Is the default of 2 liters for daily per-capita water consumption appropriate? A nationwide survey reveals water intake in Japan

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Short title: Is default of 2 L/d for per-capita water intake appropriate? Nationwide survey

ABSTRACT

Two liters per day is generally applied as the default drinking-water intake rate for risk assessments, although evidence supporting this value is insufficient. This study aimed to reveal actual water intakes from tap water and other types of drinks, and to explore the relationships between these intakes. For this purpose, we conducted a nationwide Internet questionnaire survey. Tap water intake negatively correlated with bottled water and soft drink intakes, suggesting a mutually complementary relationship. We propose an index, potential Tap Water Intake (pTWI), calculated by adding soft drinks and bottled water to tap water intake. Mean per-capita tap water intake across the entire Japanese population was estimated at 1.28 L/d, whereas mean pTWI was estimated at 1.65 L/d. Two liters per day corresponds to the 88th percentile of tap water intake and to the 76th percentile of pTWI, and covers the intake of the majority of population in Japan. This rate should continue being used for the default in the Japanese population, but the rate to cover the tap water intake of almost the entire population would be higher: it was > 2.5 L/d.

KEYWORDS: drinking water, community water, direct and indirect intake, exposure assessment

INTRODUCTION

Daily intake rates of water, drinking water, and tap water are basic factors used to assess the health risks of water contaminants and to develop regulations, policies, and guidelines. A value of 2 L/d is generally applied as the default rate of daily drinking water intake for adults for exposure assessments conducted by many countries and international organizations. In the current edition of the WHO (World Health Organization) Guidelines for Drinking-water Quality (WHO 2011), the 2 L/d rate is applied as a default assumption for an adult. WHO regards this value as an assumption because the volume of water consumed daily varies (WHO 2011), but does not explicitly provide background information for this assumption.

Regarding the volume of daily total water intake, which includes intrinsic water that is naturally contained in foods, detailed statistics can be found in many reports. Total water intake varies per country depending on dietary habit, lifestyles, and environmental conditions (Athanasatou et al. 2016). For example, the mean total water intake (L/d) for adults is 1.6 (women) and 1.7 (men) in Spain (2007 adults, 2013) (Nissensohn et al. 2016), 2.23 in 4 prefectures of Japan (242 adults, 2003-2004) (Tani et al. 2015), 2.3 (women) and 2.6 (men) in Australia (6232 adults, 2011-2012) (Sui et al. 2016), 2.1 (women) and 2.5 (men) in Germany (1528 adults, 1986-1988) (Manz et al. 2012), and 2.8–2.9 (women) and 3.5–3.8 (men) in the United States (15,702 adults, 2005-2012) (Drewnowski et al. 2013; Rosinger and Herrick 2016). The median total water intake is 1.49 L/d in 4 cities of China (747 adults) (Ma et al. 2012). Ferreira-Pego et al. (2015) collected original and published data for 13 countries, and reported that the median total fluid intakes for the total population (16,276) was 1.98, the highest was 2.47 at Germany and the lowest was 1.50 at Japan. Data for total drink intake, which does not include alcohol, intrinsic water, or water added in the preparation of food, is also found in some reports. The contribution of food moisture to total water intake is reported to be around 30–40% (Guelinckx et al. 2016; Lee et al. 2016; Szabo de Edelenyi et al. 2016). These statistics serve as fundamental data when assessing hydration and dietary status of populations (Malisova et al. 2016; Mora-Rodriguez et al. 2016).

Compared with information for total water intake, however, daily intake of tap water supplied through pipes by the public water system has not been reported for many countries. Those values of tap water intake as a beverage (i.e., plain tap water intake) that have been reported tend to be small, at 0.2 to 0.4 L/d in some European countries (Gibson et al. 2013; O'Connor et al. 2014; Ferreira-Pego et al. 2016) and around 0.6 L/d in the United States (Sebastian et al. 2011). This information may be valuable, but data for the direct plus indirect water intake are required for exposure assessment of contaminants in tap water. This is because exposure of contaminants in tap water comes from not only intake of tap water as a beverage (direct intake) but also from tap water indirectly ingested from prepared food and

beverages (indirect intake). However, estimations of direct and indirect supplied water intake have only been made in a few countries, described below.

In reports by Kahn and Stralka (2009) and the U.S. Environmental Protection Agency (USEPA) (2004), the estimated per-capita water ingestion in the United States was calculated by using combined data from four survey results from the Continuing Survey of Food Intakes by Individuals. For adults, the estimated direct and indirect daily per-capita intake of "community water"—tap water from a public water supply—is 1.10 L/d. The mean estimated direct plus indirect daily per-capita intake of "total water," which consists of water from all supply sources such as public water supply, bottle, other, and missing sources, is 1.47 L/d (Kahn and Stralka 2009). According to recent estimates (USEPA 2011) based on 2003–2006 data from the U.S. National Health and Nutrition Examination Survey, the mean ingestion rate for combined direct and indirect water from "community water" for adults is estimated at 1.04 L/d, while the rate for "total water" is 1.70 L/d. It was also reported that the percentage of the U.S. population ingesting 3 L/d or less was approximately 95% for "community water" and 90% for "total water."

In Japan, no nationwide survey has been conducted in which tap water and commercial beverages intakes are separately counted, and direct and indirect water intakes are separately counted. Recently, the marketing of not only carbonated beverages (e.g., sodas) but other types of drinks such as isotonic drinks, coffee, and tea (especially unsweetened bottled green tea and black tea) has been prevalent (Japan Soft Drink Association 2016). The intake of these commercial beverages can vary depending on personal drinking habits and scenarios (e.g., home, work-sites, and restaurants). Some people may be ingesting these commercial drinks as substitutes for drinking water, possibly reducing the national mean of daily tap water intake. Although these drinks may be complementary to tap water for some people, a mutually complementary relationship between their consumption and tap water has yet to be clearly revealed in statistical data. Moreover, if their consumption reduces the national mean of daily tap water intake, the risk of water contaminants based on the national mean would be underestimated for non-consumers of commercial drinks due to their tap water intake being relatively higher than that of consumers. Conversely, using the larger intake of those consuming primarily tap water may overestimate the risk for the population. However, statistical analysis exploring this possibility has not been conducted as yet.

Here, we conducted a nationwide Internet questionnaire survey of direct and indirect tap water intake and water intake via other types of drinks including soft drinks, alcoholic drinks, and milk in Japan. Correlation analyses revealed a mutual complementary relationship between tap water and these other intakes for hydration. Finally, we propose an index of potential Tap Water Intake (pTWI), applicable to the assessment of health risks of contaminants in drinking water.

METHODS

Development of the questionnaire

The survey questionnaire presented several sets of questions about water intake, characteristics of the respondent, and other details. The questions related to water intake are shown in Figure S1 of the Supplementary Material. For easier comprehension by respondents, questions regarding intake were grouped into: a) tap water including drinks and ice cubes made with tap water (Codes W01–06 in Figure S1), b) commercial drinks including water and tea served free-of-charge in restaurants and presumably produced with tap water (W07–14), c) steamed rice and soup made at home (W15,16), and d) steamed rice and soup eaten outside the home or purchased in the market place (W17,18). W11 includes water added to non-alcoholic commercial beverages, such as tea and coffee, by manufacturers. Intrinsic and added water in commercial fruit and vegetable juices are also included in W11. W13 is alcoholic drinks. In the questionnaire sheet, intake of food other than rice and soup was not described because rice and soup are the two major sources of indirect tap water intake in Japan (MHLW [Ministry of Health, Labour and Welfare, Japan] 2016) and the inclusion of other food would make the questionnaire complicated, discouraging the respondents from answering honestly.

