tapwater intake rates, expressed as mL (grams) per day by age group are presented in Table 3-6. These data follow a lognormal distribution. The same data, expressed as mL (grams) per kg body weight per day are presented in Table 3-7. A summary of these tables, showing the mean, the 10th and 90th percentile intakes, expressed as both $\mathrm{mL} /$ day and $\mathrm{mL} / \mathrm{kg}$-day as a function of age, is presented in Table 3-8. This shows that the mean and 90th percentile intake for adults (ages 20 to 65+ ) is approximately $1,410 \mathrm{~mL} /$ day and 2,280 $\mathrm{mL} /$ day and for all ages the mean and 90th percentile is $1,190 \mathrm{~mL}$ /day and $2,090 \mathrm{~mL}$ /day. Note that older adults have greater intakes than do adults between age 20 and 65, an observation bearing on the interpretation of the Cantor, et al. (1987)
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| Table 3-3. A verage Daily Total Tapwater Intake of Canadians, by A ge and Season (L/day) ${ }^{\text {a }}$ |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| A ge (years) |  |  |  |  |  |  |  |
|  | $<3$ | 3-5 | 6-17 | 18-34 | 35-54 | $\leq 55$ |  |
| A verage |  |  |  |  |  |  |  |
| Summer | 0.57 | 0.86 | 1.14 | 1.33 | 1.52 | 1.53 | 1.31 |
| W inter | 0.66 | 0.88 | 1.13 | 1.42 | 1.59 | 1.62 | 1.37 |
| Summer/W inter | 0.61 | 0.87 | 1.14 | 1.38 | 1.55 | 1.57 | 1.34 |
| 90th Percentile |  |  |  |  |  |  |  |
| Summer/W inter | 1.50 | 1.50 | 2.21 | 2.57 | 2.57 | 2.29 | 2.36 |
| a Includes tapwater and foods and beverages derived from tapwater. |  |  |  |  |  |  |  |
| Source: Canadian M inistry of N ational Health and W elfare, 1981. |  |  |  |  |  |  |  |


| Table 3-4. A verage Daily Total Tapwater Intake of Canadians as a Function of Level of Physical Activity at W ork and in Spare Time (16 Y ears and Older, Combined Seasons, L/day) |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | W ork |  | Spare Time |  |
| Activity Level ${ }^{\text {a }}$ | Consumption ${ }^{\text {b }}$ <br> L/day | Number of Respondents | Consumption ${ }^{\text {b }}$ L/day | Number of Respondents |
| Extremely Active | 1.72 | 99 | 1.57 | 52 |
| V ery Active | 1.47 | 244 | 1.51 | 151 |
| Somewhat Active | 1.47 | 217 | 1.44 | 302 |
| N ot V ery A ctive | 1.27 | 67 | 1.52 | 131 |
| Not At All A ctive | 1.30 | 16 | 1.35 | 26 |
| Did N ot State | 1.30 | 45 | 1.31 | 26 |
| TOTAL |  | 688 |  | 688 |
| a The levels of physical activity listed here were not defined any further by the survey report, and categorization of activity level by survey participants is assumed to be subjective. <br> b Includes tapwater and foods and beverages derived from tapwater. |  |  |  |  |
| Source: Canadian M inistry of N ational Health and W elfare, 1981. |  |  |  |  |

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| Table 3-5. A verage Daily Tapwater Intake A pportioned A mong V arious Beverages (Both Sexes, by Age, Combined Seasons, L/day) ${ }^{\text {a }}$ |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Age Group (years) |  |  |  |  |  |
|  | Under 3 | 3-5 | 6-17 | 18-34 | 35-54 | 55 and Over |
| Total Number <br> in Group 34 <br> $\begin{array}{lllll}47 & 250 & 232 & 254 & 153\end{array}$ |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| W ater | 0.14 | 0.31 | 0.42 | 0.39 | 0.38 | 0.38 |
| Ice/M ix | 0.01 | 0.01 | 0.02 | 0.04 | 0.03 | 0.02 |
| Tea | * | 0.01 | 0.05 | 0.21 | 0.31 | 0.42 |
| Coffee | 0.01 | * | 0.06 | 0.37 | 0.50 | 0.42 |
| "Other Type of Drink" | 0.21 | 0.34 | 0.34 | 0.20 | 0.14 | 0.11 |
| Reconstituted Milk | 0.10 | 0.08 | 0.12 | 0.05 | 0.04 | 0.08 |
| Soup | 0.04 | 0.08 | 0.07 | 0.06 | 0.08 | 0.11 |
| Homemade Beer/W ine | * | * | 0.02 | 0.04 | 0.07 | 0.03 |
| Homemade Popsicles | 0.01 | 0.03 | 0.03 | 0.01 | * | * |
| Baby Formula, etc. | 0.09 | * | * | * | * | * |
| TOTAL | 0.61 | 0.86 | 1.14 | 1.38 | 1.55 | 1.57 |
| a Includes tapwater and foods and beverages derived from tapwater. <br> * Less than 0.01 L /day |  |  |  |  |  |  |
| Source: Canadian M inistry of National Health and Welfare, 1981. |  |  |  |  |  |  |

study which surveyed a population that was older than the national average (see Section 3.3).

Ershow and Cantor (1989) also measured total water intake for the same age groups and concluded that it averaged $2,070 \mathrm{~mL} /$ day for all groups combined and that tapwater intake ( $1,190 \mathrm{~mL} /$ day ) is 55 percent of the total water intake. (The detailed intake data for various age groups are presented in Table 3-9). They also concluded that, for all age groups combined, the
proportion of tapwater consumed as drinking water, foods, and beverages is 54 percent, 10 percent and 36 percent, respectively. (The detailed data on proportion of tapwater consumed for various age groups are presented in Table 3-10). They found that males of all age groups had higher total water and tapwater consumption rates than females; the variation of each from the combined-sexes mean was about 8 percent.

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| Table 3-7. Total Tapwater Intake (mL/kg-day) for Both Sexes Combined ${ }^{\text {a }}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Number of Observations |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Age (yr) | Actual Count | Weighted Count | Mean | SD | S.E. of Mean | 1 | 5 | 10 | 25 | 50 | 75 | 90 | 95 | 99 |
| $<0.5$ | 182 | 201.2 | 52.4 | 53.2 | 3.9 | * | 0.0 | 0.0 | 14.8 | 37.8 | 66.1 | 128.3 | 155.6 | * |
| 0.5-0.9 | 221 | 243.2 | 36.2 | 29.2 | 2.0 | * | 0.0 | 0.0 | 15.3 | 32.2 | 48.1 | 69.4 | 102.9 | * |
| 1-3 | 1498 | 1687.7 | 46.8 | 28.1 | 0.7 | 2.7 | 11.8 | 17.8 | 27.2 | 41.4 | 60.4 | 82.1 | 101.6 | 140.6 |
| 4-6 | 1702 | 1923.9 | 37.9 | 21.8 | 0.5 | 3.4 | 10.3 | 14.9 | 21.9 | 33.3 | 48.7 | 69.3 | 81.1 | 103.4 |
| 7-10 | 2405 | 2742.4 | 26.9 | 15.3 | 0.3 | 2.2 | 7.4 | 10.3 | 16.0 | 24.0 | 35.5 | 47.3 | 55.2 | 70.5 |
| 11-14 | 2803 | 3146.9 | 20.2 | 11.6 | 0.2 | 1.5 | 4.9 | 7.5 | 11.9 | 18.1 | 26.2 | 35.7 | 41.9 | 55.0 |
| 15-19 | 2998 | 3677.9 | 16.4 | 9.6 | 0.2 | 1.0 | 3.9 | 5.7 | 9.6 | 14.8 | 21.5 | 29.0 | 35.0 | 46.3 |
| 20-44 | 7171 | 13444.5 | 18.6 | 10.7 | 0.1 | 1.6 | 4.9 | 7.1 | 11.2 | 16.8 | 23.7 | 32.2 | 38.4 | 53.4 |
| 45-64 | 4560 | 8300.4 | 22.0 | 10.8 | 0.2 | 4.4 | 8.0 | 10.3 | 14.7 | 20.2 | 27.2 | 35.5 | 42.1 | 57.8 |
| 65-74 | 1663 | 2740.2 | 21.9 | 9.9 | 0.2 | 4.6 | 8.7 | 10.9 | 15.1 | 20.2 | 27.2 | 35.2 | 40.6 | 51.6 |
| 75+ | 878 | 1401.8 | 21.6 | 9.5 | 0.3 | 3.8 | 8.8 | 10.7 | 15.0 | 20.5 | 27.1 | 33.9 | 38.6 | 47.2 |
| I Infants (ages < 1) | 403 | 444.3 | 43.5 | 42.5 | 2.1 | 0.0 | 0.0 | 0.0 | 15.3 | 35.3 | 54.7 | 101.8 | 126.5 | 220.5 |
| Children (ages 1-10) | 5605 | 6354.1 | 35.5 | 22.9 | 0.3 | 2.7 | 8.3 | 12.5 | 19.6 | 30.5 | 46.0 | 64.4 | 79.4 | 113.9 |
| Teens (ages 11-19) | 5801 | 6824.9 | 18.2 | 10.8 | 0.1 | 1.2 | 4.3 | 6.5 | 10.6 | 16.3 | 23.6 | 32.3 | 38.9 | 52.6 |
| Adults (ages 20-64) | 11731 | 21744.9 | 19.9 | 10.8 | 0.1 | 2.2 | 5.9 | 8.0 | 12.4 | 18.2 | 25.3 | 33.7 | 40.0 | 54.8 |
| Adults (ages 65+) | 2541 | 4142.0 | 21.8 | 9.8 | 0.2 | 4.5 | 8.7 | 10.9 | 15.0 | 20.3 | 27.1 | 34.7 | 40.0 | 51.3 |
| All | 26081 | 39510.2 | 22.6 | 15.4 | 0.1 | 1.7 | 5.8 | 8.2 | 13.0 | 19.4 | 28.0 | 39.8 | 50.0 | 79.8 |
| a Total tapwater is defined as "all water from the household tap consumed di rectly as a beverage or used to prepare foods and beverages * Value not reported due to insufficient number of observations. <br> Source: Ershow and Cantor, 1989. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

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| Table 3-8. Summary of Tapwater Intake by Age |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| A ge Group | Intake (mL/day) |  | Intake (mL/kg-day) |  |
|  | M ean | 10th-90th Percentiles | M ean | 10th-90th Percentiles |
| Infants (< 1 year) | 302 | 0-649 | 43.5 | 0-100 |
| Children (1-10) | 736 | 286-1,294 | 35.5 | 12.5-64.4 |
| Teens (11-19) | 965 | 353-1,701 | 18.2 | 6.5-32.3 |
| A dults (20-64) | 1,366 | 559-2,268 | 19.9 | 8.0-33.7 |
| A dults (65+) | 1,459 | 751-2,287 | 21.8 | 10.9-34.7 |
| All ages | 1,193 | 423-2,092 | 22.6 | 8.2-39.8 |
| Source: Ershow and Cantor (1989) |  |  |  |  |


| Age (yr) | M ean | Percentile Distribution |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | 5 | 10 |  |  | 75 | 90 | 95 | 99 |
| < 1 | 26 | 0 | 0 | 0 | 12 | 22 | 37 | 55 | 62 | 82 |
| 1-10 | 45 | 6 | 19 | 24 | 34 | 45 | 57 | 67 | 72 | 81 |
| 11-19 | 47 | 6 | 18 | 24 | 35 | 47 | 59 | 69 | 74 | 83 |
| 20-64 | 59 | 12 | 27 | 35 | 49 | 61 | 72 | 79 | 83 | 90 |
| 65+ | 65 | 25 | 41 | 47 | 58 | 67 | 74 | 81 | 84 | 90 |
| a Does not include pregnant women, lactating women, or breast-fed children. <br> b Total tapwater is defined as "all water from the household tap consumed directly as a beverage or used to prepare foods and beverages." <br> $0=$ Less than 0.5 percent. |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Source: Ershow and Cantor, 1989. |  |  |  |  |  |  |  |  |  |  |

