# Current patterns of water and beverage consumption among Mexican children and adolescents aged 1–18 years: analysis of the Mexican National Health and Nutrition Survey 2012

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## Abstract

*Objective:* To evaluate patterns of water consumption from plain water, beverages and foods among Mexican children and adolescents and to compare actual patterns of total daily water intake with the Dietary Reference Intakes (DRI).
*Design:* We analysed one 24 h dietary recall from Mexican children and adolescents. We calculated intakes of total daily water and water from foods and from beverages. Actual total water intake per capita was subtracted from the DRI for water to calculate the shortfall.
*Setting:* Mexican National Health and Nutrition Survey in 2012.
*Subjects:* Mexican children and adolescents (*n* 6867) aged 1–18 years.
*Results:* Approximately 73 % of children and adolescents aged 1–18 years reported drinking plain water. Beverages and plain water represented 65·5 % and 26·5 % of total daily water intake, respectively. Among 1–3-year-olds, the top three main sources of water were from foods, plain water and water from plain milk. Among 4–8- and 9–13-year-olds, the main sources were from foods, plain water and *agua fresca* (fruit water). Among 14–18-year-olds, the main sources of water were plain water, water from foods and soda. A higher proportion of 1–3-year-olds and 4–8-year-olds met the DRI for water (38 % and 29 %, respectively). Among 9–13-year-olds and 14–18-year-olds, 13–19 % of children met the DRI for water.
*Conclusions:* Total daily water intakes remain below DRI levels in all age groups. Although plain water still contributes the greatest proportion to daily water intake among fluids, caloric beverages are currently major sources of water especially among older children and adolescents.

Water is a critical nutrient and its importance for the prevention of nutrition-related diseases has received attention recently because of the shift towards higher consumption of fluids as caloric beverages[1,2]. When consumed adequately, water has no side-effects and provides no energy, which makes it one of the most recommended options as a beverage among populations facing obesity and its related complications[3,4]. In Mexico, the lack of available potable water in households and schools coincides with the increased proliferation of caloric sweetened beverages such as soda and *agua fresca* (fruit water made in stalls or at home, usually with sugar added)[5–7]. In this context, adequate hydration among children in Mexico has become a cause of public health concern[4,8]. Although previous studies have investigated patterns of beverage consumption in Mexican children[5,6], to date no studies have focused on total daily water consumption from both food and

beverage sources. This research is timely in Mexico as the recently passed 10 % tax on beverages containing added sugar has been accompanied by a requirement that the government sets aside 80 % of the revenue for obesity prevention and other policies to promote potable water consumption, particularly in elementary schools[9,10].

Total daily water intake includes plain water (bottled or tap), water from other beverages and water from food sources (both intrinsic water in foods and water added in food preparations). Adequate Intakes (AI) for water are established using observed total water intakes in the population, desirable water volume per 4184 kJ (1000 kcal) and also desirable urine osmolality[8,11]. The Dietary Reference Intakes (DRI) for water and electrolytes reported by the US Institute of Medicine (IOM) established the AI for total daily water as between 1·3 and 1·7 litres/d in 1–3- and 4–8-year-olds and between 2·1 and 3·3 litres/d in

9–13- and 14–18-year-olds. The desirable level of water per 4184 kJ (1000 kcal) is thought to be approximately 1–1·5 litres in children depending on activity levels and water losses[11,12].

The present study investigated current patterns of water consumption from plain water, beverages and foods among Mexican children and adolescents by age group and gender. This analysis used dietary data from children and adolescents aged 1–18 years who participated in the Mexican National Health and Nutrition Survey 2012 (NHNS 2012). In addition, we compared actual patterns of total daily water intake with the DRI recommended by the US IOM.

## Methods

### Survey design and sample: Mexican National Health and Nutrition Survey 2012

We analysed dietary data from 6867 children and adolescents aged 1–18 years included in the NHNS 2012. The NHNS 2012 is a cross-sectional, probabilistic, population-based survey with a multistage and stratified sampling, representative of Mexico[13]. The main objective of the NHNS 2012 was to characterize the health and nutritional status of the Mexican population. Information was collected from October 2011 to May 2012. The NHNS 2012 surveyed 50 528 Mexican households within thirty-seven federal entities. The household response rate was 87 %. The NHNS 2012 sampling system included a pro-portional sample of both rural (population < 2500 inhabitants) and urban (population > 2500 inhabitants) areas that was drawn to be representative of four regional strata: (i) North (Baja California, Baja California Sur, Coahuila, Chihuahua, Durango, Nuevo León, Sonora and Tamaulipas); (ii) Center (Aguascalientes, Colima, Estado de México, Guanajuato, Jalisco, Michoacán, Morelos, Nayarit, Querétaro, San Luis Potosí, Sinaloa and Zacatecas); (iii) Mexico City; and (iv) South (Campeche, Chiapas, Guerrero, Hidalgo, Oaxaca, Puebla, Quintana Roo, Tabasco, Tlaxcala, Veracruz and Yucatán). Additional detailed description of the sampling procedures and survey methodology can be found else-where[13]. The study was conducted according to the guidelines laid down in the Declaration of Helsinki and the survey protocol was revised and approved by the Ethics Committee of the Mexican National Institute of Public Health. Informed consent was obtained from each participant or participant's parent/guardian (assent was obtained for children aged ≥ 10 years).