The questionnaire sheet mostly used the unit "mL" as a measure of water volume because the unit is familiar in daily life, but it was also supplemented with illustrations and the volume of typical vessels such as a cup for respondents to make it convenient to quantify the intake amount. Respondents were asked to print out the questionnaire sheet after downloading it. They selected two work days and one non-work day in the survey periods, which were January and February for the winter survey and August and September for the summer survey. They were asked to keep records of intake according to the questions, rather than to fill in the sheet after recalling their intake during the previous period (selected days) to avoid forgetting their intake (Bardosono et al. 2015). After recording and completing the questionnaire sheet, respondents entered the answers on the questionnaire website.

Participant recruitment and Internet survey

In accordance with the above-mentioned questionnaire and survey plan, Internet surveys were conducted twice, in the winter and in the summer of 2012, by the consumer monitoring company Nikkei Research Inc. (Tokyo, Japan). This company had 171,735 persons registered nationwide as of January 13, 2012. As one of the daughter companies of Nikkei Inc., which publishes a financial newspaper with nationwide circulation of about 3 million, this company was considered to be trustworthy. The Internet diffusion

rate at 2012 was high: it was 79.5%, but it could not guarantee that those reachable for internet surveys were completely the same as the population as a whole. However, we tried to minimize sample bias in the recruitment process. We first divided the registered persons by four regions (Northeast, East, Middle, and West, Figure S2), two genders, and three age brackets (20 to 39, 40 to 59, and 60 to 79 years). In short, we divided the registered persons into 24 (= 4 × 2 × 3) groups. From the company's registration list, we tried to recruit 50 respondents for each group (a total of 1200 people). Other characteristics such as occupation and annual income were not considered in the recruitment because of the difficulty, although they may indirectly affect water intake rate. Respondents were recruited through invitation emails. We allowed up to four members in the same household to participate in this survey. Respondents received an honorarium payment for their participation. Ethical review for the study was waived by the Hokkaido University Ethical Review Committee.

Tally method of questionnaire results

The items (questions) in the questionnaire (Figure S1) were categorized in terms of food/beverage type and water source into the following eight categories (Figure S3). The codes W01–07 were tabulated as category C1 "Tap Water Drink." This consisted of plain drinking water from the tap and beverages such as tea and ice cubes made with tap water. The water source of the tap water was almost always the public supply system (coverage of the public water supply system is 97.9% as of 2015, MHLW 2017). The category C2 "Bottled Water" consisted of W08–10 and included not only plain bottled water but also tea, coffee, ice, and other beverages made with bottled water, and water from household water dispensers; C3 "Water-in-rice" was the tap water absorbed during the cooking of rice (W15 and W17); and C4 "Soup" was the water in soup, including broth used for noodles (W16 and W18). For these categories, participants were asked to record only the ingested amounts. Codes W11–W14 were assigned to the following category designations: C5 "Soft Drink" (W11), C6 "Milk" (W12), C7 "Alcohol" (W13), and C8 "Miscellaneous" (Misc.; W14).

We used several combined categories to represent water characteristics (Figure 1). The category designated as "Tap+bottled Drink Intake" was the sum of C1 and 2; "Tap Water Intake" was the sum of categories C1, 3, and 4; "Tap+bottled Water Intake" consisted of C1–4 and was equivalent to the sum of Tap Water Intake and Bottled Water Intake. The summation of the categories from C1–5 was called "pTWI" (potential tap water intake). Category "All-water Intake" was defined as the summation of all the categories (C1–8).

Water intake in each category was summed in the unit of mL/d with the following assumptions. One ice cube had a volume of 15 mL according to the questionnaire sheet; the proportion of tap water absorbed during cooking rice was estimated at 52.7%, based on figures for moisture in dry rice and normally steamed rice of 15.5% and 60.0%, respectively (MEXT [Ministry of Education, Culture, Sports, Science

and Technology, Japan] 2010), using algorithms from USEPA (2004). Therefore, one kilogram of steamed rice intake was converted to an indirect tap water intake of 527 mL.

Statistical analysis

All statistical analyses were performed with the original water intake data without the adjustment for demographic strata described above. Mann-Whitney *U*-tests and Kendall rank correlation tests were selected as nonparametric analyses. This was because the data included respondents with zero-volume intake, and the intake volumes were not normally distributed. The software R (R Development Core Team 2016) was used for all statistical analyses. P-value range of less than 0.05 was classed as statistically significant.

Adjustment for demographic strata

Water intakes representing the whole population of the country were estimated as follows. The adult population (in units of a thousand; Statistics Bureau, Japan 2011) for each of the 24 population groups (Table S1) was divided by the number of the respondents recruited from the population group (Table S2). The quotients of the division were rounded to integer values. Water intake data of each respondent was replicated by factoring in the rounded figure of the corresponding population group to construct a new larger dataset (Table S3). This new adjusted dataset took into account the actual demographic structure in Japan. Percentiles and mean of estimated water intakes were calculated using this adjusted dataset.