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| Table 3-10. General Dietary Sources of Tapwater for Both Sexes ${ }^{\text {a,b }}$ |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| A ge (yr) | Source | \% of Tapwater |  |  |  |  |  |  |  |
|  |  | $M$ ean | Standard <br> Deviation | 5 | 25 | 50 | 75 | 95 | 99 |
| < 1 | Food ${ }^{\text {c }}$ | 11 | 24 | 0 | 0 | 0 | 10 | 70 | 100 |
|  | Drinking W ater | 69 | 37 | 0 | 39 | 87 | 100 | 100 | 100 |
|  | Other Beverages | 20 | 33 | 0 | 0 | 0 | 22 | 100 | 100 |
|  | All Sources | 100 |  |  |  |  |  |  |  |
| 1-10 | Food ${ }^{\text {c }}$ |  | 16 | 0 | 5 | 10 | 19 | 44 | 100 |
|  | Drinking W ater | $65$ | $25$ | 0 | $52$ | 70 | 84 | 96 | 100 |
|  | Other Beverages | $20$ |  | 0 |  | 15 | 32 | 63 | 93 |
|  | All Sources | 100 |  |  |  |  |  |  |  |
| 11-19 | Food ${ }^{\text {c }}$ | 13 | 15 | 0 | 3 | 8 | 17 | 38 | 100 |
|  | Drinking W ater | 65 | 25 | 0 | 52 | 70 | 85 | 98 | 100 |
|  | Other Beverages | $22$ | 23 | 0 | 0 | 16 | 34 | 68 | 96 |
|  | All Sources |  |  |  |  |  |  |  |  |
| 20-64 | Food ${ }^{\text {c }}$ | 8 | 10 | 0 | 2 | 5 | 11 | 25 | 49 |
|  | Drinking W ater | 47 | 26 | 0 | 29 | 48 | 67 | 91 | 100 |
|  | Other Beverages | $45$ | 26 | 0 | 25 | 44 | 63 | 91 | 100 |
|  | All Sources | 100 |  |  |  |  |  |  |  |
| 65+ | Food ${ }^{\text {c }}$ | 8 | 9 | 0 | 2 | 5 | 11 | 23 | 38 |
|  | Drinking W ater | 50 | 23 | 0 | 36 | 52 | 66 | 87 | 99 |
|  | Other Beverages | $42$ | 23 | 3 | 27 | 40 | 57 | 85 | 100 |
|  | All Sources | 100 |  |  |  |  |  |  |  |
| All | Food ${ }^{\text {c }}$ | 10 | 13 | 0 | 2 | 6 | 13 | 31 | 64 |
|  | Drinking W ater | 54 | 27 | 0 | 36 | 56 | 75 | 95 | 100 |
|  | Other Beverages | $36$ | 27 | 0 | 14 | 34 | 55 | 87 | 100 |
|  | All Sources | 100 |  |  |  |  |  |  |  |
| a Does not include pregnant women, lactating women, or breast-fed children. <br> b Individual values may not add to totals due to rounding. <br> c Food category includes soups. <br> $0=$ Less than 0.5 percent. <br> Source: Ershow and Cantor, 1989. |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |

Ershow and Cantor (1989) also presented data on total water intake and tapwater intake for children of various ages. They found, for infants and children between the ages of 6 months and 15 years, that the total water intake per unit body weight increased smoothly and sharply from $30 \mathrm{~mL} / \mathrm{kg}$-day above age 15 years to 190 $\mathrm{mL} / \mathrm{kg}$-day for ages less than 6 months. This probably represents metabolic requirements for water as a dietary constituent. However, they found that the intake of tapwater alone went up only slightly with decreasing age (from 20 to $45 \mathrm{~mL} / \mathrm{kg}$-day as age decreases from 11 years to less than 6 months). They attributed this small effect
of age on tapwater intake to the large number of alternative water sources (besides tapwater) used for the younger age groups.

With respect to region of the country, the northeast states had slightly lower average tapwater intake ( 1,200 $\mathrm{mL} / \mathrm{day}$ ) than the three other regions (which were approximately equal at $1,400 \mathrm{~mL} /$ day $)$.

This survey has an adequately large size $(26,446$ individuals) and it is a representative sample of the United States population with respect to age distribution, sex, racial composition, and residential location. It is therefore suitable as a description of national tapwater consumption.

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The chief limitation of the study is that the data were collected in 1978 and do not reflect the expected increase in the consumption of soft drinks and bottled water or changes in the diet within the last 18 years. Since the data were collected for only a three-day period, the extrapolation to chronic intake is uncertain.

Roseberry and Burmaster - Lognormal Distributions for Water Intake - Roseberry and Burmaster (1992) fit lognormal distributions to the water intake data reported by Ershow and Cantor (1989) and estimated population-wide distributions for total fluid and total tapwater intake based on proportions of the population in each age group. Their publication shows the data and the fitted log-normal distributions graphically. The mean was estimated as the zero intercept, and the standard deviation was estimated as the slope of the best fit line for the natural logarithm of the intake rates plotted against their corresponding $z$-scores (Roseberry and Burmaster, 1992). Least squares techniques were used to estimate the best fit straight lines for the transformed data. Summary statistics for the best-fit lognormal distribution are presented in Table 3-11. In this table, the simulated balanced population represents an adjustment to account for the different age distribution of the United States population in 1988 from the age distribution in 1978 when Ershow and Cantor collected their data. Table 3-12 summarizes the quantiles and means of tapwater intake as estimated from the best-fit distributions. The mean total tapwater intake rates for the two adult populations (age 20 to 65 years, and $65+$ years) were estimated to be 1.27 and $1.34 \mathrm{~L} /$ day.

These intake rates were based on the data originally presented by Ershow and Cantor (1989). Consequently, the same advantages and disadvantages associated with the E rshow and Cantor (1989) apply to this data set.

### 3.3. RELEVANT GENERAL POPULATION STUDIES ON DRINKING WATER INTAKE <br> Cantor et al. - National Cancer Institute Study -

 The National Cancer Institute ( NCI ), in a population-based, case control study investigating the possible relationship between bladder cancer and drinking water, interviewed approximately 8,000 adult white individuals, 21 to 84 years of age ( 2,805 cases and 5,258 controls) in their homes, using a standardized questionnaire (Cantor et al., 1987). The cases and controls resided in one of five metropolitan areas (A tlanta, Detroit, New Orleans, San Francisco, and Seattle) and five States (Connecticut, Iowa, New Jersey, New M exico, and $U$ tah). The individuals interviewed were asked torecall the level of intake of tapwater and other beverages in a typical week during the winter prior to the interview. Total beverage intake was divided into the following two components: 1) beverages derived from tapwater; and 2) beverages from other sources. Tapwater used in cooking foods and in ice cubes was apparently not considered. Participants also supplied information on the primary source of the water consumed (i.e., private well, community supply, bottled water, etc.). The control population was randomly selected from the general population and frequency matched to the bladder cancer case population in terms of age, sex, and geographic location of residence. The case population consisted of Whites only, had no people under the age of 21 years and 57 percent were over the age of 65 years. The fluid intake rates for the bladder cancer cases were not used because their participation in the study was based on selection factors that could bias the intake estimates for the general population. Based on responses from 5,258 W hite

| Table 3-11. Summary Statistics for Best-Fit Lognormal Distributions for W ater Intake Rates ${ }^{\text {a }}$ |  |  |  |
| :---: | :---: | :---: | :---: |
| In Total Fluid Intake R ate |  |  |  |
| Group | $\mu$ | $\sigma$ | $\mathrm{R}^{2}$ |
| $0<$ age < 1 | 6.979 | 0.291 | 0.996 |
| $1 \leq$ age < 11 | 7.182 | 0.340 | 0.953 |
| $11 \leq$ age < 20 | 7.490 | 0.347 | 0.966 |
| $20 \leq$ age < 65 | 7.563 | 0.400 | 0.977 |
| 65 < age | 7.583 | 0.360 | 0.988 |
| All ages | 7.487 | 0.405 | 0.984 |
| Simulated balanced population | 7.492 | 0.407 | 1.000 |
| In Total T apwater Intake |  |  |  |
| Group | $\mu$ | $\sigma$ | $\mathrm{R}^{2}$ |
| $0<$ age < 1 | 5.587 | 0.615 | 0.970 |
| $1 \leq$ age < 11 | 6.429 | 0.498 | 0.984 |
| $11 \leq$ age < 20 | 6.667 | 0.535 | 0.986 |
| $20 \leq$ age < 65 | 7.023 | 0.489 | 0.956 |
| 65 < age | 7.088 | 0.476 | 0.978 |
| All ages | 6.870 | 0.530 | 0.978 |
| Simulated balanced population | 6.864 | 0.575 | 0.995 |
| a These values were used in the following equations to estimate the quantiles and averages for total tapwater intake shown in Tables 3-12. |  |  |  |
| 97.5 percentile intake rate $=\exp [\mu+(1.96 \cdot \sigma)]$ |  |  |  |
| 75 percentile intake rate $=\exp [\mu+(0.6745$ 洨] |  |  |  |
| 50 percentile intake rate $=\exp [\mu]$ |  |  |  |
| 25 percentile intake rate $=\exp [\mu-(0.6745 \cdot \sigma)]$ |  |  |  |
| 2.5 percentile intake rate $=\exp [\mu-(1.96 \cdot \sigma)]$ |  |  |  |
| M ean intake rate - $\left.\exp \left[\mu+0.5{ }^{2} \sigma^{2}\right)\right]$ |  |  |  |
| Source: Roseberry and Bur | master, |  |  |

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| Table 3-12. Estimated Quantiles and M eans for Total Tapwater Intake R ates ( $\mathrm{mL} / \mathrm{day})^{\text {a }}$ |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| A ge Group |  |  | Percen |  |  | A rithmetic |
| (years) | 2.5 | 25 | 50 | 75 | 97.5 | A verage |
| $0<$ age < 1 | 80 | 176 | 267 | 404 | 891 | 323 |
| $1 \leq$ age < 11 | 233 | 443 | 620 | 867 | 1,644 | 701 |
| 11 < age < 20 | 275 | 548 | 786 | 1,128 | 2,243 | 907 |
| 20 < age < 65 | 430 | 807 | 1,122 | 1,561 | 2,926 | 1,265 |
| $65 \leq$ age | 471 | 869 | 1,198 | 1,651 | 3,044 | 1,341 |
| All ages | 341 | 674 | 963 | 1,377 | 2,721 | 1,108 |
| Simulated Balanced Population | 310 | 649 | 957 | 1,411 | 2,954 | 1,129 |
| a Total tapwater is defined as "all water from the household tap consumed directly as a beverage or used to prepare foods and beverages." |  |  |  |  |  |  |
| Source: Roseber |  |  |  |  |  |  |

controls (3,892 males; 1,366 females), average tapwater intake rates for a "typical" week were compiled by sex, age group, and geographic region. These rates are listed in Table 3-13. The average total fluid intake rate was $2.01 \mathrm{~L} /$ day for men of which 70 percent ( $1.4 \mathrm{~L} /$ day) was derived from tapwater, and $1.72 \mathrm{~L} /$ day for women of which 79 percent ( $1.35 \mathrm{~L} /$ day) was derived from tapwater. Frequency distribution data for the 5,081 controls, for which the authors had information on both tapwater
consumption and cigarette smoking habits, are presented in Table 3-14. These data follow a lognormal distribution having an average value of $1.30 \mathrm{~L} /$ day and an upper 90th percentile value of approximately $2.40 \mathrm{~L} /$ day. These values were determined by graphically interpolating the data of Table 3-14 after plotting it on log probability graph paper. These values represent the usual level of intake for this population of adults in the winter.


