



## Community Water Fluoridation

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### Total Water Intake

#### Lack of association between daily temperature and children's water intake in the United States – 1999-2004

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##### Background

A study in the 1950s assessed the effect of maximum daily temperature on water intake among children aged 0 to 10 years in two communities in California.<sup>1</sup> Findings indicated that children ingested more water on days with higher maximum daily temperatures, and less water on days with lower maximum daily temperatures. Two studies published after 1990<sup>2,3</sup> reassessed the effect of maximum daily temperature on water intake from drinking water, other beverages, and food. One of these studies<sup>3</sup> linked monthly averages for maximum daily temperature from 1961–1990 with 24-hour dietary interview data from the National Health and Nutrition Examination Survey (NHANES) 1988–1994 for children aged 1 to 10 years. Neither study found an association between water intake and maximum daily temperature. Authors attributed the contradictory findings to changes in children's environments and behaviors since the 1950s, mainly the wider use of air conditioning and lower levels of outdoor physical activity. The objective of this report is to describe the effect of maximum daily temperature on total water intake among children aged 1 to 10 years during 1999–2004.

##### Definitions

National Health and Nutrition Examination Survey (NHANES). An ongoing national survey of people from all age groups representing the non-institutionalized United States population. NHANES includes an interview at home and examination and laboratory tests at a mobile examination center. The examination component includes a 24-hour dietary interview for foods ingested the day before the interview. For more information, see: <http://www.cdc.gov/nchs/nhanes.htm>.

Total Water Intake. Consumption of water from all dietary sources, including plain water (from the tap), water mixed with other beverages (such as juice, soda, sports drinks, dairy and non-dairy milk), and water from or mixed with foods. For more information, see: <http://www.cdc.gov/nchs/tutorials/dietary/index.htm>.

Climate Normal. Defined as the arithmetic mean of a climatologic element—for example, maximum daily temperature—over three consecutive decades for a time period such as a month or a year. For more information, see: <http://www.ncdc.noaa.gov/faqs/climfaq23.html>

## Data Sources

### Total Water Intake Data

We obtained data for total water intake from the NHANES 1999–2004 24-hour dietary interview. This interview measures total water intake as defined above from midnight to midnight on the day before the NHANES examination. We report total water intake in milliliters per kilogram of body weight per day (ml/kg/day) among children aged 1 to 10 years. Body weight as measured during the NHANES examination was used in this calculation.

Further description of the dietary interview can be found in NHANES Dietary Interviewer's Training Manual available at <http://www.cdc.gov/nchs/about/major/nhanes/datalink.htm>. Further information about NHANES can be obtained at <http://www.cdc.gov/nchs>.

### Maximum Daily Temperature Data

We obtained data on temperature for the monthly and annual averages from the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center Climatology 81 Monthly Station Normals for 1971–2000 and daily temperature observations from National Weather Service Cooperative Summary of the Day (DS-3200). We used three types of data for maximum daily temperature: 1) maximum daily temperature on the day of dietary intake; 2) monthly averages, 30-year normals for the month in which the dietary intake occurred; and 3) annual averages, 30-year normals for maximum daily temperature over the course of a year. When there was more than one weather station in a county, we calculated county temperature values as the average of the values obtained from those weather stations.

### Data Linkage and Analysis

We prepared analytical data files from NHANES and NOAA data sets. In the NHANES data set, all participants have a county of residence, but these data were not released to the public. In the NOAA data sets, temperature information was available only for those counties with weather stations. We used the NCHS Research Data Center (RDC) to link the two data sets by the participant's county of residence. A working data set, accessible only at the RDC, included individual values for total water intake and county values for the three temperature measures, but sample sizes varied for each temperature measure. For example, of the 7,658 children aged 1 to 10 years who participated in the MEC exam, 4,493 had complete data for water intake and maximum temperature on the day of water intake (Table 1), 4,609 had complete data using maximum daily temperature during the month of water intake (Table 2), and 5,396 had complete data using the annual average maximum daily temperature (Table 3).

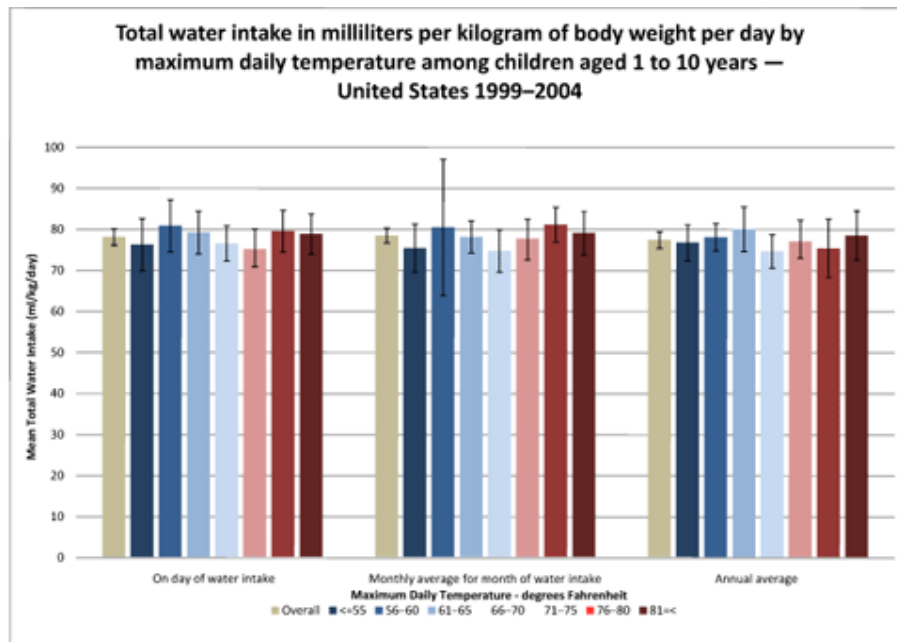
Survey participants were assigned temperature values based on the day of water intake and county of residence. We grouped temperature averages into seven ranges for analysis:  $\leq 55$ , 56–60, 61–65, 66–70, 71–75, 76–80, and  $\geq 81$  degrees Fahrenheit ( $^{\circ}$ F). No counties had annual averages for maximum daily temperature below 50 $^{\circ}$ F or above 86 $^{\circ}$ F. We chose these temperature ranges to assure sufficient sample size to obtain stable estimates for total water intake. Fewer than five participants with total water intake (ml/day) beyond six standard deviations of the mean for their age were excluded from the analysis. The actual number excluded cannot be reported to protect the privacy of participants.