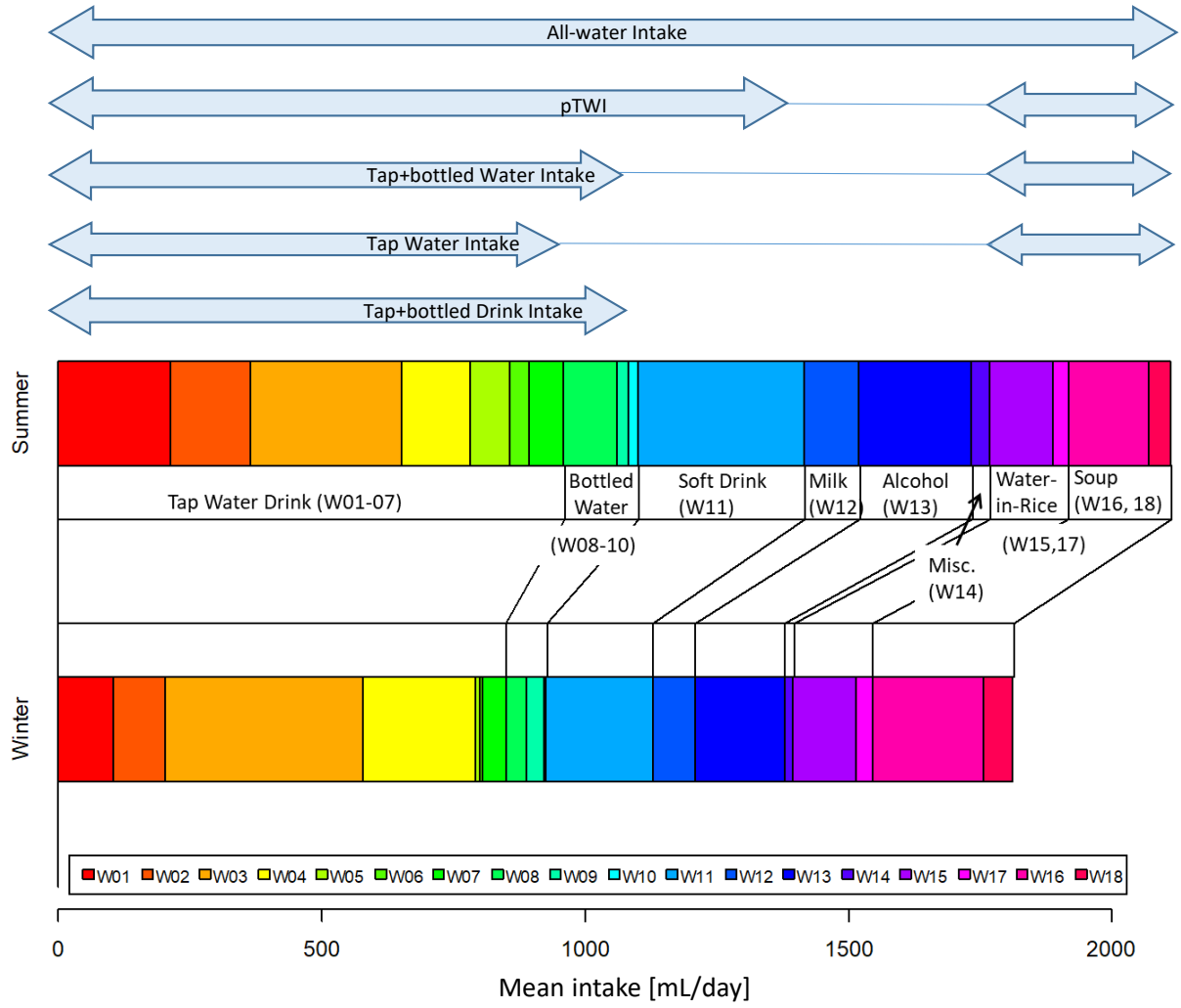

Figure 1. Mean values of water intakes and the relationships between water codes (W01–18), water categories, and combined categories. For details of the water codes and categories see Figure S1 and S3, respectively, in Supplementary Material.

Table 1. Results from the questionnaire: mean water intake and number of respondents who answered zero intake during the 3-day survey for each category.

Category		Water code in the questionnaire	Mean water intake [mL/day]		Number of subjects with zero intake			
					Winter		Summer	
No.	Designation		Winter	Summer	(*n* = 1188)	(%)	(*n* = 1278)	(%)
C1	Tap Water Drink	W01–07	850	961	27	2.3	27	2.1
	Cold tap water	W01, 02, 07	247	431				
	Hot tap water	W03, 04	590	416				
	Ice cubes	W05, 06	12	113				
C2	Bottled Water	W08–10	77	141	870	73.2	798	62.4
C3	Water-in-rice	W15, 17	150	148	22	1.9	19	1.5
C4	Soup	W16, 18	267	195	48	4.0	144	11.3
C5	Soft Drink	W11	201	316	317	26.7	259	20.3
C6	Milk	W12	82	103	546	46.0	500	39.1
C7	Alcohol	W13	169	215	633	53.3	623	48.7
C8	Misc.	W14	17	34	1033	87.0	1053	82.4

RESULTS

Internet surveys

Respondents were recruited from near evenly distributed geographical regions, ages, and gender. The number of respondents in the winter and the summer surveys were 1190 and 1278, respectively. We checked all the data to see whether the entered values fall extremely far outside the bounds of common sense or not. The data of two respondents in the winter survey was omitted. The data of 1188 and 1278 respondents in the winter and the summer surveys, respectively, were provided for statistical analyses (Table S2). Because the surveys were conducted during two work days and one non-work day, weekly-weighted average intakes were calculated for each respondent: the two work day intakes were each multiplied by 2.5 and the non-work day intake was multiplied by 2, before dividing the total by 7. The weekly-weighted average intakes are shown in Table 1 and Figure 1; details are shown in Tables S4, S5, and S6. For simplicity, weekly-weighted average intakes are referred to as "uptakes" below.

Mean per-capita intakes of Tap Water Drink intakes for all the respondents were 850 and 961 mL/d in winter and summer, respectively; the intake in summer was approximately 13% higher than that in winter. Mean per-capita intakes of Tap+bottled Drink (Tap Water Drink plus Bottled Water) Intakes were 928 and 1,102 mL/d in winter and summer, respectively; those of Tap Water Intake were 1,266 and 1,304 mL/d for winter and summer, respectively; and those of pTWI were 1,545 and 1,761 mL/d for winter and summer, respectively.

When assessing cold and hot water separately, the cold-water intake in summer (431 mL/d) was approximately 75% higher than that in winter (247 mL/d). Consumption of bottled water and soft drinks were 83% and 57% higher in summer than in winter, respectively. Consumption of water-in-rice (tap water in the form of steamed rice) was almost equal between winter and summer. There were a few respondents (~2%) who did not drink water supplied from the public water system (Tap Water Drink) (Table 1). The percentages of respondents who did not drink bottled water were 73% and 62% during winter and summer, respectively.

The median value of Tap Water Drink intakes for the respondents who did not consume any bottled water or soft drinks (tap water-only consumer) were 986 and 1,071 mL/d in winter (n = 253, 21%) and summer (n = 185, 14.5%), respectively (Figure 2). In contrast, the median values of Tap Water Drink intakes for those who drank Bottled Water and/or Soft Drink as well as Tap Water Drink (bottled-water/soft-drink consumers) was 739 and 838 mL/d in winter (n = 935) and summer (n = 1,093), respectively. The differences between the tap water-only and the bottled-water/soft-drink consumers

were statistically significant ($p < 0.001$, Mann-Whitney *U*-test); significant differences were also observed when tests were conducted separately for males and females.

Correlation analysis

Kendall's tau rank correlation tests were performed to examine whether Tap Water Drink intake is associated with intakes of Bottled Water, Soft Drink, Milk, Alcohol, or Misc., and to assess whether the intake of Tap+bottled Drink is associated with intakes of Soft Drink, Milk, Alcohol, or Misc. The correlation coefficients are shown in Table 2 and Figure S4. We also conducted correlation analyses among all categories; the results are shown in Figures S5 and S6. A significant negative correlation was found between Tap Water Drink and Bottled Water ($\tau = -0.11$, $p < 0.001$). Negative correlations were also found between Soft Drink and Tap Water Drink ($p < 0.001$) and between Soft Drink and Tap+bottled Drink ($p < 0.001$).

Estimation of water intakes after the demographic adjustment

After the demographic adjustment, the intake values corresponding to the <5% and >95% populations were somewhat changed (Tables S6 and S7); however, the demographic adjustment did not result in substantial changes to the mean and median values. The winter and summer datasets were merged to estimate intake distributions of the adult population, male and female. Percentiles and means are shown in Figure 3 and Table 3, and cumulative distribution curves are depicted in Figures S7 and S8. Intake values were distributed widely: for example, the mean and 95th percentile values of Tap Water Intake were 1,312 and 2,533 mL/d for male and 1,263 and 2,395 mL/d for female, respectively. The 5th percentile, median, mean, and 95th percentile of Tap Water Intake for the entire population were 406, 1,202, 1,287, and 2,465 mL/d, respectively. The equivalent values for pTWI were 774, 1,546, 1,653, and 2,913 mL/d, respectively. Two liters per day corresponds to about the 95th percentile of intake of Tap Water Drink, the 88th percentile of Tap Water Intake, and the 76th percentile of pTWI. Details are given in Tables S8–10.