### Dietary intake data

Dietary intake data were collected by trained interviewers using one 24 h recall in a stratified nationally representative sub-sample of the population, which captured approxi-mately one-sixth of the total population. Respondents reported all foods and beverages consumed for the previous 24 h period. This methodology is considered adequate to study the distribution of consumption of foods, energy and nutrients in population studies[14]. The main meal planner was asked to report dietary intake for children < 15 years of age. For the NHNS 2012, an automated five-step multiple-pass method was implemented to improve dietary recall. This multiple-step method is based on different probes that start asking for all foods and beverages consumed plus other typically forgotten foods, with a final probe for anything else that was consumed. During the interview, participants were asked to report consumption of foods, dishes (or prepara-tions) and beverages, as well as the amount consumed, both purchased and food prepared at home. For foods prepared at home, participants were asked to report the detailed recipe. In addition, they were asked about food and bev-erages consumed between principal meals both inside and outside the home. Each interviewer was provided with a manual with photographs of commonly consumed foods, a food scale, measuring cups and serving spoons of various sizes to help in estimating the amount of food or beverages (in grams or millilitres) reported by each participant. In order to capture current changes in the Mexican food supply, we used the most recent food composition table, which was based on a combination of the chemical analyses conducted in Mexico on some unique foods and the food composition tables from the US Department of Agriculture's Food and Nutrient Database for Dietary Studies (FNDDS)[15,16]. Food composition tables capture macro- and micronutrients, water and fibre content in each food and beverage. The present analysis included all participants aged 1–18 years with complete dietary data.

### Beverage grouping system and category definition

Beverages were grouped and classified using their food description or their energy density (kJ/kcal per 100 ml). First, beverage ingredients that were recorded separately were combined into a single beverage group (e.g. if coffee, milk and sugar were recorded as part of a single preparation, we combined that information into a single group called 'coffee with milk and sugar'). We also aggregated some beverage groups that had similar nutri-tional or behavioural values. Most beverage groups were created using keyword searches at their food description. Sodas were further divided into 'caloric' and 'low calorie' versions using keyword searches (e.g. soda was classified as low calorie if the food description indicated that the beverage was 'light' or 'low calorie'). Other beverages such as coffee/tea with milk and/or sugar added were classified as 'low calorie' if they had less than 837 kJ (20 kcal)/100 g. Otherwise, they were classified as 'calo-ric'. Beverages were finally grouped into ten broad groups that represent all beverages consumed by the Mexican population: (i) water; (ii) *agua fresca* (fruit water made in stalls or at home, usually with sugar added); (iii) coffee/tea; (iv) soda; (v) fruit & vegetable juice; (vi) milk & milk beverages; (vii) *atole* (corn-starch beverage); (viii) sports

& energy drinks; (ix) alcoholic beverages; and (x) other beverages (see online supplementary material, Supplemental Table 1).

### Socio-economic index and BMI

The socio-economic index was generated by imputing deciles of income level to the households on the NHNS 2012, using demographic and socio-economic variables (i.e. characteristics of the head of the household, demographic household structure, home characteristics and appliances, household expenditure and level of marginalization of the geographic area), and based on the National Income and Expenditure Survey 2010[17]. The socio-economic index was divided into tertiles and was used as a proxy for low, medium and high socio-economic status in the present study.

Participants' weight and height were measured by trained staff using a standardized protocol[13,18]. Weight and height were used to calculate standardized measures of BMI. To classify overweight and obesity we used the WHO criteria[19,20], which classified obesity as BMI > 3 SD above the WHO growth standard median and overweight as BMI > 2 SD for children aged < 5 years. For children and adolescents aged 5–18 years, obesity was defined as BMI > 2 SD and overweight as BMI > 1 SD above the WHO growth standard median.

### Statistical analysis

All analyses were performed using the statistical software package Stata release 13 (2013). Survey commands were used to account for survey design and weighting to generate nationally representative results. Age was used to separate participants into different age groups: 1–3 years, 4–8 years, 9–13 years and 14–18 years. All analyses were performed for the entire sample and for each age and gender subpopulation.

To examine patterns of water and beverage consumption, we first calculated the mean total water intake (from foods and beverages); the mean water intake from all beverages and from plain water (ml/capita per d); and the percentage of consumers of plain water in the entire population and for each sociodemographic group. Then, we calculated the mean total volume of water that comes from each beverage group and the water volume from all foods (ml of water/capita per d). The proportion of volume of water that comes from each beverage type was calculated by dividing the mean total volume of water from each beverage type by the mean total volume of water intake per day. To investigate the contribution of foods and beverages to total daily energy intake (kJ/kcal), we calculated the mean daily per capita intake from all foods, all beverages and each beverage type. Using the IOM recommendations of water intake for each age and gender group, we calculated the total shortfall in water consumption, the proportion of children who met or failed to meet the DRI of water per day, and the mean of ratio of water to energy (litres/4184 kJ (1000 kcal)).

The mean of one 24 h recall should give a reasonable estimate of the mean intake at the population level, but might result in an over/underestimation of the proportion above or below a threshold value because it does not account for day-to-day variation in food consumption[14,21]. Then, the proportion of children and adolescents failing to meet the DRI for water might be overestimated. Estimates are presented as means with their standard errors. Statistically significant differences were tested using Student's *t* test with the Bonferroni correction. A two-sided *P* value of 0·05 was set to denote statistical significance.

## Results

### Sociodemographic characteristics and water consumption patterns

Water consumption patterns by sociodemographic group are shown in Table 1. Overall, intakes of total water, water from beverages and plain water were significantly higher among older compared with younger children and among males compared with females (Table 1). Approximately 73 % of all children studied reported any consumption of plain water. Intakes of water were generally not significantly different between children in urban *v.* rural areas. There were a few differences between children in northern *v.* southern geographic areas and between higher *v.* lower socio-economic levels. Obese children and adolescents reported significantly higher amounts of total water, water from beverages and plain water compared with normal or overweight children.