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| Table 3-14. Frequency Distribution of Total Tapwater Intake R ates ${ }^{\text {a }}$ |  |  |
| :---: | :---: | :---: |
| Consumption <br> R ate (L/day) | Frequency ${ }^{\text {b }}$ (\%) | Cumulative Frequency ${ }^{\text {b }}$ (\%) |
| $\begin{gathered} \leq 0.80 \\ 0.81-1.12 \\ 1.13-1.44 \\ 1.45-1.95 \\ \geq 1.96 \end{gathered}$ | $\begin{aligned} & 20.6 \\ & 21.3 \\ & 20.5 \\ & 19.5 \\ & 18.1 \end{aligned}$ | $\begin{gathered} 20.6 \\ 41.9 \\ 62.4 \\ 81.9 \\ 100.0 \end{gathered}$ |
| Represents consumption of tapwater and beverages derived from tapwater in a "typical" winter week. Extracted from Table 3 in Cantor et al. (1987). <br> urce: C antor, et al., 1987. |  |  |

A limitation associated with this data set is that the population surveyed was older than the general population and consisted exclusively of Whites. Also, the intake data are based on recall of behavior from the winter previous to the interview. Extrapolation to other seasons and intake durations is difficult.

The authors presented data on person-years of residence with various types of water supply sources (municipal versus private, chlorinated versus nonchlorinated, and surface versus well water). Unfortunately, these data can not be used to draw conclusions about the $N$ ational average apportionment of surface versus groundwater since a large fraction (24 percent) of municipal water intake in this survey could not be specifically attributed to either ground or surface water.

National Academy of Sciences-D rinking Water and Health - NAS (1977) calculated the average per capita water (liquid) consumption per day to be 1.63 L . This figure was based on a survey of the following literature sources: Evans (1941); Bourne and Kidder (1953); Walker et al. (1957); Wolf (1958); Guyton (1968); M CN all and Schlegel (1968); Randall (1973); NAS (1974); and Pike and Brown (1975). Although the calculated average intake rate was 1.63 L per day, NAS (1977) adopted a larger rate ( 2 L per day) to represent the intake of the majority of water consumers. This value is relatively consistent with the total tapwater intakes rate estimated from the key studies presented previously. However, the use of the term "liquid" was not clearly defined in this study, and it is not known whether the populations surveyed are representative of the adult U.S. population. Consequently, the results of this
study are of limited use in recommending total tapwater intake rates and this study is not considered a key study. Pennington - Total Diet Study - Based on data from the U.S. Food and Drug Administration's (FDA's) Total Diet Study, Pennington (1983) reported average intake rates for various foods and beverages for five age groups of the population. The Total Diet Study is conducted annually to monitor the nutrient and contaminant content of the U.S. food supply and to evaluate trends in consumption. Representative diets were developed based on 24-hour recall and 2-day diary data from the 1977-1978 U.S. Department of A griculture (USDA) Nationwide Food Consumption Survey (NFCS) and 24-hour recall data from the Second National Health and Nutrition Examination Survey (NHANES II). The number of participants in NFCS and NHANES II was approximately 30,000 and 20,000, respectively. The diets were developed to "approximate 90 percent or more of the weight of the foods usually consumed" (Pennington, 1983). The source of water (bottled water as distinguished from tapwater) was not stated in the Pennington study. For the purposes of this report, the consumption rates for the food categories defined by Pennington were used to calculate total fluid and total water intake rates for five age groups. Total water includes water, tea, coffee, soft drinks, and soups and frozen juices that are reconstituted with water. Reconstituted soups were assumed to be composed of 50 percent water, and juices were assumed to contain 75 percent water. Total fluids include total water in addition to milk, ready-to-use infant formula, milk-based soups, carbonated soft drinks, alcoholic beverages, and canned fruit juices. These intake rates are presented in Table $3-15$. Based on the average intake rates for total water for

| Table 3-15. Intake Rates of Total Fluids and Total Tapwater by A ge Group |  |  |
| :---: | :---: | :---: |
| A verage Daily Consumption Rate (L/day) |  |  |
| A ge Group | Total Fluids ${ }^{\text {a }}$ | Total Tapwater ${ }^{\text {b }}$ |
| 6-11 months | 0.80 | 0.20 |
| 2 years | 0.99 | 0.50 |
| 14-16 years | 1.47 | 0.72 |
| 25-30 years | 1.76 | 1.04 |
| 60-65 years | 1.63 | 1.26 |
| a Includes milk, "ready-to-use" formula, milk-based soup, carbonated soda, alcoholic beverages, canned juices, water, coffee, tea, reconstituted juices, and reconstituted soups. Does not include reconstituted infant formula. <br> b Includes water, coffee, tea, reconstituted juices, and reconstituted soups. <br> Source: Derived from Pennington, 1983. |  |  |
|  |  |  |
|  |  |  |

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the two adult age groups, 1.04 and 1.26 L/day, the average adult intake rate is about 1.15 L /day. These rates should be more representative of the amount of sourcespecific water consumed than are total fluid intake rates. Because this study was designed to measure food intake, and it used both USDA 1978 data and NHANES II data, there was not necessarily a systematic attempt to define tapwater intake per se, as distinguished from bottled water. For this reason, it is not considered a key tapwater study in this document.

USDA - Food and Nutrient Intakes by Individuals in the United States, 1 Day, 1989-91. - USDA (1995) collected data on the quantity of "plain drinking water" and various other beverages consumed by individuals in 1 day during 1989 through 1991. The data were collected as part of USDA 's Continuing Survey of Food Intakes by

Individuals (CSFII). The data used to estimate mean per capita intake rates combined one-day dietary recall data from 3 survey years: 1989, 1990, and 1991 during which 15,128 individuals supplied one-day intake data. Individuals from all income levels in the 48 conterminous states and W ashington D.C. were included in the sample. A complex three-stage sampling design was employed and the overall response rate of for the study was 58 percent. To minimize the biasing effects of the low response rate and adjust for the seasonality a series of weighting factors was incorporated into the data analysis. The intake rates based on this study are presented in Table 3-16. Table 316 includes data for: a) "plain drinking water", which might be assumed to mean tapwater directly consumed rather than bottled water; b) coffee and tea, which might be assumed to be constituted from tapwater; and 3) fruit

| Table 3-16 M ean Per Capita Drinking W ater Intake Based on USDA, CSFII Data From 1989-91 (mL/day) |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{gathered} \hline \text { Sex and Age } \\ \text { (years) } \end{gathered}$ | Plain Drinking W ater | Coffee | Tea | Fruit Drinks and $A$ des $^{\text {a }}$ | Total |
| $M$ ales and Females: |  |  |  |  |  |
| Under 1 | 194 | 0 | < 0.5 | 17 | 211.5 |
| 1-2 | 333 | $<0.5$ | 9 | 85 | 427.5 |
| 3-5 | 409 | 2 | 26 | 100 | 537 |
| 5 \& U | 359 | 1 | 17 | 86 | 463 |
| M ales: |  |  |  |  |  |
| 6-11 | 537 | 2 | 44 | 114 | 697 |
| 12-19 | 725 | 12 | 95 | 104 | 936 |
| 20-29 | 842 | 168 | 136 | 101 | 1,247 |
| 30-39 | 793 | 407 | 136 | 50 | 1,386 |
| 40-49 | 745 | 534 | 149 | 53 | 1,481 |
| 50-59 | 755 | 551 | 168 | 51 | 1,525 |
| 60-69 | 946 | 506 | 115 | 34 | 1,601 |
| 70-79 | 824 | 430 | 115 | 45 | 1,414 |
| 80 and over | 747 | 326 | 165 | 57 | 1,295 |
| 20 and over | 809 | 408 | 139 | 60 | 1,416 |
| Females: |  |  |  |  |  |
| 6-11 | 476 | 1 | 40 | 86 | 603 |
| 12-19 | 604 | 21 | 87 | 87 | 799 |
| 20-29 | 739 | 154 | 120 | 61 | 1,074 |
| 30-39 | 732 | 317 | 136 | 59 | 1,244 |
| 40-49 | 781 | 412 | 174 | 36 | 1,403 |
| 50-59 | 819 | 438 | 137 | 37 | 1,431 |
| 60-69 | 829 | 429 | 124 | 36 | 1,418 |
| 70-79 | 772 | 324 | 161 | 34 | 1,291 |
| 80 and over | 856 | 275 | 149 | 28 | 1,308 |
| 20 and over | 774 | 327 | 141 | 46 | 1,288 |
| All individuals | 711 | 260 | 114 | 65 | 1,150 |
| Includes regular and low calorie fruit drinks, punches, and ades, including those made from powdered mix and frozen concentrate. Excludes fruit juices and carbonated drinks. <br> Source: USDA, 1995. |  |  |  |  |  |

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drinks and ades, which might be assumed to be reconstituted from tapwater rather than canned products; and 4) the total of the three sources. With these assumptions, the mean per capita total intake of water is estimated to be $1,416 \mathrm{~mL} /$ day for adult males (i.e., 20 years of age and older), $1,288 \mathrm{~mL}$ /day for adult females (i.e., 20 years of age and older) and $1,150 \mathrm{~mL} /$ day for all ages and both sexes combined. Although these assumptions appear reasonable, a close reading of the definitions used by USDA (1995) reveals that the word "tapwater" does not occur, and this uncertainty prevents the use of this study as a key study of tapwater intake.

The advantages of using these data are that; 1) the survey had a large sample size; 2) the authors attempted to represent the general United States population by oversampling low-income groups and by weighting the data to compensate for low response rates; and 3) it reflects more recent intake data than the key studies. The disadvantages are that: 1) the response rate was low; 2) the word "tapwater" was not defined and the assumptions that must be used in order to compare the data with the other tapwater studies might not be valid; 3) the data collection period reflects only a one-day intake period, and may not reflect long-term drinking water intake patterns; and 4) data on the percentiles of the distribution of intakes were not given.

Gillies and Paulin - New Zealand Study - Gillies and Paulin (1983) conducted a study to evaluate variability of mineral intake from drinking water. A study population of 109 adults ( 75 females; 34 males) ranging in age from 16 to 80 years (mean age $=44$ years) in New Zealand was asked to collect duplicate samples of water consumed directly from the tap or used in beverage preparation during a 24 -hour period. Participants were asked to collect the samples on a day when all of the water consumed would be from their own home. Individuals were selected based on their willingness to participate and their ability to comprehend the collection procedures. The mean total tapwater intake rate for this population was 1.25 ( $\pm 0.39$ ) L/day, and the 90th percentile rate was 1.90 L/day. The median total tapwater intake rate (1.26 L/day) was very similar to the mean intake rate (Gillies and Paulin, 1983). The reported range was 0.26 to 2.80 L/day.