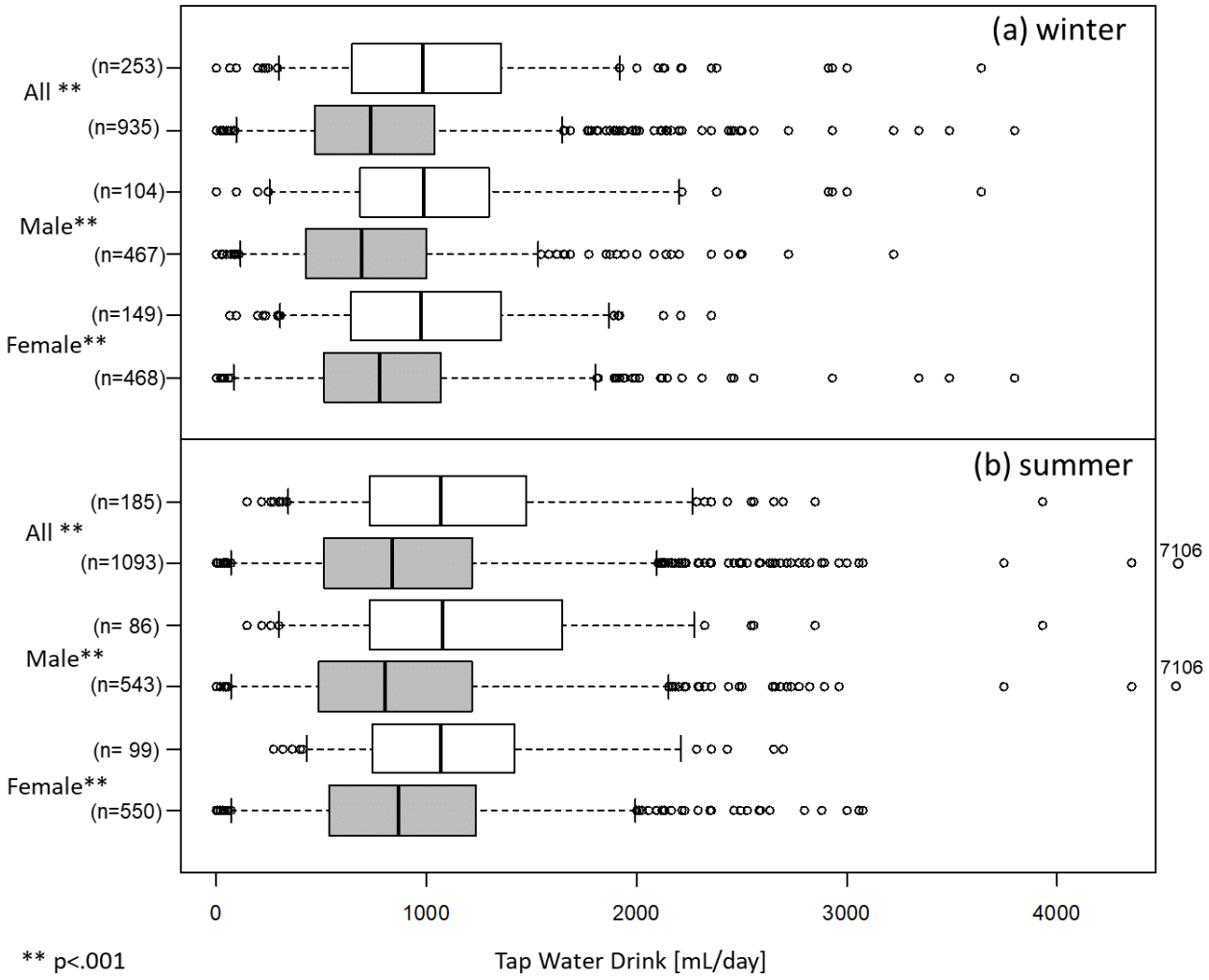

Figure 2. Tap Water Drink intakes in (a) winter and (b) summer. Comparison of Tap Water Drink intakes between people who did not drink Bottled Water or Soft Drink (tap-water-only consumer; white box) and people who drank Bottled Water and/or Soft Drink (grey box). The ends of each whisker represent the 5th and the 95th percentiles. Values outside the axis range are shown outside the frame. **, $p < 0.001$, Mann-Whitney U-test.

Table 2. Results of Kendall's rank correlation tests.

		Kendall's tau coefficient (* p < 0.05 and ** p < 0.001)				
Winter	(n = 1188)	Bottled Water	Soft Drink	Milk	Alcohol	Miscellaneous
Tap Water Drink		-0.11** (p < 0.001)	-0.15** (p < 0.001)	0.027 (p = 0.19)	-0.066* (p = 0.002)	0.0002 (p = 0.99)
Tap+bottled Drink			-0.13** (p < 0.001)	0.040 (p = 0.06)	-0.040 (p = 0.06)	0.020 (p = 0.39)
Summer	(n = 1278)	Bottled Water	Soft Drink	Milk	Alcohol	Miscellaneous
Tap Water Drink		-0.11** (p < 0.001)	-0.13** (p < 0.001)	0.077** (p < 0.001)	-0.014 (p = 0.48)	0.002 (p = 0.94)
Tap+bottled Drink			-0.14** (p < 0.001)	0.090** (p < 0.001)	0.002 (p = 0.91)	0.049* (p = 0.02)

Table 3. Estimated percentiles and means of water intakes (the winter and summer data were merged)

Percentiles (mL/day)	1%	5%	10%	25%	**50%**	75%	90%	95%	99%	**Mean**
(For the entire population)										
All-water Intake	621	924	1084	1424	**1830**	2335	2914	3427	4639	**1957**
pTWI	487	774	908	1196	**1546**	1979	2501	2913	3898	**1653**
Tap+bottled Water Intake	305	520	687	951	**1292**	1732	2239	2592	3523	**1395**
Tap Water Intake	213	406	567	861	**1202**	1614	2103	2465	3145	**1287**
Tap+bottled Drink Intake	57	243	364	616	**921**	1309	1793	2129	3011	**1022**
(For males)										
All-water Intake	726	1051	1255	1555	**1959**	2552	3174	3678	4764	**2125**
pTWI	512	800	975	1287	**1597**	2064	2597	3051	4349	**1738**
Tap+bottled Water Intake	285	495	646	967	**1313**	1724	2312	2692	3533	**1416**
Tap Water Intake	220	433	567	886	**1217**	1632	2163	2533	3302	**1312**
Tap+bottled Drink Intake	0	214	300	557	**868**	1271	1800	2170	3011	**991**
(For females)										
All-water Intake	529	841	1008	1308	**1690**	2183	2674	2994	4256	**1796**
pTWI	468	744	867	1120	**1482**	1920	2364	2705	3806	**1572**
Tap+bottled Water Intake	366	562	710	933	**1275**	1735	2149	2497	3351	**1375**
Tap Water Intake	203	395	563	849	**1179**	1596	2058	2395	3011	**1263**
Tap+bottled Drink Intake	98	300	436	654	**954**	1364	1786	2071	3057	**1051**