### Patterns of water intake from food and beverage sources by age group

Table 2 and Supplemental Table 2 show the main sources of water from all foods and different beverage types by age group among Mexican children and adolescents. Among 1–3-year-olds, the top three main sources of water were moisture in foods, plain water and water from plain milk. Among 4–8- and 9–13-year-olds, the main sources of water were moisture in foods, plain water and *agua fresca* (fruit water). Among 14–18-year-olds, the main sources of water were plain water, moisture in foods and soda.

Overall, beverages contributed about 65·5 % of total daily water intakes in all children aged 1–18 years, among which plain water contributed 26·5 % of total daily water intake (Supplemental Table 2). Among beverages, plain water, *agua fresca*, caloric soda and plain high-fat milk provided the most daily water in all children. Although the proportion of water coming from all beverages and plain water was higher in older children, compared with younger children (1–4 years) the volume of water coming from caloric sweetened beverages such as soda and *agua fresca* was higher, whereas the proportion of water from milk and milk beverages was lower in older children and adolescents.

**Table 1** Demographic characteristics and consumption of water by sociodemographic group; children and adolescents aged 1–18 years (*n* 6867), Mexican National Health and Nutrition Survey, 2012

| | | | Total water consumption (ml/d) | | | | | | |
| | | | Water from foods and beverages | | Water from all beverages | | Plain water | | |
| | *n* | % | Mean | SE | Mean | SE | Mean | SE | % of consumers |
|---|---|---|---|---|---|---|---|---|---|
| Total population | 6867 | 100 | 1613·6 | 18·4 | 1057·1 | 14·7 | 427·1 | 9·6 | 72·7 |
| **Gender** | | | | | | | | | |
| Male | 3477 | 50·6 | 1703·6[a] | 28·8 | 1133·0[a] | 23·6 | 460·6[a] | 15·4 | 73·5[a] |
| Female | 3390 | 49·4 | 1521·6[b] | 20·9 | 979·5[b] | 16·3 | 392·8[b] | 11·7 | 72·0[a] |
| **Age group (years)** | | | | | | | | | |
| 1–3 | 1623 | 14·7 | 1283·0[a] | 31·2 | 743·2[a] | 23·0 | 227·0[a] | 9·5 | 68·7[a] |
| 4–8 | 2185 | 29·2 | 1426·8[b] | 25·7 | 922·1[b] | 21·5 | 350·2[b] | 13·2 | 72·9[a,b] |
| 9–13 | 1747 | 30·9 | 1658·4[c] | 28·3 | 1061·2[c] | 20·0 | 426·9[c] | 14·7 | 72·1[a,b] |
| 14–18 | 1312 | 25·2 | 1966·5[d] | 51·2 | 1390·3[d] | 41·0 | 632·2[d] | 28·0 | 75·6[b] |
| **Area** | | | | | | | | | |
| Urban | 4237 | 70·9 | 1605·0[a] | 21·2 | 1064·9[a] | 17·8 | 428·2[a] | 12·1 | 71·7[a] |
| Rural | 2630 | 29·1 | 1634·6[a] | 36·7 | 1038·1[a] | 25·9 | 424·2[a] | 15·2 | 75·2[b] |
| **Geographic area** | | | | | | | | | |
| North | 1593 | 19·0 | 1542·3[a] | 30·5 | 1034·2[a,b] | 23·9 | 415·4[a] | 17·5 | 70·4[a] |
| Central | 2521 | 31·5 | 1553·4[a,b] | 33·3 | 1009·9[a] | 24·3 | 422·7[a] | 16·6 | 73·4[a] |
| Mexico City and metropolitan area | 329 | 16·2 | 1730·9[a,b] | 66·1 | 1094·0[a,b] | 56·5 | 411·0[a] | 33·9 | 69·3[a] |
| South | 2424 | 33·3 | 1654·1[b] | 26·4 | 1096·8[b] | 21·9 | 445·7[a] | 14·7 | 75·2[a] |
| **Socio-economic level** | | | | | | | | | |
| Low | 2528 | 32·5 | 1574·4[a] | 29·4 | 1004·0[a] | 23·3 | 405·3[a] | 14·6 | 73·5[a] |
| Medium | 2447 | 34·1 | 1630·0[a] | 37·1 | 1074·8[a,b] | 28·6 | 434·0[a] | 16·8 | 72·3[a] |
| High | 1892 | 33·4 | 1635·0[a] | 30·0 | 1090·6[b] | 25·3 | 441·2[a] | 18·3 | 72·5[a] |
| **BMI category** | | | | | | | | | |
| Normal | 5163 | 72·5 | 1580·7[a] | 21·3 | 1022·7[a] | 16·9 | 407·9[a] | 10·3 | 73·0[a] |
| Overweight | 1094 | 17·7 | 1635·6[a] | 40·8 | 1091·5[a] | 32·9 | 418·7[a] | 19·0 | 70·6[a] |
| Obese | 610 | 9·8 | 1816·5[b] | 60·2 | 1248·6[b] | 52·3 | 583·3[b] | 45·5 | 74·4[a] |

Estimates were weighted to adjust for unequal probability of sampling.
[a,b,c,d]Statistical comparisons are made within each sociodemographic group. Mean estimates with unlike superscript letters were significantly different, Bonferroni-adjusted Student's *t* test (*P* < 0·05).

### Patterns of water intake from food and beverage sources by gender and age group

Analyses by gender were generally consistent with those performed by age with some differences between males and females (Fig. 1). Compared with females, males of any age had higher total daily water intakes, although these differences were significant only among 9–13-year-olds and 14–18-year-olds. Among 4–8-year-olds and 14–18-year-olds, intake of water from plain water was significantly higher in males compared with females. In addition, water intake from soda (caloric and low calorie) was significantly higher among 14–18-year-old males compared with females of the same age.