The advantage of these data are that they were generated using duplicate sampling techniques. Because this approach is more objective than recall methods, it may result in more accurate response. However, these data are based on a short-term survey that may not be representative of long-term behavior, the population
surveyed is small and the procedures for selecting the survey population were not designed to be representative of the New Zealand population, and the results may not be applicable to the United States. For these reasons the study is not regarded as a key study in this document. Hopkins and Ellis - Drinking Water Consumption in Great Britain - A study conducted in Great Britain over a 6 -week period during September and October 1978, estimated the drinking water consumption rates of 3,564 individuals from 1, 320 households in E ngland, Scotland, and W ales (Hopkins and Ellis, 1980). The participants were selected randomly and were asked to complete a questionnaire and a diary indicating the type and quantity of beverages consumed over a 1-week period. Total liquid intake included total tapwater taken at home and away from home; purchased alcoholic beverages; and non-tapwater-based drinks. Total tapwater included water content of tea, coffee, and other hot water drinks; homemade alcoholic beverages; and tapwater consumed directly as a beverage. The assumed tapwater contents for these beverages are presented in Table 3-17. Based on

| Table 3-17. A ssumed Tapwater Content of Beverages |  |
| :---: | :---: |
| Beverage | \% Tapwater |
| Cold W ater | 100 |
| Home-made Beer/Cider/L ager | 100 |
| Home-made W ine | 100 |
| Other H ot W ater Drinks | 100 |
| Ground/Instant Coffee: ${ }^{\text {a }}$ |  |
| Black | 100 |
| W hite | 80 |
| Half Milk | 50 |
| All Milk | 0 |
| Tea | 80 |
| Hot Milk | 0 |
| Cocoa/Other Hot M ilk Drinks | 0 |
| W ater-based Fruit Drink | 75 |
| Fizzy Drinks | 0 |
| Fruit Juice $1^{\text {b }}$ | 0 |
| Fruit Juice $2^{\text {b }}$ | 75 |
| Milk | 0 |
| M ineral W ater ${ }^{\text {c }}$ | 0 |
| Bought cider/beer/lager | 0 |
| Bought Wine | 0 |
| a Black - coffee with all water, milk not added; White - coffee with $80 \%$ water, $20 \%$ milk; <br> Half Milk - coffee with $50 \%$ water, $50 \%$ milk; All Milk - coffee with all milk, water not added; |  |
| Fruit juice: individuals were asked in the questionnaire if they consumed ready-made fruit juice (type 1 above), or the variety that is diluted (type 2); |  |
| c Information on volume of mineral water consumed was obtained only as "number of bottles per week." A bottle was estimated at 500 mL , and the volume was split so that $2 / 7$ was assumed to be consumed on weekends, and 5/7 during the week. <br> Source: Hopkins and Ellis, 1980. |  |

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responses from 3,564 participants, the mean intake rates and frequency distribution data for various beverage categories were estimated by Hopkins and Ellis (1980). These data are listed in Table 3-18. The mean per capita total liquid intake rate for all individuals surveyed was $1.59 \mathrm{~L} /$ day, and the mean per capita total tapwater intake rate was 0.95 L /day, with a 90 th percentile value of about 1.3 L/day (which is the value of the percentile for the home tapwater alone in Table 3-18). Liquid intake rates were also estimated for males and females in various age groups. Table 3-19 summarizes the total liquid and total tapwater intake rates for 1,758 males and 1,800 females grouped into six age categories (Hopkins and Ellis, 1980). The mean and 90th percentile intake values for adults over age 18 years are, respectively, $1.07 \mathrm{~L} /$ day and 1.87 L/day, as determined by pooling data for males and females for the three adult age ranges in Table 3-19. This calculation assumes, as does Table 3-18 and 3-19, that the underlying distribution is normal and not lognormal.

The advantage of using these data is that the responses were not generated on a recall basis, but by recording daily intake in diaries. The latter approach may result in more accurate responses being generated. A lso, the use of total liquid and total tapwater was well defined in this study. However, the relatively short-term nature of the survey make extrapolation to long-term consumption patterns difficult. A lso, these data were based on the population of Great Britain and not the United States. Drinking patterns may differ among these populations as a result of varying weather conditions and socio-economic factors. For these reasons this study is not considered a key study in this document.
U.S. EPA - Office of Radiation Programs - Using data collected by USDA in the 1977-78 NFCS, U.S. EPA (1984) determined daily food and beverage intake levels by age to be used in assessing radionuclide intake through food consumption. Tapwater, water-based drinks, and soups were identified subcategories of the total beverage category. Daily intake rates for tapwater, water-based drinks, soup, and total beverage are presented in Table 3-20. As seen in Table 3-20, mean tapwater intake for different adult age groups (age 20 years and older) ranged from 0.62 to $0.76 \mathrm{~L} /$ day, water-based drinks intake ranged from 0.34 to $0.69 \mathrm{~L} /$ day, soup intake ranged from 0.03 to $0.06 \mathrm{~L} /$ day, and mean total beverage intake levels ranged from 1.48 to 1.73 L /day. Total tapwater intake rates were estimated by combining the average daily intakes of tapwater, water-based drinks, and soups for each age group. For adults (ages 20 years and older), mean total tapwater intake rates range from 1.04 to 1.47

L/day, and for children (ages < 1 to 19 years), mean intake rates range from 0.19 to $0.90 \mathrm{~L} /$ day. These intake rates do not include reconstituted infant formula. The total tapwater intake rates, derived by combining data on tapwater, water-based drinks, and soup should be more representative of source-specific drinking water intake than the total beverage intake rates reported in this study. These intake rates are based on the same USDA NFCS data used in Ershow and Cantor (1989). Therefore, the data limitations discussed previously also apply to this study.

International Commission on Radiological Protection - Reference Man - Data on fluid intake levels have also been summarized by the International Commission on Radiological Protection (ICRP) in the Report of the Task Group on Reference $M$ an (ICRP, 1981). These intake levels for adults and children are summarized in Table 3-21. The amount of drinking water (tapwater and water-based drinks) consumed by adults ranged from about 0.37 L /day to about $2.18 \mathrm{~L} /$ day under "normal" conditions. The levels for children ranged from 0.54 to $0.79 \mathrm{~L} /$ day. Because the populations, survey design, and intake categories are not clearly defined, this study has limited usefulness in developing recommended intake rates for use in exposure assessment. It is reported here as a relevant study because the findings, although poorly defined, are consistent with the results of other studies.

National Human Activity Pattern Survey (NHAPS) The U.S. EPA collected information on the number of glasses of drinking water and juice reconstituted with tapwater consumed by the general population as part of the National Human Activity Pattern Survey (Tsang and K lepeis, 1996). NHAPS was conducted betw een October 1992 and September 1994. Over 9,000 individuals in the 48 contiguous United States provided data on the duration and frequency of selected activities and the time spent in selected microenvironments via 24 -hour diaries. Over 4,000 NHAPS respondents also provided information of the number of 8 -ounce glasses of water and the number of 8 -ounce glasses of juice reconstituted with water than they drank during the 24-hour survey period (Tables 3-22 and $3-23)$. The median number of glasses of tapwater consumed was 1-2 and the median number of glasses of juice with tapwater consumed was 1-2.

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| Table 3-18. Intake of Total Liquid, Total Tapwater, and Various Beverages (L/day) |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | All Individuals |  |  |  |  | Consumers Only |  |  |  |
| Beverage | Mean Intake | Approx. Std. Error of Mean | Approx. 95\% Confidence Interval for $\qquad$ | 10 and 90 <br> Percentiles | $\begin{gathered} 1 \text { and } 99 \\ \text { Percentiles } \end{gathered}$ | Percentage of Total Number of Indi viduals | Mean Intake | Approx. Std. Error of Mean | Approx. 95\% Confidence Interval for Mean |
| Total Liquid | 1.589 | 0.0203 | 1.547-1.629 | 0.77-2.57 | 0.34-4.50 | 100.0 | 1.589 | 0.0203 | 1.547-1.629 |
| Total Liquid Home | 1. 104 | 0.0143 | 1.075-1.133 | 0.49-1.79 | 0.23-3.10 | 100.0 | 1.104 | 0.0143 | 1.075-1.133 |
| Total Liquid Away | 0.484 | 0.0152 | 0.454-0.514 | 0.00-1.15 | 0.00-2.89 | 89.9 | 0.539 | 0.0163 | 0.506-0.572 |
| Total Tapwater | 0.955 | 0.0129 | 0.929-0.981 | 0.39-1.57 | 0.10-2.60 | 99.8 | 0.958 | 0.0129 | 0.932-0.984 |
| Total Tapwater Home | 0.754 | 0.0116 | 0.731-0.777 | 0.26-1.31 | 0.02-2.30 | 99.4 | 0.759 | 0.0116 | 0.736-0.782 |
| Total Tapwater Away | 0.201 | 0.0056 | 0.190-0.212 | 0.00-0.49 | 0.00-0.96 | 79.6 | 0.253 | 0.0063 | 0.240-0.266 |
| Tea | 0.584 | 0.0122 | 0.560-0.608 | 0.01-1.19 | 0.00-2.03 | 90.9 | 0.643 | 0.0125 | 0.618-0.668 |
| Coffee | 0.190 | 0.0059 | 0.178-0.202 | 0.00-0.56 | 0.00-1.27 | 63.0 | 0.302 | 0.0105 | 0.281-0.323 |
| Other Hot <br> Water Drinks | 0.011 | 0.0015 | 0.008-0.014 | 0.00-0.00 | 0.00-0.25 | 9.2 | 0.120 | 0.0133 | 0.093-0.147 |
| Cold Water | 0.103 | 0.0049 | 0.093-0.113 | 0.00-0.31 | 0.00-0.85 | 51.0 | 0.203 | 0.0083 | 0.186-0.220 |
| Fruit Drinks | 0.057 | 0.0027 | 0.052-0.062 | 0.00-0.19 | 0.00-0.49 | 46.2 | 0.123 | 0.0049 | 0.113-0.133 |
| Non Tapwater | 0.427 | 0.0058 | 0.415-0.439 | 0.20-0.70 | 0.06-1.27 | 99.8 | 0.428 | 0.0058 | 0.416-0.440 |
| Home brew | 0.010 | 0.0017 | 0.007-0.013 | 0.00-0.00 | 0.00-0.20 | 7.0 | 0.138 | 0.0209 | 0.096-0.180 |
| Bought <br> Alcoholic <br> Beverages | 0.206 | 0.0123 | 0.181-0.231 | 0.00-0.68 | 0.00-2.33 | 43.5 | 0.474 | 0.0250 | 0.424-0.524 |
| a Consumers on <br> Source: Hop | defined <br> and Ellis, | oly those indi vid 30. | ls who reported | suming the b | rage during the | period. |  |  |  |



## Volume I - General Factors

Chapter 3 - Drinking Water Intake


| Table 3-21. M easured Fluid Intakes (mL/day) |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Subject | Total Fluids | Milk | Tapwater | W ater-Based Drinks ${ }^{\text {a }}$ |
| A dults ("normal" conditions) ${ }^{\text {b }}$ | 1000-2400 | 120-450 | 45-730 | 320-1450 |
| A dults (high environmental temperature to $32^{\circ} \mathrm{C}$ ) | $\begin{aligned} & 2840-3410 \\ & 3256 \pm \\ & S D=900 \end{aligned}$ |  |  |  |
| A dults (moderately active) | 3700 |  |  |  |
| Children (5-14 yr) | 1000-1200 | 330-500 | ca. 200 | ca. 380 |
|  | 1310-1670 | 540-650 |  |  |
| Includes tea, coffee, soft drinks, beer, cider, wine, etc. <br> b "Normal" conditions refer to typical environmental temperature and activity levels. Source: ICRP, 1981. |  |  |  |  |