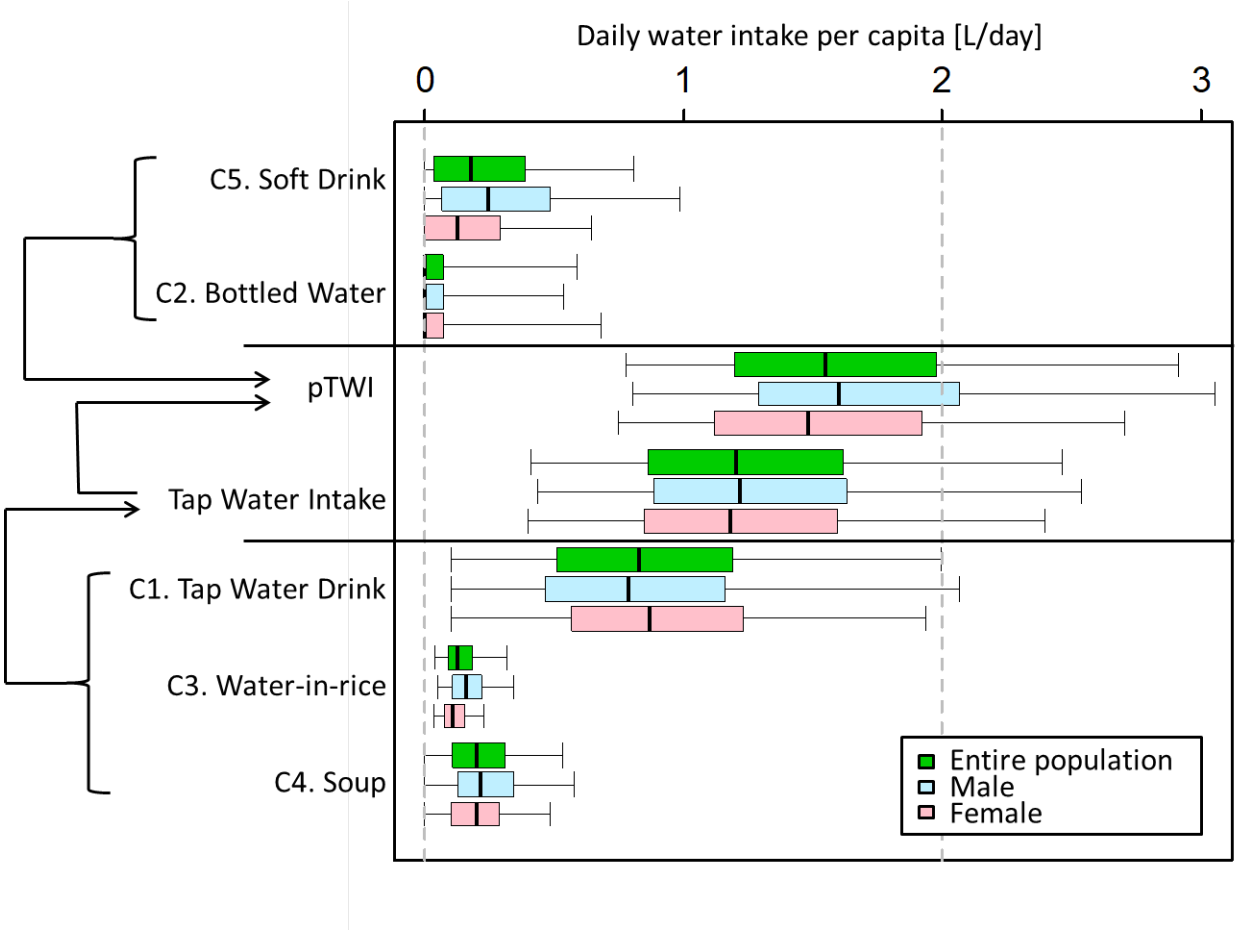

Figure 3. Box plot of pTWI, tap water intake and categories included in pTWI. Whiskers show 1st and 99th percentiles.

DISCUSSION

Water intake for risk assessment of the public water system

For the assessment and management of health risks to human population from contaminants in public water systems, the ingestion rate of tap water is fundamental information. Here, the mean values of Tap Water Intake (1,287 mL/d for the whole adult population) by our estimation are larger than the values of the community water intake for adults in the United States reported by Kahn and Stralka (2009). They reported that the mean community water intake, which was defined as direct and indirect intake of tap water from a community or municipal water supply, was 1,104 mL/d for "all individuals" and 1,183 mL/d for "consumers only," that is, respondents that reported ingestion of tap water during their survey (Kahn and Stralka 2009). The difference between our values and their values may reflect the different rates of consumption of bottled water. In fact, the difference between studies decreased when we compared total water intake (termed Tap+bottled Water in our study), which was 1,466 mL/d in their data and 1,395 mL/d in our data. The difference in Tap Water Intake (community water intake) and similarity in Tap+bottled Water intake (total water intake) suggests a mutually-dependent relationship between tap water intake and bottled water intake.

The negative correlation between Tap Water Drink intake and Bottled Water intake in our data (Table 2) supports this relationship: Soft Drink intake was also negatively correlated with Tap Water Drink intake. These results clearly indicate that both Soft Drink and Bottled Water served as substitute sources for water ingestion, at least in part in place of tap water intake.

Kahn and Stralka (2009) provided water intake data for a "consumers only" group, which excluded those who did not drink tap water during the survey period, as well as intake data for all survey respondents. In addition, they mentioned that estimates for "consumers only" were often the primary focus in analyses of risk due to ingestion of potentially contaminated water. The consumers-only group excludes those who did not drink community water, but includes those who drink both bottled water and commercial beverages.

In our survey, the number of people who did not drink water supplied from the public water system was very small (2%), but most people (62–73%) did not drink bottled water and a substantial percentage of people (20–27%) did not consume soft drinks (Table 1). This result may be due not only to the diversity of people's preferences for types of beverage and water consumption, but also the availability and convenience of them. Tap Water Drink intake for tap water–only consumers was significantly higher

than that for bottled-water and/or soft-drink consumers (Figure 2). For risk assessment of tap water, a water intake rate of 2 L/d is normally placed in the context of intake of the whole population of tap water consumers, but it should also be discussed in the context of water intake of the subpopulation who do not drink bottled water or soft drinks. The water intake of the subpopulation that does not consume bottled water or soft drinks is not easily estimated. The demographic distribution of tap water–only consumers is unknown. Even in our Internet survey, the number of tap water–only consumers was around 200. Therefore, pTWI estimated for the entire set of respondents can be applied as a tap water intake index. Use of pTWI rather than Tap Water Intake for risk assessment has additional merit because some commercial beverages are produced from water from public water supplies (Asami et al. 2009), and some contaminants (e.g., chlorate) remain in the final products of commercial beverages and foods even after water has been further purified at the production plant (Asami et al. 2009, 2013). Therefore, the use of Tap Water Intake may underestimate the potential exposure to some toxic substances from tap water. On the other hand, given the assumption that bottled water and purchased foods and beverages that contain water are widely distributed and less likely to contain source- and site-specific water, the use of total water intake may overestimate the potential exposure to toxic substances present only in public water supplies (USEPA 2011). Therefore, we propose that both Tap Water Intake and pTWI should be used for risk assessments of drinking water on a case-by-case basis. We do not recommend using either Tap Water Intake or pTWI exclusively, but risk managers should determine which is more appropriate given their particular circumstance.