### Contribution of foods and beverages to total daily energy intake

The contribution of different beverages and all foods to total daily energy intake is shown in Table 3 (kJ) and Supplemental Tables 3 (kcal) and 4 (g or ml). The top three sources of energy from beverages in all children aged 1–18 years were flavoured milk beverages, soda and plain high-fat milk. Older children and adolescents had significantly lower energy intakes from plain high- and low-fat milk but higher energy intake from caloric soda.

### Actual water intakes in relation to recommended intakes

Patterns of total daily water intake were compared with the intakes recommended by the IOM for each age and gender group (Fig. 2). The shortfall in water consumption relative to the IOM recommendations was lower among younger children aged 1–3 years and 4–8 years compared with those aged 9–13 years and 14–18 years of both genders. A higher proportion of 1–3-year-olds and 4–8-year-olds met the recommended intake of water (38 % and 29 %, respectively). Among 9–13-year-olds and 14–18-year-olds, 13–19 % of children met the daily water recommendations.

Figure 3 illustrates the mean ratio of water to energy (litres/per 4184 kJ (1000 kcal)) by age and gender group. This ratio ranged between 0·82 and 0·98 litres/4184 kJ in the children studied. Younger children (1–3 years old) had 0·98 litres/4184 kJ, which was the highest ratio of water per 4184 kJ among all age groups.

### Discussion

Using nationally representative data on Mexican children and adolescents, we showed that, although plain water and moisture in foods still contribute the greatest proportion of

**Table 2** Volume of water (ml/d) from different beverage groups and water in foods consumed by age group; children and adolescents aged 1–18 years (*n* 6867), Mexican National Health and Nutrition Survey, 2012

| | Age 1–3 years | | | Age 4–8 years | | | Age 9–13 years | | | Age 14–18 years | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Per capita (ml/d) | | | Per capita (ml/d) | | | Per capita (ml/d) | | | Per capita (ml/d) | | |
| | Mean | SE | % of total | Mean | SE | % of total | Mean | SE | % of total | Mean | SE | % of total |
| Total daily water | 1283·0[a] | 31·2 | 100 | 1426·8[b] | 25·7 | 100 | 1658·4[c] | 28·3 | 100 | 1966·5[d] | 51·2 | 100 |
|   Water from foods | 539·8[a,b] | 22·6 | 42·1 | 504·8[a] | 11·6 | 35·4 | 597·2[b] | 16·5 | 36·0 | 576·2[b] | 22·5 | 29·3 |
|   Water from beverages† | 743·2[a] | 23·0 | 57·9 | 922·1[b] | 21·5 | 64·6 | 1061·2[c] | 20·0 | 64·0 | 1390·3[d] | 41·0 | 70·7 |
| Water | | | | | | | | | | | | |
|   Plain | 227·0[a] | 9·5 | 17·7 | 350·2[b] | 13·2 | 24·5 | 426·9[c] | 14·7 | 25·7 | 632·2[d] | 28·0 | 32·2 |
|   Flavoured/caloric | 7·3[a] | 2·3 | 0·6 | 19·4[a,b] | 4·2 | 1·4 | 15·1[a,b] | 2·5 | 0·9 | 24·9[b] | 5·6 | 1·3 |
|   *Agua fresca* (fruit water) | 55·7[a] | 6·0 | 4·3 | 125·5[b] | 10·1 | 8·8 | 142·9[b] | 11·6 | 8·6 | 120·3[b] | 14·4 | 6·1 |
| Coffee/tea | | | | | | | | | | | | |
|   Caloric | 27·4[a] | 2·6 | 2·1 | 39·1[b] | 3·3 | 2·7 | 59·2[c] | 4·8 | 3·6 | 74·4[c] | 6·4 | 3·8 |
|   Plain/low calorie | 40·4[a] | 17·5 | 3·1 | 35·1[a] | 4·0 | 2·5 | 44·0[a] | 5·3 | 2·7 | 38·5[a] | 4·3 | 2·0 |
| Soda | | | | | | | | | | | | |
|   Caloric | 28·9[a] | 2·0 | 2·3 | 62·7[b] | 4·0 | 4·4 | 115·6[c] | 6·2 | 7·0 | 216·4[d] | 11·9 | 11·0 |
|   Low calorie | 7·2[a] | 1·1 | 0·6 | 24·2[a,b] | 7·8 | 1·7 | 26·9[b] | 7·0 | 1·6 | 37·5[b] | 6·5 | 1·9 |
| Fruit & vegetable juice | | | | | | | | | | | | |
|   100 % natural juice | 7·6[a] | 1·9 | 0·6 | 6·6[a] | 1·1 | 0·5 | 7·1[a] | 1·6 | 0·4 | 16·5[a] | 5·9 | 0·8 |
|   Fruit/vegetable drinks | 49·5[a] | 4·5 | 3·9 | 51·1[a] | 3·8 | 3·6 | 37·4[a] | 3·7 | 2·3 | 54·8[a] | 9·2 | 2·8 |
| Milk & milk beverages | | | | | | | | | | | | |
|   Plain, high fat | 145·8[a] | 8·1 | 11·4 | 79·1[b] | 5·5 | 5·5 | 66·2[b] | 5·0 | 4·0 | 46·8[c] | 4·8 | 2·4 |
|   Plain, low fat | 13·4[a] | 3·8 | 1·0 | 8·5[a] | 1·9 | 0·6 | 3·6[a,b] | 1·1 | 0·2 | 2·2[b] | 0·8 | 0·1 |
|   Milk beverages, flavoured | 81·3[a] | 9·6 | 6·3 | 70·3[a] | 4·7 | 4·9 | 69·8[a,b] | 8·1 | 4·2 | 50·3[b] | 5·1 | 2·6 |
|   Milk with cereal | 16·5[a] | 2·0 | 1·3 | 24·1[a] | 2·4 | 1·7 | 17·5[a] | 2·2 | 1·1 | 20·8[a] | 2·8 | 1·1 |
| *Atole* | | | | | | | | | | | | |
|   Milk base | 19·2[a] | 5·4 | 1·5 | 7·9[a] | 1·2 | 0·6 | 11·7[a] | 1·7 | 0·7 | 6·6[a] | 1·3 | 0·3 |
|   Water base | 8·4[a] | 1·6 | 0·7 | 10·9[a] | 1·7 | 0·8 | 11·9[a] | 2·3 | 0·7 | 8·3[a] | 2·2 | 0·4 |
| Sports & energy drinks | 1·6[a] | 0·8 | 0·1 | 3·4[a] | 1·5 | 0·2 | 2·5[a] | 1·3 | 0·1 | 4·0[a] | 2·2 | 0·2 |
| Alcoholic beverages | – | – | – | – | – | – | 0·7[a] | 0·7 | 0·0 | 30·0[b] | 9·7 | 1·5 |
| Other beverages | 6·1[a] | 1·3 | 0·5 | 4·1[a,b] | 0·6 | 0·3 | 2·1[b] | 0·6 | 0·1 | 5·8[a,b] | 2·3 | 0·3 |