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| Table 3-22. Number of Glasses of Tapwater Consumed in 24-Hour Period |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Number of Respondents |  |  |  |  |  |  |  |
|  | All | None | 1-2 | 3-5 | 6-9 | 10-19 | 20+ | DK |
| Overall | 4,663 | 1,334 | 1,225 | 1,253 | 500 | 151 | 31 | 138 |
| Gender |  |  |  |  |  |  |  |  |
| M ale | 2,163 | 604 | 582 | 569 | 216 | 87 | 25 | 65 |
| Female | 2,498 | 728 | 643 | 684 | 284 | 64 | 6 | 73 |
| Ref | 2 | 2 | - | - | - | - | - | - |
| Age |  |  |  |  |  |  |  |  |
| 1-4 | 263 | 114 | 96 | 40 | 7 | 1 | 0 | 5 |
| 5-11 | 348 | 90 | 127 | 86 | 15 | 7 | 2 | 20 |
| 12-17 | 326 | 86 | 109 | 88 | 22 | 7 | - | 11 |
| 18-64 | 2,972 | 908 | 751 | 769 | 334 | 115 | 26 | 54 |
| > 64 | 670 | 117 | 127 | 243 | 112 | 20 | 2 | 42 |
| R ace |  |  |  |  |  |  |  |  |
| White | 3,774 | 1,048 | 1,024 | 1,026 | 416 | 123 | 25 | 92 |
| Black | 463 | 147 | 113 | 129 | 38 | 9 | 1 | 21 |
| A sian | 77 | 25 | 18 | 23 | 6 | 1 | - | 4 |
| Some Others | 96 | 36 | 18 | 22 | 6 | 7 | 2 | 5 |
| Hispanic | 193 | 63 | 42 | 40 | 28 | 10 | 2 | 7 |
| Ref | 60 | 15 | 10 | 13 | 6 | 1 | 1 | 9 |
| Hispanic |  |  |  |  |  |  |  |  |
| No | 4,244 | 1,202 | 1,134 | 1,162 | 451 | 129 | 26 | 116 |
| Y es | 347 | 116 | 80 | 73 | 41 | 18 | 4 | 13 |
| DK | 26 | 5 | 6 | 7 | 4 | 3 | - | 1 |
| Ref | 46 | 11 | 5 | 11 | 4 | 1 | 1 | 8 |
| Employment |  |  |  |  |  |  |  |  |
| Fullime | 2,017 | 637 | 525 | 497 | 218 | 72 | 18 | 40 |
| Part-time | 379 | 90 | 94 | 120 | 50 | 13 | 7 | 5 |
| Not Employed | 1,309 | 313 | 275 | 413 | 188 | 49 | 3 | 54 |
| Ref | 32 | 6 | 4 | 11 | 1 | 2 | 1 | 4 |
|  |  |  |  |  |  |  |  |  |
| < High School | 399 | 89 | 95 315 | 118 | 51 | 14 | 2 | 28 |
| High School Grad | 1,253 | 364 | 315 | 330 | 132 | 52 | 13 | 37 |
| < College | 895 | 258 | 197 | 275 | 118 | 31 | 5 | 9 |
| College Grad | 650 | 195 | 157 | 181 | 82 | 19 | 4 | 6 |
| Post Grad | 445 | 127 | 109 | 113 | 62 | 16 | 3 | 12 |
|  |  |  |  |  |  |  |  |  |
| N ortheast | 1,048 | 351 | 262 | 266 | 95 | 32 | 7 | 28 |
| M idwest | 1,036 | 243 | 285 | 308 | 127 | 26 | 9 | 33 |
| South | 1,601 | 450 | 437 | 408 | 165 | 62 | 11 | 57 |
| West | 978 | 290 | 241 | 271 | 113 | 31 | 4 | 20 |
|  |  |  |  |  |  |  |  |  |
| W eekday | 3,156 1,507 | 864 | 840 385 | 862 | 334 | 96 | 27 | 106 32 |
| W eekend | 1,507 | 470 | 385 | 391 | 166 | 55 | 4 | 32 |
| Season |  |  |  |  |  |  |  |  |
| W inter | 1,264 | 398 | 321 | 336 339 | 128 | 45 33 | 10 | 26 |
| Spring | 1,181 1,275 | 337 352 | 282 | 339 344 | 127 | 33 41 | 10 | 40 |
| Summer | 1,275 943 | 352 247 | 323 299 | 344 234 | 155 90 | 41 32 | 9 | 40 |
| Fall | 943 | 247 | 299 | 234 | 90 | 32 | 7 | 32 |
|  |  |  |  |  |  |  |  |  |
| Y Y es | 341 | - 96 | 83 | 91 | 40 | 16 | 1 | 13 |
| DK | 35 | 6 | 5 | 7 | 1 | 1 | 1 | 10 |
|  |  |  |  |  |  |  |  |  |
| No | 4,500 125 | 1,308 18 | 1,195 25 | 1,206 40 | 47 | 143 | 29 1 | 123 |
| Y es | 125 | r 8 | 5 5 | 7 | 3 | 2 | 1 | 9 |
|  |  |  |  |  |  |  |  |  |
| No | 4,424 | 1,280 | 1,161 | 1,189 | 474 | 142 | 29 | 124 |
| Yes | 203 36 | 48 6 | 55 9 | 58 6 | 24 2 | 9 | 1 | 5 9 |
| DK |  |  |  |  |  |  |  |  |
| NOTE: "•" = M issing Data <br> "DK" = Don't know <br> $\mathrm{N}=$ sample size <br> Ref $=$ refused <br> Source: Tsang and Kleipeis, 1996 |  |  |  |  |  |  |  |  |

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| Table 3-23. Number of Glasses of Juice Reconstituted with Tapwater Consumed in 24-Hour Period |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Number of Respondents |  |  |  |  |  |  |  |
|  | All | None | 1-2 | 3-5 | 6-9 | 10-19 | 20+ | DK |
| Overall | 4,663 | 1,877 | 1,418 | 933 | 241 | 73 | 21 | 66 |
| Gender |  |  |  |  |  |  |  |  |
| M ale | 2,163 | 897 | 590 | 451 | 124 | 35 | 17 | 33 |
| Female | 2,498 | 980 | 826 | 482 | 117 | 38 | 4 | 33 |
| Ref | 2 | - | 2 | - | - | - | - | - |
| Age |  |  |  |  |  |  |  |  |
| 1-4 | 263 | 126 | 71 | 48 | 11 | 4 | 1 | 2 |
| 5-11 | 348 | 123 | 140 | 58 | 12 | 2 | 1 | 11 |
| 12-17 | 326 | 112 | 118 | 63 | 18 | 7 | 1 | 4 |
| 18-64 | 2,972 | 1,277 | 817 | 614 | 155 | 46 | 16 | 30 |
| > 64 | 670 | 206 | 252 | 133 | 43 | 12 | 2 | 14 |
| Race |  |  |  |  |  |  |  |  |
| White | 3,774 | 1,479 | 1,168 | 774 | 216 | 57 | 16 | 44 |
| Black | 463 | 200 | 142 | 83 | 15 | 9 | 1 | 7 |
| A sian | 77 | 33 | 27 | 15 | 1 | - | - | 0 |
| Some Others | 96 | 46 | 19 | 24 | 2 | 1 | 3 | 1 |
| Hispanic | 193 | 95 | 51 | 30 | 5 | 5 | 1 | 5 |
| Ref | 60 | 24 | 11 | 7 | 2 | 1 | - | 9 |
|  |  |  |  |  |  |  |  |  |
| No | 4,244 | 1,681 | 1,318 | 863 | 226 | 64 | 17 | 49 |
| Y es | 347 | 165 | 87 | 61 | 14 | 7 | 4 | 7 |
| DK | 26 | 11 | 6 | 5 | - | 1 | - | 3 |
| Ref | 46 | 20 | 7 | 4 | 1 | 1 | - | 7 |
| Employment |  |  |  |  |  |  |  |  |
| Fulltime | 2,017 | 871 | 559 | 412 | 103 | 32 | 9 | 20 |
| Part-time | 379 | 156 | 102 | 88 | 19 | 7 | 2 | 5 |
| Not Employed | 1,309 | 479 | 426 | 265 | 75 | 20 | 7 | 21 |
| Ref | 32 | 15 | 4 | 4 | 2 | 1 | - | 3 |
| Education 146 |  |  |  |  |  |  |  |  |
| < High School | 399 | 146 | 131 | 82 | 25 | 7 | 2 | 4 |
| High School Grad | 1,253 | 520 | 355 | 254 | 68 | 21 | 7 | 17 |
| < College | 895 | 367 | 253 | 192 | 47 | 18 | 5 | 11 |
| College Grad | 650 | 274 | 201 | 125 | 31 | 7 | 1 | 5 |
| Post Grad | 445 | 182 | 130 | 92 | 26 | 5 | 3 | 4 |
| Census Region 240200050 |  |  |  |  |  |  |  |  |
| Northeast | 1,048 | 440 | 297 | 220 | 51 | 13 | 4 | 15 |
| M idwest | 1,036 | 396 | 337 | 200 | 63 | 17 | 4 | 14 |
| South | 1,601 | 593 | 516 | 332 | 84 | 26 | 10 | 28 |
| W est | 978 | 448 | 268 | 181 | 43 | 17 | 3 | 9 |
| Day of Week 3156 |  |  |  |  |  |  |  |  |
| W eekday | 3,156 | 1,261 | 969 | 616 | 162 | 51 | 11 | 46 |
| W eekend | 1,507 | 616 | 449 | 307 | 79 | 22 | 10 | 20 |
|  |  |  |  |  |  |  |  |  |
| W inter | 1,264 | 529 | 382 | 245 | 66 | 23 | 4 | 10 |
| Spring | 1,181 | 473 | 382 | 215 | 54 | 19 | 8 | 17 |
| Summer | 1,275 | 490 | 389 | 263 | 68 | 18 | 6 | 28 |
| Fall | 943 | 385 | 265 | 210 | 53 | 13 | 3 | 11 |
|  |  |  |  |  |  |  |  |  |
| No | 4,287 341 | 1,734 130 | 1,313 102 | 853 74 | 216 25 | 69 3 | 20 1 | 55 5 |
| Yes | 341 35 | 130 13 | 102 3 | 74 6 | $\stackrel{.}{ }$ | 3 1 | 1 | 6 |
| DK |  |  |  |  |  |  |  |  |
| No | 4,500 | 1,834 | 1,362 | 900 | 231 | 67 | 20 | 59 |
| Y es | 125 38 | 31 12 | 53 3 | 25 | 7 | 5 | 1 | 1 |
| DK | 38 | 12 | 3 | 8 | 3 | 1 | - | 6 |
| Bronchitis/Emphyszema | 4,424 | 1,782 | 1,361 | 882 | 230 | 65 | 21 | 57 |
| No Y es | +203 | - 84 | 53 | 44 | 10 | 6 | . | 3 |
| DK | 36 | 11 | 4 | 7 | 1 | 2 | - | 6 |
| NOTE: "•" = M issing Data <br> "DK" = Don't know <br> $\mathrm{N}=$ sample size <br> Ref = refused <br> Source: T sang and K lepeis, 1996 |  |  |  |  |  |  |  |  |

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## Chapter 3 - Drinking Water Intake

For both individuals who drank tapwater and individuals who drank juices reconstituted with tapwater, the number of glasses ranged from 1 to 20. The highest percentage of the population (37.1 percent) who drank tapwater consumed 3-5 glasses and the highest percentage of the population ( 51.5 percent) who consumed juice reconstituted with tapwater drank 1-2 glasses. B ased on the assumption that each glass contained 8 ounces of water $(226.4 \mathrm{~mL})$, the total volume of tapwater and juice with tapwater consumed would range from $0.23 \mathrm{~L} /$ day (1 glass) to $4.5 \mathrm{~L} /$ day ( 20 glasses) for respondents who drank tapwater. Using the same assumption, the volume of tapwater consumed for the population who consumed 3-5 glasses would be 0.68 L/day to $1.13 \mathrm{~L} /$ day and the volume of juice with tapwater consumed for the population who consumed 1-2 glasses would be 0.23 L /day to 0.46 L/day. A ssuming that the average individual consumes 35 glasses of tapwater plus 1-2 glasses of juice with tapwater, the range of total tapwater intake for this individual would range from $0.9 \mathrm{~L} /$ day to $1.64 \mathrm{~L} /$ day. These values are consistent with the average intake rates observed in other studies.