Implication of tap water intake and pTWI rates

It is common practice to use 2 L/d as a default value to represent water intake in risk assessments and for determining drinking water quality guidelines and standards. In the current study, the estimated mean intake rate of drinking water was lower than 2 L/d: for example, mean Tap Water Intake and pTWI were 1,287 and 1,653 mL/d, respectively. Therefore 2 L/d would exceed (i.e., cover) the intake of most of the population in Japan, although the intake rate was distributed widely.

In terms of the Tap Water Drink intake, 2L/d exceeded the rate across almost the entire Japanese population (95.0% of total; 94.3% of males and 95.7% of females). When tap water ingested in rice and soup was added to Tap Water Drink intake to give Tap Water Intake, 2L/d covered 88.0% of the population (87.8% of males and 88.1% of females). For pTWI, it covered 75.7% of the population (73.0% of males and 78.5% of females). In the United States, 2 L/d corresponds to the 85th percentile of the cumulative distribution of community water intake for males 20 years and older and the 88th percentile for women aged 20 and older (USEPA 2004). The present study revealed that even if tap water ingested in food is added, the 2L/d value would covers the intake of the majority (>75.7%) of the Japanese population. Two liters per day should continue being used for the default in the Japanese population, but the rate to cover the tap water intake of almost the entire population would be higher: it

was > 2.5 L/d according to the result that 95th percentiles of Tap Water Intake and pTWI were 2.5 and 2.9 L/d, respectively.

CONCLUSIONS

In risk assessments and implementations for determining drinking water quality guidelines and standards, the water intake rate of 2 L/d has been used historically as a standard value worldwide, under the assumption that this value exceeds the intakes of most of the population. However, the intake of water varies depending on its definition and the population. This study has carefully specified the various intakes of water and revealed a mutual complementation between intake of tap water and other beverages.

Of the respondents, 73% and 62% did not drink bottled water during summer and winter surveys, respectively, while 21% and 14.5% did not drink bottled water or soft drinks during the same periods. Intakes of Tap Water Drink (tap water from public water supply system, which consisted of direct intake as a drink and indirect intake via beverages) for those who did not consume bottled water or soft drinks were significantly larger than those that did consume them. Furthermore, both the correlation between Soft Drink and Tap Water Drink intakes and the correlation between Bottled Water and Tap Water Drink intakes were negative and significant. Therefore, Soft Drink and/or Bottled Water are complementary to Tap Water Drink for some people. If the consumption of soft drinks and bottled water reduces the national mean Tap Water Intake, risks assessed based on that national mean would be underestimated for non-consumers of commercial drinks due to their Tap Water Intake being relatively high. Therefore, statistics of Tap Water Intake (the water source is tap water from the public water supply system) for the whole population may not be appropriate for non-consumers of bottled water and soft drinks. Considering the above-mentioned results and that fact that the source waters of some soft drinks are from public water supplies, we proposed the pTWI (water sources are tap and bottled water and soft drinks) as an alternative index.

The intake of water varied greatly among the population in Japan. Mean and 95th percentile values of Tap Water Intake were 1,287 and 2,465 mL/d, respectively. The rate of 2 L/d covers 88% of the population in terms of Tap Water Intake and 75.7% in terms of pTWI. Because the cohort used here is representative of the geographical regions, ages, and gender of the Japanese population, this study quantitatively demonstrates that the rate of 2 L/d covers the intake of the majority of the populations in

Japan. The rate to cover the intake of almost the entire population was > 2.5 L/d. These results and other statistical data presented in this study should serve as important scientific evidence for exposure assessment.

Acknowledgments

The authors thank the junior-year students (2011) of Environmental Engineering Department of Osaka University who participated in the preliminary survey; their responses were helpful in improving the questionnaire sheet. The authors also thank Dr. Kunihiko Takahashi of Nagoya University Graduate School of Medicine for advice on statistical analysis.

This work was supported by the Health and Labour Sciences Research Grant [grant numbers H25-Kenki-Ippan-007, H28-Kenki-Ippan-005] from Ministry of Health, Labour and Welfare, Japan. The views expressed in this article are those of the authors, but do not necessarily reflect the position of the supporting agency and the entities with which the authors are affiliated; therefore, no official endorsement should be inferred. The authors declare they have no actual or potential competing financial interests.

Appendix A, Supplementary Material

Table S1-S10 and Figures S1-S8 are available in the online version.

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Table 1. Results from the questionnaire: mean water intake and number of respondents who answered zero intake during the 3-day survey for each category.

Category		Water code in the questionnaire	Mean water intake [mL/day]		Number of subjects with zero intake			
					Winter		Summer	
No.	Designation		Winter	Summer	(*n* = 1188)	(%)	(*n* = 1278)	(%)
C1	Tap Water Drink	W01–07	850	961	27	2.3	27	2.1
	Cold tap water	W01, 02, 07	247	431				
	Hot tap water	W03, 04	590	416				
	Ice cubes	W05, 06	12	113				
C2	Bottled Water	W08–10	77	141	870	73.2	798	62.4
C3	Water-in-rice	W15, 17	150	148	22	1.9	19	1.5
C4	Soup	W16, 18	267	195	48	4.0	144	11.3
C5	Soft Drink	W11	201	316	317	26.7	259	20.3
C6	Milk	W12	82	103	546	46.0	500	39.1
C7	Alcohol	W13	169	215	633	53.3	623	48.7
C8	Misc.	W14	17	34	1033	87.0	1053	82.4

Table 2. Results of Kendall's rank correlation tests.

		Kendall's tau coefficient (* $p < 0.05$ and ** $p < 0.001$)				
Winter	(n = 1188)	Bottled Water	Soft Drink	Milk	Alcohol	Miscellaneous
Tap Water Drink		-0.11** ($p < 0.001$)	-0.15** ($p < 0.001$)	0.027 ($p = 0.19$)	-0.066* ($p = 0.002$)	0.0002 ($p = 0.99$)
Tap+bottled Drink			-0.13** ($p < 0.001$)	0.040 ($p = 0.06$)	-0.040 ($p = 0.06$)	0.020 ($p = 0.39$)
Summer	(n = 1278)	Bottled Water	Soft Drink	Milk	Alcohol	Miscellaneous
Tap Water Drink		-0.11** ($p < 0.001$)	-0.13** ($p < 0.001$)	0.077** ($p < 0.001$)	-0.014 ($p = 0.48$)	0.002 ($p = 0.94$)
Tap+bottled Drink			-0.14** ($p < 0.001$)	0.090** ($p < 0.001$)	0.002 ($p = 0.91$)	0.049* ($p = 0.02$)

Table 3. Estimated percentiles and means of water intakes (the winter and summer data were merged)