†Includes plain water.
[a,b,c,d]Statistical comparisons are made between age groups. Mean estimates within a row with unlike superscript letters were significantly different, Bonferroni-adjusted Student's *t* test (*P* < 0·05).

total daily water, caloric sweetened beverages such as soda and *agua fresca* are currently major sources of water especially among older children and adolescents. Plain water was the main source of total daily water in all age groups. Intakes of total daily water, water from beverages and plain water were higher among older compared with younger children and among males compared with females. Younger children aged 1–3 years obtained more water from milk and milk beverages, whereas 4–8- and 9–13-year-olds had a higher proportion of water from *agua fresca* and 14–18-year-olds had a higher proportion of water from caloric soda. There was a significantly higher volume of water coming from soda in 14–18-year-olds males compared with females. A recent study in American children aged 4–8 years and 9–13 years using the US National Health and Nutrition Examination Surveys 2005–2010 showed that approximately 72 % of children reported any amount of plain water (bottled or tap)[22]. The main sources of water in US children were plain water, milk and fruit drinks among 4–8-year-olds; and plain water, milk and soda among 9–13-year-olds. As in Mexican children, total daily water intake in US children was at below-recommended levels. Other Mexican studies focusing on beverage consumption patterns in children aged 1–4 and 5–11 years and adolescents aged 12–18 years showed large increases in caloric beverages from 1999 to 2006. The major

beverage contributors to total energy intake in 2006 among Mexican children and adolescents were high-fat milk, fruit juice (with water/sugars added, including *agua fresca*) and carbonated and non-carbonated sweetened soda[5,6]. Consistent with our results, these previous studies found that younger children had a higher proportion of energy from milk whereas older children and adolescents moved towards more caloric sweetened beverages.

In relation to the IOM DRI, total daily water intakes in all age groups remained below AI levels and most children included in our study (≥81 %) failed to meet the IOM DRI for total daily water. Children aged 1–3 years had the smallest shortfall in total water and the greatest proportion that met the DRI for total water (38 %). On the other hand, although 14–18-year-old adolescents obtained a higher proportion of water from plain water than other age groups, their shortfall in total daily water was the highest because the AI for water increases with age[12]. Another criterion of adequate hydration is the volume of water per 4184 kJ (1000 kcal), with desirable values ranging from 1 to 1·5 litres. Only 1–3-year-old children approximated the desirable water:energy ratio with 0·98 litres/4184 kJ. Children aged 4–8 years and 9–13 years of both genders had the lowest water:energy ratios. Similarly, in the US study only 25 % of 4–8-year-olds, 15 % of 9–13-year-old males and 17 % of 9–13-year-old females met the IOM
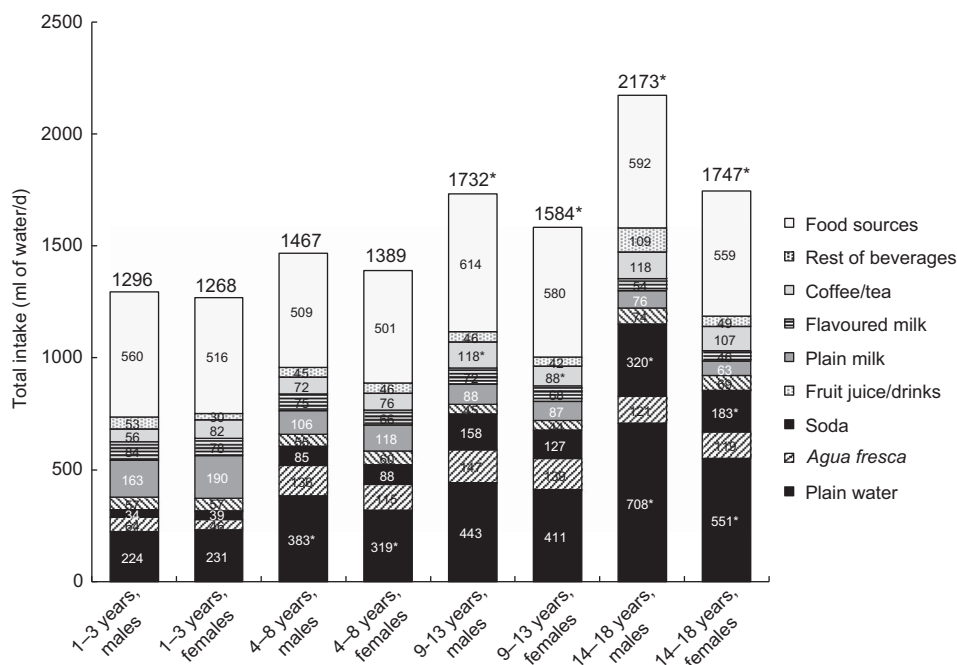
**Fig. 1** Total daily water intake from all sources by age group and gender; children and adolescents aged 1–18 years (*n* 6867), Mexican National Health and Nutrition Survey, 2012. 'Rest of beverages' are flavoured water, milk-/water-based *atole*, sports & energy drinks, alcoholic beverages, meal replacements, chocolate water and Yakult; 'coffee/tea' includes caloric and plain/low-calorie coffee/tea; 'plain milk' includes high-fat and low-fat milk and milk added to cereal; 'soda' includes regular and diet soda. Comparisons are made between males and females for each age and beverage group; * indicates a significant difference between males and females, Bonferroni-adjusted Student's *t* test, *P* < 0.05