The advantages of NHAPS is that the data were collected for a large number of individuals and that the data are representative of the U.S. population. How ever, evaluation of drinking water intake rates was not the primary purpose of the study and the data do not reflect the total volume of tapwater consumed. However, using the assumptions described above, the estimated drinking water intake rates from this study are within the same ranges observed for other drinking water studies.

AIHC Exposure Factors Handbook - The Exposure Factors Sourcebook (AIHC, 1994) presented drinking water intake rate recommendations for adults. A lthough AIHC (1994) provided little information on the studies used to derive mean and upper percentile recommendations, the references indicate that several of the studies used were the same as ones categorized as relevant studies in this Handbook. The mean adult drinking water recommendations in AIHC (1994) and this Handbook are in agreement. However, the upper percentile value recommended by AIHC (1994) (2.0 L/day) is slightly lower than that recommended by this Handbook (2.4 L/day). Based on data provided by Ershow and Cantor (1989), 2.0 L/day corresponds to only approximately the 84th percentile of the drinking water intake rate distribution. Thus, a slightly higher value is appropriate for representing the upper percentile (i.e., 90 to 95th percentile) of the distribution. AIHC (1994) also presents simulated distributions of drinking water intake
based on Roseberry and Burmaster (1992). These distributions are also described in detail in Section 3.2 of this Handbook. AIHC (1994) has been classified as a relevant rather than a key study because it is not the primary source for the data used to make recommendations for this document.

### 3.4. PREGNANT AND LACTATING WOMEN

Ershow et al., 1991 - Intake of Tapwater and Total Water by Pregnant and Lactating Women - Ershow et al. (1991) used data from the 1977-78 USDA NFCS to estimate total fluid and total tapwater intake among pregnant and lactating women (ages 15 to 49 years). Data for 188 pregnant women, 77 lactating women, and 6,201 non-pregnant, non-lactating control women were evaluated. The participants were interviewed based on 24 hour recall, and then asked to record a food diary for the next 2 days. "Tapwater" included tapwater consumed directly as a beverage and tapwater used to prepare food and tapwater-based beverages. "Total water" was defined as all water from tapwater and non-tapwater sources, including water contained in food. Estimated total fluid and total tapwater intake rates for the three groups are presented in Tables 3-24 and 3-25, respectively. L actating women had the highest mean total fluid intake rate ( $2.24 \mathrm{~L} /$ day) compared with both pregnant women ( $2.08 \mathrm{~L} /$ day) and control women ( $1.94 \mathrm{~L} /$ day). L actating women also had a higher mean total tapwater intake rate (1.31 L/day) than pregnant women (1.19 L/day) and control women ( $1.16 \mathrm{~L} /$ day). The tapwater distributions are neither normal nor lognormal, but lactating women had a higher mean tapwater intake than controls and pregnant women. Ershow et al. (1991) also reported that rural women ( $n=1,885$ ) consumed more total water ( 1.99 L/day) and tapwater (1.24 L/day) than urban/suburban women ( $n=4,581,1.93$ and 1.13 L/day, respectively). Totalwater and tapwater intake rates were lowest in the northeastern region of the U nited States (1.82 and 1.03 L/day) andhighest in the western region of the United States ( 2.06 L /day and $1.21 \mathrm{~L} /$ day). M ean intake per unit body weight was highest among lactating women for both total fluid and total tapw ater intake. Total tapwater intake accounted for over 50 percent of mean total fluid in all three groups of women (Table 3-25). Drinking water accounted for the largest single proportion of the total fluid intake for control (30 percent), pregnant (34 percent), and lactating women (30 percent) (Table 3-26). All other beverages combined accounted for approximately 46 percent, 43 percent, and 45 percent of the total water intake for control, pregnant, and lactating
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| Table 3-24. Total Fluid Intake of W omen 15-49 Y ears Old |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reproductive Status ${ }^{\text {a }}$ | M ean | Standard <br> Division | Percentile Distribution |  |  |  |  |  |  |
|  |  |  | 5 | 10 | 25 | 50 | 75 | 90 | 95 |
| mL/day |  |  |  |  |  |  |  |  |  |
| Control | 1940 | 686 | 995 | 1172 | 1467 | 1835 | 2305 | 2831 | 3186 |
| Pregnant | 2076 | 743 | 1085 | 1236 | 1553 | 1928 | 2444 | 3028 | 3475 |
| L actating | 2242 | 658 | 1185 | 1434 | 1833 | 2164 | 2658 | 3169 | 3353 |
| $\underline{\mathrm{mL} / \mathrm{kg} / \text { day }}$ |  |  |  |  |  |  |  |  |  |
| Control | 32.3 | 12.3 | 15.8 | 18.5 | 23.8 | 30.5 | 38.7 | 48.4 | 55.4 |
| Pregnant | 32.1 | 11.8 | 16.4 | 17.8 | 22.8 | 30.5 | 40.4 | 48.9 | 53.5 |
| L actating | 37.0 | 11.6 | 19.6 | 21.8 | 28.4 | 35.1 | 45.0 | 53.7 | 59.2 |

a Number of observations: nonpregnant, nonlactating controls $(\mathrm{n}=6,201)$; pregnant $(\mathrm{n}=188)$; lactating ( $\mathrm{n}=77$ ). Source: Ershow et al., 1991.

| Table 3-25. Total Tapwater Intake of W omen 15-49 Y ears Old |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reproductive Status ${ }^{\text {a }}$ | M ean | Standard Deviation | Percentile Distribution |  |  |  |  |  |  |
|  |  |  | 5 | 10 | 25 | 50 | 75 | 90 | 95 |
| mL/day |  |  |  |  |  |  |  |  |  |
| Control | 1157 | 635 | 310 | 453 | 709 | 1065 | 1503 | 1983 | 2310 |
| Pregnant | 1189 | 699 | 274 | 419 | 713 | 1063 | 1501 | 2191 | 2424 |
| L actating | 1310 | 591 | 430 | 612 | 855 | 1330 | 1693 | 1945 | 2191 |
| $\underline{\mathrm{mL} / \mathrm{kg} / \text { day }}$ |  |  |  |  |  |  |  |  |  |
| Control | 19.1 | 10.8 | 5.2 | 7.5 | 11.7 | 17.3 | 24.4 | 33.1 | 39.1 |
| Pregnant | 18.3 | 10.4 | 4.9 | 5.9 | 10.7 | 16.4 | 23.8 | 34.5 | 39.6 |
| L actating | 21.4 | 9.8 | 7.4 | 9.8 | 14.8 | 20.5 | 26.8 | 35.1 | 37.4 |
| Fraction of daily fluid intake that is tapwater (\%) |  |  |  |  |  |  |  |  |  |
| Control | 57.2 | 18.0 | 24.6 | 32.2 | 45.9 | 59.0 | 70.7 | 79.0 | 83.2 |
| Pregnant | 54.1 | 18.2 | 21.2 | 27.9 | 42.9 | 54.8 | 67.6 | 76.6 | 83.2 |
| L actating | 57.0 | 15.8 | 27.4 | 38.0 | 49.5 | 58.1 | 65.9 | 76.4 | 80.5 |
| a Number of observations: nonpregnant, nonlactating controls $(\mathrm{n}=6,201)$; pregnant $(\mathrm{n}=188)$; lactating $(\mathrm{n}=77)$. Source: Ershow et al., 1991. |  |  |  |  |  |  |  |  |  |

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| Table 3-26. Total Fluid (mL/Day) Derived from V arious Dietary Sources by Women A ged 15-49 Y ears ${ }^{\text {a }}$ |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sources |  | Control Women |  | Pregnant W omen |  |  | L actating W omen |  |  |
|  | M ean ${ }^{\text {b }}$ |  | ntile | M ean ${ }^{\text {b }}$ | Percentile |  | M ean ${ }^{\text {b }}$ | Percentile |  |
|  |  | 50 | 95 |  | 50 | 95 |  | 50 | 95 |
| Drinking W ater | 583 | 480 | 1440 | 695 | 640 | 1760 | 677 | 560 | 1600 |
| Milk and Milk Drinks | 162 | 107 | 523 | 308 | 273 | 749 | 306 | 285 | 820 |
| Other Dairy Products | 23 | 8 | 93 | 24 | 9 | 93 | 36 | 27 | 113 |
| M eats, Poultry, Fish, Eggs | 126 | 114 | 263 | 121 | 104 | 252 | 133 | 117 | 256 |
| Legumes, Nuts, and Seeds | 13 | 0 | 77 | 18 | 0 | 88 | 15 | 0 | 72 |
| Grains and Grain Products | 90 | 65 | 257 | 98 | 69 | 246 | 119 | 82 | 387 |
| Citrus and Noncitrus Fruit Juices | 57 | 0 | 234 | 69 | 0 | 280 | 64 | 0 | 219 |
| Fruits, Potatoes, V egetables, Tomatoes | 198 | 171 | 459 | 212 | 185 | 486 | 245 | 197 | 582 |
| Fats, Oils, Dressings, Sugars, Sweets | 9 | 3 | 41 | 9 | 3 | 40 | 10 | 6 | 50 |
| Tea | 148 | 0 | 630 | 132 | 0 | 617 | 253 | 77 | 848 |
| Coffee and Coffee Substitutes | 291 | 159 | 1045 | 197 | 0 | 955 | 205 | 80 | 955 |
| Carbonated Soft Drinks ${ }^{\text {c }}$ | 174 | 110 | 590 | 130 | 73 | 464 | 117 | 57 | 440 |
| Noncarbonated Soft Drinks ${ }^{\text {c }}$ | 38 | 0 | 222 | 48 | 0 | 257 | 38 | 0 | 222 |
| Beer | 17 | 0 | 110 | 7 | 0 | 0 | 17 | 0 | 147 |
| W ine Spirits, Liqueurs, M ixed Drinks | 10 | 0 | 66 | 5 | 0 | 25 | 6 | 0 | 59 |
| All Sources | 1940 | NA | NA | 2076 | NA | NA | 2242 | NA | NA |
| a Number of observations: nonpregnant, nonlactating controls $(\mathrm{n}=6,201)$; pregnant ( $\mathrm{n}=188$ ); lactating $(\mathrm{n}=77)$. <br> b Individual means may not add to all-sources total due to rounding. <br> c Includes regular, low-calorie, and noncalorie soft drinks. <br> NA: Not appropriate to sum the columns for the 50th and 95th percentiles of intake. <br> Source: Ershow et al., 1991. |  |  |  |  |  |  |  |  |  |

women, respectively. Food accounted for the remaining portion of total water intake.

The same advantages and limitations associated with the Ershow and Cantor (1989) data also apply to these data sets (Section 3.2). A further advantage of this study is that it provides information on estimates of total water and tapwater intake rates for pregnant and lactating women. This topic has rarely been addressed in the literature.