Percentiles (mL/day)	1%	5%	10%	25%	**50%**	75%	90%	95%	99%	**Mean**
(For the entire population)										
All-water Intake	621	924	1084	1424	**1830**	2335	2914	3427	4639	**1957**
pTWI	487	774	908	1196	**1546**	1979	2501	2913	3898	**1653**
Tap+bottled Water Intake	305	520	687	951	**1292**	1732	2239	2592	3523	**1395**
Tap Water Intake	213	406	567	861	**1202**	1614	2103	2465	3145	**1287**
Tap+bottled Drink Intake	57	243	364	616	**921**	1309	1793	2129	3011	**1022**
(For males)										
All-water Intake	726	1051	1255	1555	**1959**	2552	3174	3678	4764	**2125**
pTWI	512	800	975	1287	**1597**	2064	2597	3051	4349	**1738**
Tap+bottled Water Intake	285	495	646	967	**1313**	1724	2312	2692	3533	**1416**
Tap Water Intake	220	433	567	886	**1217**	1632	2163	2533	3302	**1312**
Tap+bottled Drink Intake	0	214	300	557	**868**	1271	1800	2170	3011	**991**
(For females)										
All-water Intake	529	841	1008	1308	**1690**	2183	2674	2994	4256	**1796**
pTWI	468	744	867	1120	**1482**	1920	2364	2705	3806	**1572**
Tap+bottled Water Intake	366	562	710	933	**1275**	1735	2149	2497	3351	**1375**
Tap Water Intake	203	395	563	849	**1179**	1596	2058	2395	3011	**1263**
Tap+bottled Drink Intake	98	300	436	654	**954**	1364	1786	2071	3057	**1051**

Figure 1

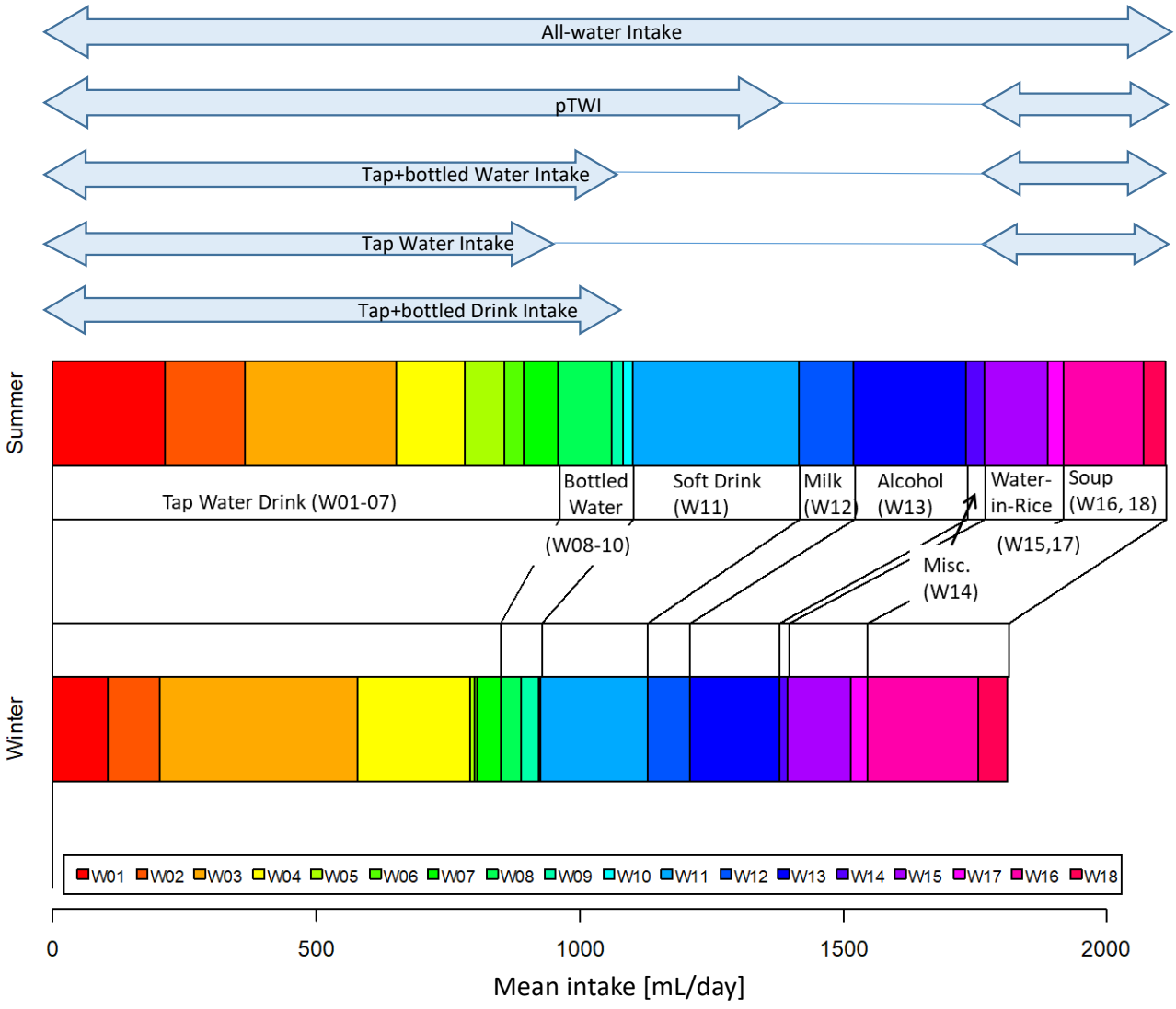

All-water Intake
pTWI
Tap+bottled Water Intake
Tap Water Intake
Tap+bottled Drink Intake
Summer
Winter
Tap Water Drink (W01-07)
Bottled Water (W08-10)
Soft Drink (W11)
Milk (W12)
Alcohol (W13)
Misc. (W14)
Water-in-Rice (W15,17)
Soup (W16, 18)
W01 W02 W03 W04 W05 W06 W07 W08 W09 W10 W11 W12 W13 W14 W15 W17 W16 W18
0
500
1000
1500
2000
Mean intake [mL/day]