**Table 3** Contribution of foods and beverages to total energy intake (kJ/d) consumed by age group; children and adolescents aged 1–18 years (*n* 6867), Mexican National Health and Nutrition Survey (NHNS), 2012

| | Age 1–3 years | | | Age 4–8 years | | | Age 9–13 years | | | Age 14–18 years | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Per capita (kJ/d) | | | Per capita (kJ/d) | | | Per capita (kJ/d) | | | Per capita (kJ/d) | | |
| | Mean | SE | % of total | Mean | SE | % of total | Mean | SE | % of total | Mean | SE | % of total |
| Total daily energy (kJ) | 5464.3[a] | 98.2 | 100 | 7086.4[b] | 96.9 | 100 | 8356.0[c] | 129.9 | 100 | 9069.8[d] | 195.6 | 100 |
|   Energy from foods | 4075.3[a] | 92.1 | 74.6 | 5681.8[b] | 86.0 | 80.2 | 6890.3[c] | 121.8 | 82.5 | 7330.8[c] | 170.9 | 80.8 |
|   Energy from beverages | 1389.0[a] | 52.7 | 25.4 | 1404.6[a] | 34.3 | 19.8 | 1465.7[a] | 37.9 | 17.5 | 1739.0[b] | 62.9 | 19.2 |
| Water | | | | | | | | | | | | |
|   Plain | – | – | – | – | – | – | – | – | – | – | – | – |
|   Flavoured/caloric | 8.7[a] | 2.6 | 0.2 | 23.5[b] | 4.8 | 0.3 | 19.7[a,b] | 3.8 | 0.2 | 29.8[b] | 6.8 | 0.3 |
| *Agua fresca* (fruit water) | 109.1[a] | 22.3 | 2.0 | 191.4[b] | 19.7 | 2.7 | 194.4[b] | 16.0 | 2.3 | 188.5[a,b] | 26.4 | 2.1 |
| Coffee/tea | | | | | | | | | | | | |
|   Caloric | 128.2[a,b] | 21.4 | 2.3 | 131.3[a] | 13.9 | 1.9 | 151.7[a,b] | 14.1 | 1.8 | 197.4[b] | 20.5 | 2.2 |
|   Plain/low calorie | 9.3[a] | 1.5 | 0.2 | 15.3[a,b] | 2.1 | 0.2 | 16.7[b] | 2.1 | 0.2 | 16.0[b] | 1.9 | 0.2 |
| Soda | | | | | | | | | | | | |
|   Caloric | 58.9[a] | 4.1 | 1.1 | 126.9[b] | 8.1 | 1.8 | 235.6[c] | 12.6 | 2.8 | 443.9[d] | 24.5 | 4.9 |
|   Low calorie | 1.2[a] | 0.4 | 0.0 | 3.9[a] | 1.6 | 0.1 | 3.2[a] | 1.2 | 0.0 | 3.5[a] | 2.3 | 0.0 |
| Fruit & vegetable juice | | | | | | | | | | | | |
|   100 % natural juice | 13.7[a] | 3.2 | 0.3 | 12.7[a] | 2.2 | 0.2 | 15.5[a] | 3.6 | 0.2 | 34.4[a] | 12.6 | 0.4 |
|   Fruit/vegetable drinks | 105.3[a] | 9.0 | 1.9 | 108.4[a] | 7.9 | 1.5 | 81.5[a] | 7.6 | 1.0 | 117.6[a] | 18.2 | 1.3 |
| Milk & milk beverages | | | | | | | | | | | | |
|   Plain, high fat | 399.5[a] | 22.7 | 7.3 | 217.9[b] | 15.5 | 3.1 | 186.3[b] | 14.3 | 2.2 | 127.6[c] | 13.2 | 1.4 |
|   Plain, low fat | 25.0[a] | 7.6 | 0.5 | 19.1[a] | 4.5 | 0.3 | 7.3[a,b] | 2.0 | 0.1 | 4.4[b] | 1.5 | 0.0 |
|   Milk beverages, flavoured | 311.7[a] | 33.8 | 5.7 | 286.4[a] | 17.9 | 4.0 | 290.2[a] | 26.7 | 3.5 | 233.5[a] | 27.7 | 2.6 |
|   Milk with cereal | 98.1[a] | 12.6 | 1.8 | 159.9[b] | 16.1 | 2.3 | 130.9[a,b] | 19.9 | 1.6 | 145.9[a,b] | 21.5 | 1.6 |
| *Atole* | | | | | | | | | | | | |
|   Milk base | 70.9[a,b] | 14.0 | 1.3 | 58.2[a,b] | 9.3 | 0.8 | 83.9[b] | 12.6 | 1.0 | 40.3[a] | 8.0 | 0.4 |
|   Water base | 25.1[a] | 5.7 | 0.5 | 32.6[a] | 6.2 | 0.5 | 39.3[a] | 7.3 | 0.5 | 41.3[a] | 14.7 | 0.5 |
| Sports & energy drinks | 1.6[a] | 0.9 | 0.0 | 3.8[a] | 1.7 | 0.1 | 2.8[a] | 1.4 | 0.0 | 4.8[a] | 2.4 | 0.1 |
| Alcoholic beverages | – | – | – | 0.0[a] | 0.0 | 0.0 | 0.9[a] | 0.9 | 0.0 | 72.7[b] | 21.1 | 0.8 |
| Other beverages | 22.6[a] | 5.0 | 0.4 | 13.2[a] | 2.0 | 0.2 | 5.9[b] | 1.6 | 0.1 | 37.6[a,b] | 17.9 | 0.4 |