### 3.5. HIGH ACTIVITY LEVELS/ HOT CLIMATES

McNall and Schlegel, 1968 - Practical Thermal Environmental Limits for Young Adult Males Working in Hot, Humid Environments - McNall and Schlegel (1968) conducted a study that evaluated the physiological tolerance of adult males working under varying degrees of physical activity. Subjects were required to pedal pedaldriven propeller fans for 8 -hour work cycles under varying environmental conditions. The activity pattern for
each individual was: cycled at 15 minute pedalling and 15 miute rest for each 8 -hour period. Two groups of eight subjects each were used. Work rates were divided into three categories as follows: high activity level [0.15 horsepower (hp) per person], medium activity level ( 0.1 hp per person), and low activity level ( 0.05 hp per person). Evidence of physical stress (i.e., increased body temperature, blood pressure, etc.) was recorded, and individuals were eliminated from further testing if certain stress criteria were met. The amount of water consumed by the test subjects during the work cycles was also recorded. Water was provided to the individuals on request. The water intake rates obtained at the three different activity levels and the various environmental temperatures are presented in Table 3-27. The data presented are for test subjects with continuous data only (i.e., those test subjects who were not eliminated at any stage of the study as a result of stress conditions). W ater intake was the highest at all activity levels when environmental temperatures were increased. The highest

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| :--- | ---: |
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intake rate was observed at the low activity level at $100^{\circ} \mathrm{F}$ ( $0.65 \mathrm{~L} /$ hour) however, there were no data for higher activity levels at $100^{\circ} \mathrm{F}$. It should be noted that this study estimated intake on an hourly basis during various levels of physical activity. These hourly intake rates cannot be converted to daily intake rates by multiplying by 24 hours/day because they are only representative of intake during the specified activity levels and the intake rates for the rest of the day are not known. Therefore, comparison of intake rate values from this study cannot be made with values from the previously described studies on drinking w ater intake.
and 10) construction. Only personal drinking water consumption factors are described here.

Drinking water consumption planning factors are based on the estimated amount of water needed to replace fluids lost by urination, perspiration, and respiration. It assumes that water lost to urinary output averages one quart/day ( $0.9 \mathrm{~L} /$ day) and perspiration losses range from almost nothing in a controlled environment to 1.5 quarts/day (1.4 L/day) in a very hot climate where individuals are performing strenuous work. W ater losses to respiration are typically very low except in extreme cold where water losses can range from 1 to 3 quarts/day


U nited States Army - Water Consumption Planning Factors Study - The U.S. A rmy has developed water consumption planning factors to enable them to transport an adequate amount of water to soldiers in the field under various conditions (U.S. A rmy, 1983). Both climate and activity levels were used to determine the appropriate water consumption needs. Consumption factors have been established for the following uses: 1) drinking, 2) heat treatment, 3) personal hygiene, 4) centralized hygiene,
5) food preparation, 6) laundry, 7) medical treatment, 8) vehicle and aircraft maintenance, 9) graves registration,
( 0.9 to $2.8 \mathrm{~L} /$ day). This occurs when the humidity of inhaled air is near zero, but expired air is 98 percent saturated at body temperature (U.S. Army, 1983). Drinking water is defined by the U.S. Army (1983) as "all fluids consumed by individuals to satisfy body needs for internal water." This includes soups, hot and cold drinks, and tapw ater. Planning factors have been established for hot, temperate, and cold climates based on the following mixture of activities among the work force: 15 percent of the force performing light work, 65 percent of the force performing medium work, and 20 percent of the

force performing heavy work. H ot climates are defined as tropical and arid areas where the temperature is greater than $80^{\circ} \mathrm{F}$. Temperate climates are defined as areas where the mean daily temperature ranges from $32^{\circ} \mathrm{F}$ to $80^{\circ} \mathrm{F}$. Cold regions are areas where the mean daily temperature is less than $32^{\circ} \mathrm{F}$. Drinking water consumption factors for these three climates are presented in Table 3-28. These factors are based on research on individuals and small unit training exercises. The estimates are assumed to be conservative because they are rounded up to account for the subjective nature of the activity mix and minor water losses that are not considered (U.S. A rmy, 1983). The advantage of using these data is that they provide a conservative estimate of drinking water intake among individuals performing at various levels of physical activity in hot, temperate, and cold climates. However, the planning factors described here are based on assumptions about water loss from urination, perspiration, and respiration, and are not based on survey data or actual measurements.

| Table 3-28. Planning Factors for Individual Tapwater Consumption |  |  |
| :---: | :---: | :---: |
| Environmental Condition | Recommended Planning Factor (gal/day) ${ }^{\text {a }}$ | Recommended Planning Factor (L/day) ${ }^{\text {a,b }}$ |
| Hot | $3.0{ }^{\text {c }}$ | 11.4 |
| Temperate | $1.5{ }^{\text {d }}$ | 5.7 |
| Cold | $2.0{ }^{\text {e }}$ | 7.6 |

${ }^{\text {a }}$ Based on a mix of activities among the work force as follows: $15 \%$ light work; $65 \%$ medium work; $20 \%$ heavy work. These factors apply to the conventional battlefield where no nuclear, biological, or chemical weapons are used.
b Converted from gal/day to L/day.
c This assumes 1 quart/12-hour rest period/man for perspiration losses and 1 quart/day/man for urination plus 6 quarts/12-hours light work/man, 9 quarts/12-hours moderate work/man, and 12 quarts/12-hours heavy work/man.
d This assumes 1 quart/12-hour rest period/man for perspiration losses and 1 quart/day/man for urination plus 1 quart/12-hours light work/man, 3 quarts/12-hours moderate work/man, and 6 quarts/12-hours heavy work/man.
e This assumes 1 quart/12-hour rest period/man for perspiration losses, 1 quart/day/man for urination, and 2 quarts/day/man for respiration losses plus 1 quart/12-hours light work/man, 3 quarts/ 12 -hours moderate work/man, and 6 quarts/ 6 -hours heavy work/man.

### 3.6. RECOMMENDATIONS

The key studies described in this section were used in selecting recommended drinking water (tapwater) consumption rates for adults and children. The studies on
other subpopulations were not classified as key versus relevant. Although different survey designs and populations were utilized by key and relevant studies described in this report, the mean and upper-percentile estimates reported in these studies are reasonably similar. The general design of both key and relevant studies and their limitations are summarized in Table 3-29. It should be noted that studies that surveyed large representative samples of the population provide more reliable estimates of intake rates for the general population. M ost of the surveys described here are based on short-term recall which may be biased toward excess intake rates. However, Cantor et al. (1987) noted that retrospective dietary assessments generally produce moderate correlations with "reference data from the past."

Adults - The total tapwater consumption rates for adults (older than 18 or 20 years) that have been reported in the key surveys can be summarized as follows:

| M ean <br> (L/day) | 90th <br> Percentile <br> (L/day) | Number in <br> Survey | Reference |
| :---: | :---: | :---: | :--- |
| 1.38 | 2.41 | 639 | Canadian M instry of Health <br> and W elfare, 1981 <br> Ershow and Cantor, 1989 |
| 1.41 | 2.28 | 11,731 |  |

For comparison, the relevant studies had the following values for daily tapwater intake:

| M ean (L/day) | 90th <br> Percentile | Reference |
| :--- | :--- | :--- |
| $1.30^{\text {a }}$ | 2.40 | Cantor et al., 1987 |
| 1.63 (calculated) | - | NAS, 1977 |
| 1.25 | 1.90 | Gillies and Paulin, 1983 |
| 1.04 (25 to 30 yrs) | -- | Pennington, 1983 |
| 1.26 (60 to 65 yrs) | - | Pennington, 1983 |
| $1.04-1.47$ (ages 20+) | -- | U.S. EPA, 1984 |
| 1.37 (20 to 64 yrs) | 2.27 | Ershow and Cantor, 1989 |
| 1.46 (65+ yrs) | 2.29 | Ershow and Cantor, 1989 |
| 1.15 | -- | USDA, 1995 |
| 1.07 | 1.87 | Hopkins and Ellis, 1980 |
| a Age of the Cantor et al. (1987) population was higher than the U.S. |  |  |
| average. |  |  |

Note that both Ershow and Cantor (1989) and Pennington (1983) found that adults above 60 years of age had larger intakes than younger adults. This is difficult to reconcile with the Cantor, et al. (1987) study because the latter, older population had a smaller average intake.Exposure Factors HandbookPageAugust 19963-25

| Table 3-29. Drinking Water Intake Surveys |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Study | Number of Individuals | Type of Water Consumed | Time Period/ Survey Type | Population Surveyed | Comments |
| KEY |  |  |  |  |  |
| Canadian Ministry of National Health and Welfare, 1981 | 970 | Total tapwater consumption | Weekday and weekend day in both summer and winter; estimation based on sizes and types of containers used | All ages; Canada | Seasonal data; indudes many tapwatercontaining items not commonly surveyed; possible bias because identification of vessel size used as survey techniques; short-term study |
| Ershow and Cantor, 1989 | Based on data from NFCS; approximately 30,000 individuals | Total tapwater; total fluid consumption | 3-day recall, diaries | All ages; large sample representative of U.S. population | Short-term recall data; seasonally bal anced data |
| Rosenberry and Burmaster, 1992 | Based on data from Ershow and Cantor, 1987 | Total tapwater; total fluid consumption | 3-day recall, diaries | All ages; large sample representative of US population | Short-term recall data; seasonally bal anced; suitable for Monte Carlo simulations |
| RELEVANT |  |  |  |  |  |
| Cantor et al., 1987 | 5,258 | Total tapwater; total fluid consumption | 1 weak/usual intake in winter based on recall | Adults only; weighted toward older adults; U.S. population | Based on recall of behavior from previous winter; short-term data; population not representative of general U.S. population |
| Gillies and Paulin, 1983 | 109 | Total tapwater consumption | 24 hours; dupl icate water samples collected | Adults only; New Zeeland | Based on short-term data |
| Hopkin and Ellis, 1980 | 3,564 | Total tapwater, total liquid consumption | 1 week period, diaries | All ages; Great Britain | Short-term diary data |
| ICRP, 1981 | Based on data from several sources | Water and water-based drinks; milk; total fluids | $N A^{\text {a }}$ | $N A^{\text {a }}$ | Survey design and intake categories not clearly defined |
| NAS 1977 | Cal culated average based on several sources | Average per capita "liquid" consumption | $N A^{\text {a }}$ | $N A^{\text {a }}$ | Total tapwater not reported; population and survey design not reported |

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| Table 3-29. Drinking Water Intake Surveys (continued) |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Study | Number of Individuals | Type of Water Consumed | Time Period/ Survey Type | Population Surveyed | Comments |
| Pennington, 1983 | Based on NFCS and NHANES II; approximately 30,000 and 20,000 participants, respectively | Total tapwater; total fluid consumption | NFCS: 24-hour recall on 2-day dairy; NHANES II:24-hour recal | NFCS: 1 month to 97 years; NHANES II: 6 months to 74 years; representative samples of US population | Based on short-term recall data |
| USDA, 1995 | Based on 89-91 CSF 11; approximately 15,000 individuals | Plain drinking water, coffee, tea, fruit drinks and ades | 1-day recall | All ages, large sample representative of U.S. population | Short-term recall data; seasonally adjusted |
| USEPA, 1984 | Based on NFCS; approximately 30,000 indi viduals | Tapwater; water based foods and beverages; soups; beverage consumption | 3-day recall, diaries | All ages; large sample representative of US population | Short-term recall data; seasonally bal anced |
| USEPA, 1995 | Over 4,000 participants of NHAPS | Number of glasses of drinking water and juice with tapwater | 24-hour diaries | All ages, large representative sample of US population | Does not provide data on the volume of tapwater consumed |
| McNall and Schlegel, 1968 | Based on 2 groups of 8 subjects each | Tapwater | 8-hour work cyde | Males between 17-25 years of age; small sample; high activity levels/ hot climates | Based on short-term data |
| U.S. Army, 1983 | NA | All fluids consumed to satisfy body needs for internal water; indudes soups, hot and cold drinks and tapwater | NA | High activity levels/hot climates | Study designed to provide water consumption planning factors for various activities and field conditions; based on estimated amount of water required to account for losses from urination, perspiration, and respiration |
| ${ }^{\text {a }}$ Not applicable. |  |  |  |  |  |

Because of these results, combined with the fact that the Cantor, et al. (1987) study was not intended to be representative of the $U$. S. population, it is not included here in the determination of the recommended value. The USDA (1995) data are not included because tapwater was not defined in the survey and because the response rate was low, although the results (showing lower intakes than the studies based on older data) may be accurately reflecting an expected lower use of tapwater (compared to 1978) because of increasing use of bottled water and soft drinks in recent years.