We conducted statistical analyses with the true strata, primary sampling units, and survey weights for the dietary interview using the SAS System for Windows (release 9.1; SAS Institute Inc, Cary, N.C.) and SUDAAN (release 9.0; Research Triangle Institute, Research Triangle Park, N.C.). Graphs include the 95% confidence limits. We used the Satterthwaite adjusted Chi Square statistic to test whether water intake was associated with maximum daily temperature and the Satterthwaite adjusted F statistic to test whether water intake was higher at warmer temperatures than at cooler temperatures. P-values of  $<0.05$  would indicate that an observed association was not likely due to chance alone.

[Top of Page](#) 

## Results

The mean total water intake was 78 milliliters per kilogram of body weight per day (ml/kg/day) among NHANES participants aged 1 to 10 years. Mean total water intake ranged from 75 ml/kg/day on days with maximum daily temperatures of 71–75 degrees Fahrenheit to 81 ml/kg/day on days with maximum daily temperatures of 56–60 degrees. Mean total water intake did not vary by temperature whether annual, monthly or daily temperature values were used. P-values for Chi Square and F statistics ranged from 0.35 to 0.79.



(A [text version](#) of this graphic is also available.)

### Discussion and Conclusion

Our results show a lack of association between total water intake and ambient temperature among children aged 1 to 10 years.

Compared with those in the 1950s, our study has two important strengths: It used a representative sample of the U.S. population, and reflects current lifestyles and environmental conditions, such as the widespread use of air conditioning. In addition, compared with a previous study using NHANES 1988–1994, we included the temperature on the day of water intake in addition to the monthly and annual averages.

Our study has also some limitations. Temperature data were not part of the study design, and some NHANES participants did not have temperature values. In addition, the logistics of transporting the Mobile Examination Centers dictated that cooler areas of the country were visited during the summer months, while warmer areas were mostly visited in the winter. These two limitations reduced the range of temperatures under which water intake was measured. Our final data set had participants reporting water intake in each temperature range and for each month of the year.

These data can have practical applications. For example, water intake patterns are important for community water fluoridation.<sup>4,5,6</sup> The 1962 Public Health Service recommendations for community water fluoridation suggest modifying the optimal amount of fluoride in the water to take into account presumed differential water intake based on ambient temperature.<sup>4,5</sup> Our results, together with two other recent studies that did not find an association between total water intake and measures of maximum daily temperature, suggest that the temperature-based approach may not be needed given current conditions.

## References

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**Table 1.** Total water intake in milliliters per kilogram of body weight per day by the maximum temperature on the day water intake was measured

Maximum Temperature on the day of water intake (degrees Fahrenheit)	Number of survey participants	Mean Total Water Intake (ml/kg/day)	95% Confidence Interval
<b>Overall</b>	<b>4,493</b>	<b>78.14</b>	<b>76.08-80.21</b>
55 degrees and cooler	199	76.29	69.66-82.91
56-60	302	80.87	74.25-87.49
61-65	552	79.25	73.82-84.69
66-70	756	76.60	72.17-81.03
71-75	725	75.20	70.13-80.27
76-80	680	79.60	74.35-84.86
81 degrees and warmer	1,279	78.86	73.73-83.99

**Table 2.** Total water intake in milliliters per kilogram of body weight per day by the average

(continued)

**Table 2.** Total water intake in milliliters per kilogram of body weight per day by the average maximum daily temperature for the month in which 24-hour water intake was measured

<b>Average maximum daily temperature during the month of water intake (degrees Fahrenheit)</b>	<b>Number of survey participants</b>	<b>Mean Total Water Intake (ml/kg/day)</b>	<b>95% Confidence Interval</b>
<b>Overall</b>	<b>4,609</b>	<b>78.54</b>	<b>76.65–80.44</b>
55 degrees and cooler	81	75.47	69.40–81.55
56–60	66	80.51	63.21–97.81
61–65	977	78.21	74.17–82.25
66–70	699	74.80	69.44–80.16
71–75	883	77.78	72.85–82.71
76–80	825	81.18	76.76–85.60
81 degrees and warmer	1,078	79.14	73.64–84.64

**Table 3.** Total water intake in milliliters per kilogram of body weight per day by the average maximum daily temperature for a year

<b>Average maximum daily temperature for a year (degrees Fahrenheit)</b>	<b>Number of survey participants</b>	<b>Mean Total Water Intake (ml/kg/day)</b>	<b>95% Confidence Interval</b>
<b>Overall</b>	<b>5,396</b>	<b>77.47</b>	<b>75.39–79.55</b>
55 degrees and cooler	186	76.81	72.21–81.40
56–60	1,290	78.13	74.63–81.62
61–65	879	80.11	74.45–85.76
66–70	596	74.71	70.49–78.93
71–75	939	77.12	71.71–82.53
76–80	1,034	75.43	68.03–82.83
81 degrees and warmer	472	78.53	72.30–84.77

[Top of Page](#) 



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