[a,b,c,d]Statistical comparisons are made between age groups. Mean estimates within a row with unlike superscript letters were significantly different, Bonferroni-adjusted Student's *t* test (*P* < 0.05).
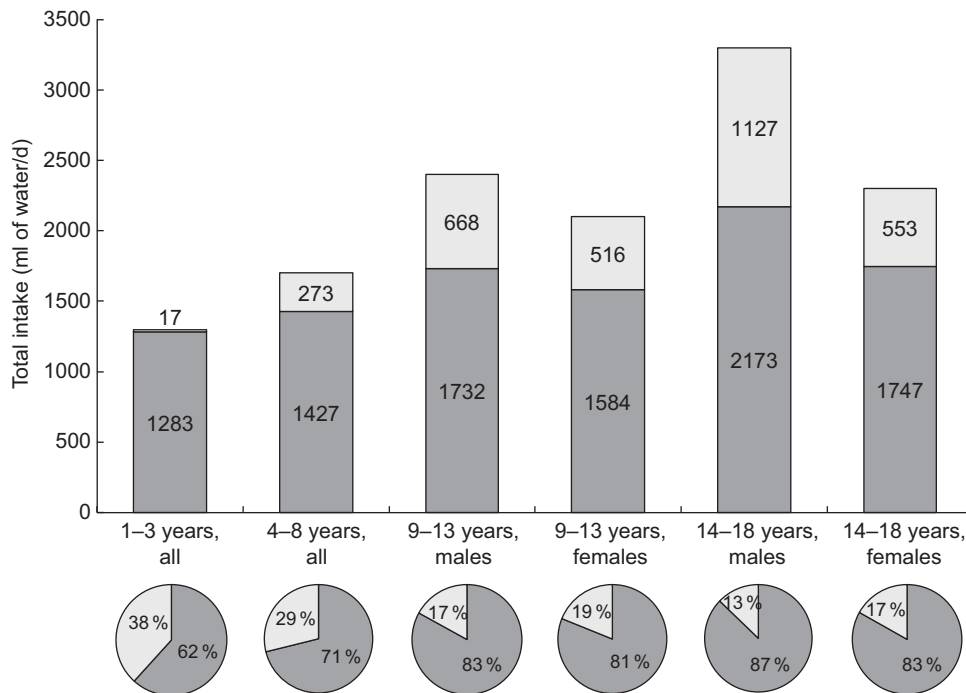
**Fig. 2** Total daily water intake from all sources (▨, consumed) by age group and gender in relation to the US Institute of Medicine recommendations (☐, shortfall); children and adolescents aged 1–18 years (*n* 6867), Mexican National Health and Nutrition Survey, 2012. The proportion of children who do (☐) or do not meet (▨) Institute of Medicine Dietary Reference Intakes is shown in the corresponding pie chart
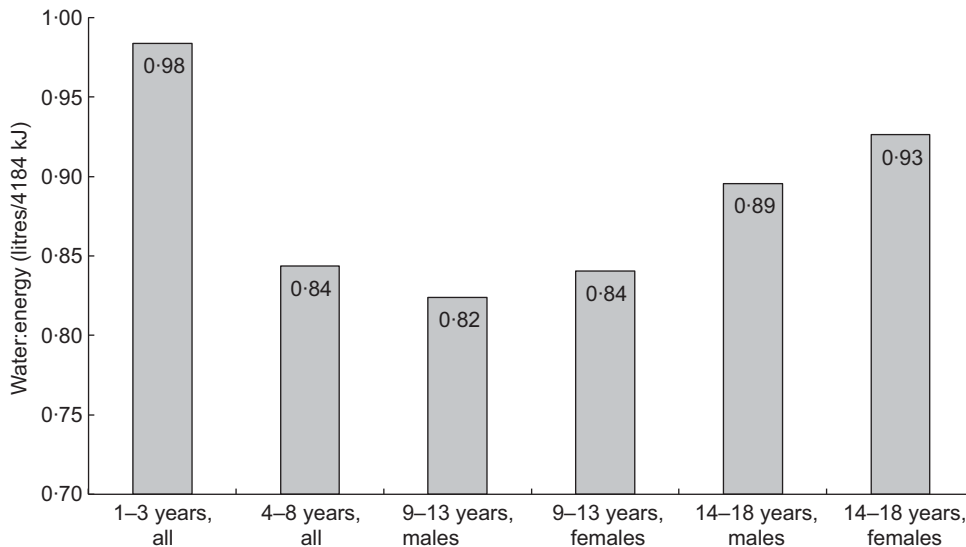