A value of $1.41 \mathrm{~L} /$ day, which is the populationweighted mean of the two national studies (Ershow and Cantor, 1989 and Canadian Ministry of Health and W elfare, 1981) is the recommended average tapwater intake rate.

The average of the 90th percentile values from the same two studies ( $2.35 \mathrm{~L} /$ day) is recommended as the appropriate upper limit. (The commonly-used 2.0 L /day intake rate corresponds to the 84th percentile of the intake rate distribution among the adults in the Ershow and Cantor (1989) study). In keeping with the desire to incorporate body weight into exposure assessments without introducing extraneous errors, the values from the Ershow and Cantor (1989) study (Tables 3-7 and 3-8) expressed as $\mathrm{mL} / \mathrm{kg}$-day are recommended in preference to the liters/day units. For adults, the mean and 90th percentile values are $21 \mathrm{~mL} / \mathrm{kg}$-day and $34.2 \mathrm{~mL} / \mathrm{kg} /$ day, respectively.

In the absence of actual data on chronic intake, the values in the previous paragraph are recommended as chronic values, although the chronic 90th upper percentile may very well be larger than $2.35 \mathrm{~L} /$ day. If a mathematical description of the intake distribution is needed, the parameters of lognormal fit to the Ershow and Cantor (1989) data (Tables 3-11 and 3-12) generated by Roseberry and Burmaster (1992) may be used. The simulated balanced population distribution of intakes generated by Roseberry and Burmaster is not recommended for use in the post-1997 time frame, since it corrects the 1978 data only for the differences in the age structure of the U. S. population between 1978 and 1988.

These recommended values are different than the 2 liters/day commonly assumed in EPA risk assessments. A ssessors are encouraged to use values which most accurately reflect the exposed population. When using values other than 2 liters/day, however, the assessors should consider if the dose estimate will be used to estimate risk by combining with a dose-response relationship which was derived assuming a tap water
intake of 2 liters/day. If such an inconsistency exists, the ssessor should adjust the dose-response relationship as described in A ppendix 1 of Chapter 1. IRIS does not use a tap water intake assumption in the derivation of RfCs and RfDs, but does make the 2 liter/day assumption in the derivation of cancer slope factors and unit risks.

Children - The tapwater intake rates for children reported in the key studies are summarized below.

|  | Mean <br> (L/day) | 90th <br> Percentile <br> (L/day) | R eference |
| :--- | :--- | :--- | :--- |
| $<1$ | 0.30 | 0.65 | Ershow and Cantor, <br> 1989 <br> Canadian M inistry of <br> N ational Health and |
| 3-5 | 0.61 | 1.50 | 1.50 |
| Welfare, 1891 <br> Canadian M inistry of <br> National Health and <br> W elfare, 1981 <br> Ershow and Cantor, <br> 1989 <br> Canadian M inistry of <br> National Health and <br> W elfare, 1981 <br> Ershow and Cantor, <br> 1989 |  |  |  |
| $11-17$ | 0.87 | 0.74 | 1.29 |

The intake rates, as expressed as liters per day, generally increase with age, and the data are consistent across ages for the two key studies except for the Canadian M inistry of Health and Welfare (1981) data for ages 6 to 17 years; it is recommended that any of the liters/day values that match the age range of interest except the Canada data for ages 6 to 17 be used. The $\mathrm{mL} / \mathrm{kg}$-day intake values show a consistent downward trend with increasing ages; using the Ershow and Cantor (1989) data in preference to the Canadian Ministry of National Health and W elfare (1981) data is recommended where the age ranges overlap.

The intakes for children as reported in the relevant studies are as follows:

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|  | M ean <br> (L/day) | Reference |
| :--- | :--- | :--- |
| A ge |  |  |
| $6-11$ months | 0.20 | Pennington, 1983 |
| $<1$ yr | 0.19 | U.S. EPA, 1984 |
| $<1$ yr | 0.32 | Roseberry and Burmaster, 1992 |
| 2 | 0.50 | Pennington, 1983 |
| $1-4$ | 0.58 | U.S. EPA, 1984 |
| $5-9$ | 0.67 | U.S. EPA, 1984 |
| $1-10$ | 0.70 | Roseberry and Burmaster, 1992 |
| $10-14$ | 0.80 | U.S. EPA, 1984 |
| $14-16$ | 0.72 | Pennington, 1983 |
| $15-19$ | 0.90 | U.S. EPA, 1984 |
| $11-19$ | 0.91 | Roseberry and Burmaster, 1992 |

Disregarding the Roseberry and Burmaster study, which is a recalculation of the Ershow and Cantor (1989) study, the non-key studies generally have lower mean intake values than the Ershow and Cantor study. The reason is not known, but the results are not persuasive enough to discount the recommendations based on the latter study. Intake rates for specific percentiles of the distribution may be selected using the lognormal distribution data generated by R oseberry and Burmaster (1992) (Tables 3-11 and 3-12).

Pregnant and Lactating Women -The data on tapwater intakes for control, pregnant, and lactating women are presented in Table 3-25. Although lactating women have higher tapwater intakes than pregnant or control (non-pregnant and non-lactating) women, they are not higher than the general population of males and females combined. If this Handbook had attempted to derive separate intake values for males and females, then these data might justify further separation of lactating from non-lactating females. However, within the scope of the current document, general population intake rates are recommended for pregnant and lactating women.

High Activity/H ot Climates - Data intake rates for individuals performing strenuous activities under various environmental conditions are limited. H owever, the data presented by M cN all and Schlegel (1968) and U.S. A rmy (1983) provide bounding intake values for these individuals. According to McNall and Schlegel (1968), hourly intake can range from 0.21 to $0.65 \mathrm{~L} /$ hour depending on the temperature and activity level. Intake among physically active individuals can range from 6 L/day in temperate climates to 11 L /day in hot climates (U.S. A rmy, 1983). A summary of the recommended values is presented in Table 3-30.

| Table 3-30. Summary of Recommended Drinking W ater Intake R ates |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| A ge Group/ Population | M ean | 90th Percentile | M ultiple Percentiles | Fitted Distributions |
| < 1 year | $0.30 \mathrm{~L} /$ day $44 \mathrm{~mL} / \mathrm{kg}$-day | 0.65 L/day $102 \mathrm{~mL} / \mathrm{kg}$-day | $\begin{gathered} \text { See Tables 3-6, 3-7, } \\ \text { and 3-8 } \end{gathered}$ | See Table 3-11 |
| $<3$ years | 0.61 L/day | 1.5 L/day | See Table3-3 |  |
| 3-5 years | 0.87 L/day | 1.5 L/day | See Table3-3 |  |
| 1-10 years | 0.74 L/day $35 \mathrm{~mL} / \mathrm{kg}$-day | 1.3 L/day $64 \mathrm{~mL} / \mathrm{kg}$-day | $\begin{gathered} \text { See Tables 3-6, 3-7, } \\ \text { and 3-8 } \end{gathered}$ | See Table 3-11 |
| 11-19 years | $\begin{gathered} 0.97 \mathrm{~L} / \mathrm{day} \\ 18 \mathrm{~mL} / \mathrm{kg} \text {-day } \end{gathered}$ | 1.7 L/day $32 \mathrm{~mL} / \mathrm{kg}$-day | See Tables 3-6, 3-7, and 3-8 | See Table 3-11 |
| A dults | $\begin{gathered} 1.4 \mathrm{~L} / \text { day } \\ 21 \mathrm{~mL} / \mathrm{kg} \text {-day } \end{gathered}$ | 2.4 L/day 34 mL/kg-day | See Tables 3-6, 3-7, and 3-8 | See Table 3-11 |
| Pregnant and Lactating W omen | 1.4 L/day $21 \mathrm{~mL} / \mathrm{kg}$-day | 2.4 L/day $34 \mathrm{~mL} / \mathrm{kg}$-day | See Tables 3-6, 3-7, and 3-8 |  |
| A dults in High Activity/H ot Climate Conditions | to $0.65 \mathrm{~L} /$ hour, | on ambient tempe | d activity level; see |  |
| A ctive A dults | day (temperate | $1 \mathrm{~L} /$ day (hot clim | Table 3-26. |  |

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A characterization of the overall confidence in the accuracy and appropriateness of these recommendations is presented in Table 3-31. Although the study of Ershow and Cantor (1989) is of high quality and consistent with the other surveys, the low currency of the information
(1978 data collection), in the presence of anecdotal information (not presented here) that the consumption of bottled water and beverages has increased since 1980 was the main reason for lowering the confidence score of the overall recommendations from high to medium.

| Table 3-31. Confidence in Tapwater Intake Recommendations |  |  |
| :---: | :---: | :---: |
| Considerations | Rationale | Rating |
| Study Elements |  |  |
| - Level of peer review | Ershow and Cantor: Thorough expert panel review. <br> Canada: Review procedures not stated; government report. Other reports: Published in scientific journals | High |
| - Accessibility | The two monographs are available from the sponsoring agencies; the others are library-accessible. | High |
| - Reproducibility | M ethods are well-described. | High |
| - Focus on factor of interest | The studies are directly relevant to tap water. | High |
| - Data pertinent to U.S. | See "representativeness" below | NA |
| - Primary data | The two monographs used recent primary data (less than one week) on recall of intake. | High |
| - Currency | Data were all collected in the 1978 era. Tap water use may have changed since then. | Low |
| - A dequacy of data collection period | These are one- to three-day intake data. However, long term variability may be small. Their use as a chronic intake measure can be assumed. | M edium |
| - Validity of approach | Competently executed study. | High |
| - Study size | L argest monograph had data for 11,000 individuals. | High |
| - Representativeness of the population | The Ershow and Cantor and Canada surveys were validated as demographically representative. | High |
| - Characterization of variability | The full distributions were given in the main studies | High |
| - Lack of bias in study design (high rating is desirable) | None apparent. | High |
| - M easurement error | No physical measurements were taken. The method relied on recent recall of standardized volumes of drinking water containers, and was not validated. | M edium |
| Other Elements |  |  |
| - Number of studies | Two key studies for the adult and child recommendations. There were six other studies for adults, one study for pregnant and lactating women, and two studies for high activity/hot climates. | High for adult and children. <br> Low for the other recommended subpopulation values. |
| - A greement between researchers | Good | High |
| Overall Rating | The excellent data are not current. | M edium |

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