**Fig. 3** Mean ratio of water to energy (litres/4184 kJ (1000 kcal)) by age and gender; children and adolescents aged 1–18 years (*n* 6867), Mexican National Health and Nutrition Survey, 2012

recommendations for total daily water[22]. The ratio of water to energy was 0.85–0.95 litres/4184 kJ in these age groups. As was pointed out by Drewnowski *et al.*[22], our results should also be interpreted cautiously. Although the mean of one 24 h recall should give a reasonable estimate of the mean intake at the population level[14,21], the proportion of children below the IOM DRI might be overestimated due to under-reporting of water intake.

Adequate hydration and healthy beverage habits in Mexican children and adolescents should be encouraged in light of these results. In 2008, an expert committee developed the Beverage Consumption Recommendations for the Mexican Population, taking into account important factors such as the health benefits, risks and nutritional implications of beverage consumption[4]. These guidelines were intended to inform consumers, health professionals and government officials of

the importance of healthy beverage habits in the context of the high rates of overweight and obesity in Mexico[18,23,24]. Overweight and obesity has been increasing since 1999 among Mexican children and adolescents[25]. Our study showed that in 2012 the prevalence of overweight and obesity was 27·5 %, suggesting that lifestyle modifications that occur as children age might impact their weight status. Approximately, beverages accounted for from one-fifth to one-quarter of the total daily energy intake among the children in the present study. The top five beverage contributors to energy intake in our population of Mexican children and adolescents were flavoured milk beverages, caloric sweetened soda, high-fat milk, *agua fresca* (fruit water) and caloric coffee/tea. Importantly, older children and adolescents had a higher consumption of beverages with high energy but low nutritional value (i.e. caloric sweetened soda), whereas younger children had a higher proportion of caloric beverages with higher nutritional and energy value (i.e. high-fat milk). Beverage displacement changes towards more sweetened beverages have been previously documented in children in relation to weight management[26,27]. Overall, consumption of caloric sweetened beverages has been extensively linked with obesity and poor heath outcomes independently of energy intake, given their effect on satiety and insulin metabolism[28–30]. Given the nutritional and health implications associated with these beverages, the Beverage Consumption Recommendations for the Mexican Population encouraged the consumption of plain water as a first choice (750–2000 ml/d), followed by no/low calorie beverages with no sugar added and skimmed milk. The committee did not recommend any daily consumption of caloric sweetened beverages (including caloric soda, *agua fresca*, juice drinks and sweetened coffee/tea), but rather an occasional consumption and small servings of these beverages[4].

There are limitations to note regarding the present study. First, the NHNS 2012 is a cross-sectional observational data set and our analysis used self-reported intake data over a 24 h period. Self-reported intake might be affected by recall bias and also by reporting errors from the proxy recall in younger children (i.e. water and other beverages drank outside home might be missed). Even though total energy intake might be under-reported, our estimates seem to be in line with those found for similar age groups of children and adolescents in the USA[31]. However, recall of water intake might be even more problematic, especially in cases when the respondent drinks water unconsciously (i.e. drinking from a water fountain in the street or drinking from a glass that is constantly refilled at a restaurant). Given that for children and adolescents the ratio of within- to between-subject variability is larger[32,33], one day of dietary recall is not representative of the usual intake, so the percentage of children who fail to meet the DRI might be over-estimated[14,21]. Also, when comparing actual water intakes with AI at the individual level, there is a lot of variation depending of physical activity levels, health status and environment that needs to be taken into account[34,35]. Seasonal variations could also affect our results because the Mexican NHNS 2012 collected data from October through May. However, although water and liquid consumption is presumably higher over the summer months, children might not meet their daily needs because the requirements also increase in high-temperature environments. Still, we expect that the NHNS captures some of the seasonal variation by including data from different geographical regions – with a wide range of temperatures – across the country. DRI for total water are set up to help achieve an adequate hydration status but there is a much inter-individual variation to consider[2]. Our analysis did not consider these additional factors and just showed a crude estimate of actual total daily water intake and the difference with the recommended intake for the general population of children and adolescents. The main strength of this analysis is that we provided current unreported nationally representative data on water and beverage intake patterns among children and adolescents in Mexico.

The present study contributes valuable information for public policies and intervention efforts that aim to improve the hydration status and beverage habits of Mexican children. Our results come at the time when the government has instituted a 10% tax in January 2014 on all beverages with added sugar as a way to reduce overweight and obesity and to encourage water consumption. Water intakes should be increased among children of all ages, especially among older children and adolescents who have more elevated requirements than younger children[12]. Although most children drink plain water on a daily basis, caloric sweetened beverages such as soda and *agua fresca* are currently major sources of total daily water especially among older children and adolescents. Public health efforts in Mexico should start by educating children on healthier beverage options for adequate hydration, and also by increasing awareness about food sources with higher water contents such as fruits and vegetables.

## Conclusion

Our study is one of the first to carefully explore current water consumption patterns among Mexican children and adolescents. Plain water still contributes the greatest proportion to daily water intake from beverages. However, caloric beverages are currently major sources of water especially among older children and adolescents. Although total daily water intakes remain below DRI levels in all age groups, the study identifies key age and gender groups that will benefit from targeted interventions that aim to improve the nutritional and hydration status of children and adolescents in Mexico.

## Acknowledgements

## Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S1368980014000998

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