Figure 2

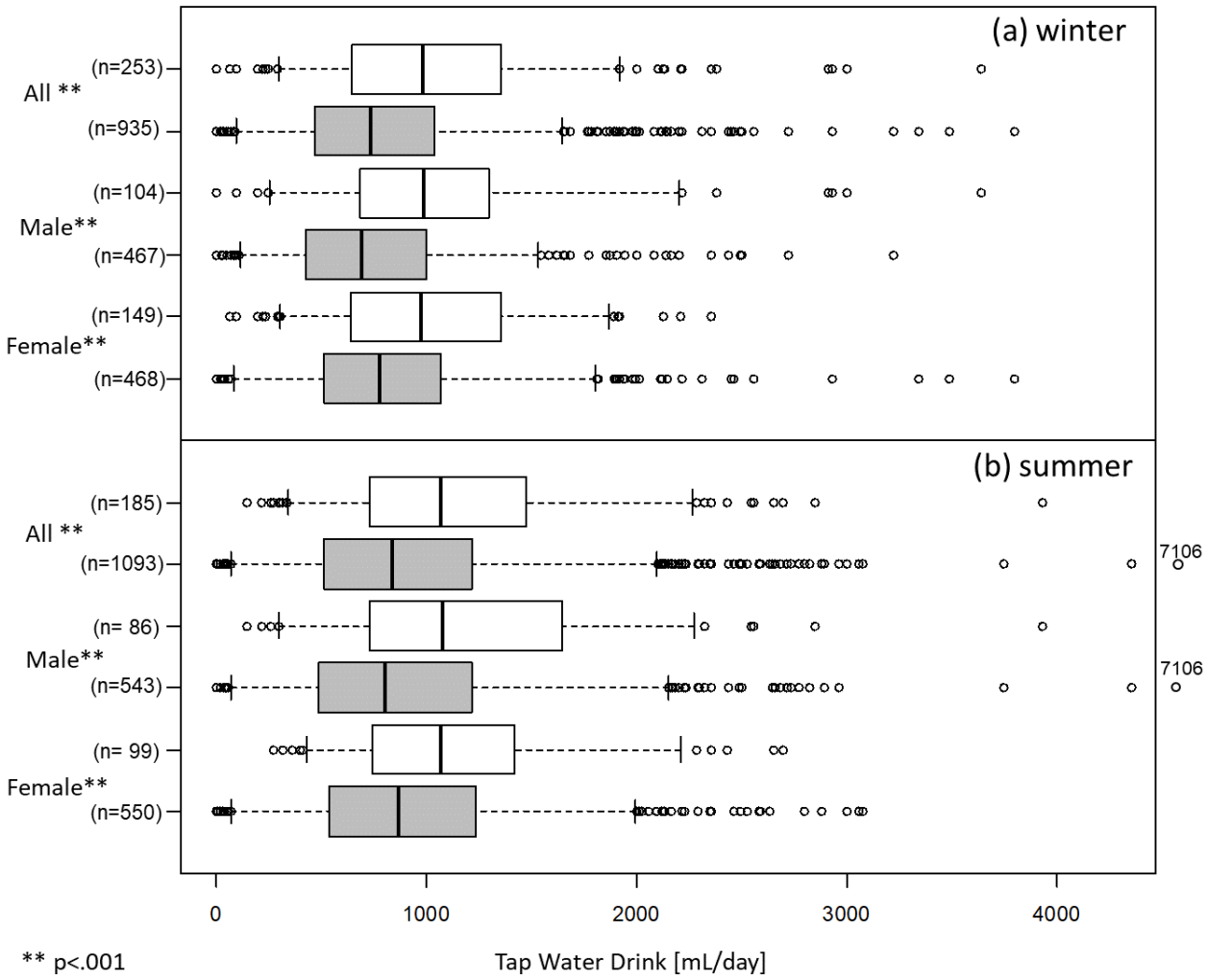
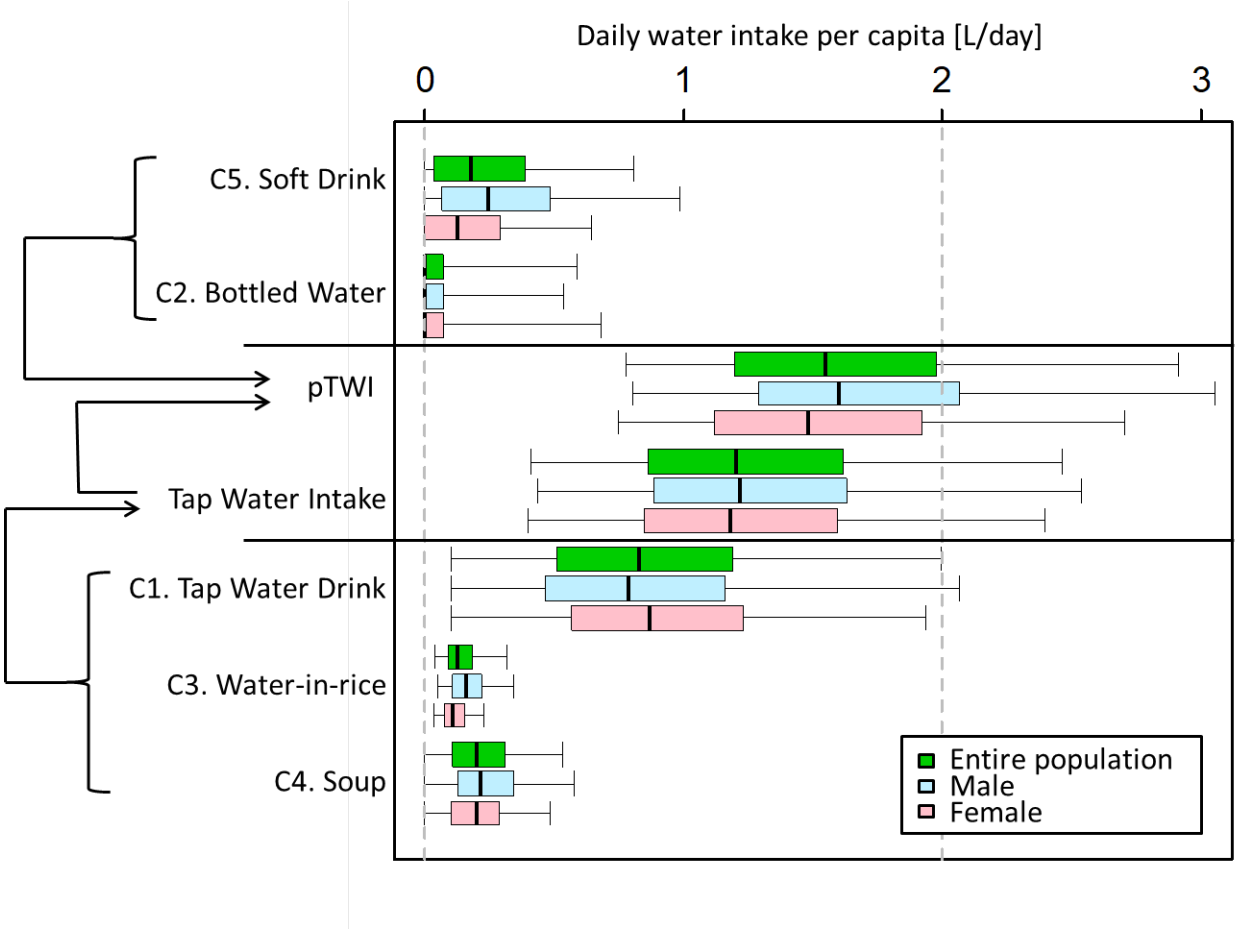

(a) winter
(n=253)
All **
(n=935)
(n=104)
Male**
(n=467)
(n=149)
Female**
(n=468)
(b) summer
(n=185)
All **
(n=1093)
7106
(n= 86)
Male**
(n=543)
7106
(n= 99)
Female**
(n=550)
0
1000
2000
3000
4000
** p<.001
Tap Water Drink [mL/day]

Figure 3


Daily water intake per capita [L/day]
0
1
2
3
C5. Soft Drink
C2. Bottled Water
pTWI
Tap Water Intake
C1. Tap Water Drink
C3. Water-in-rice
C4. Soup
Entire population
Male
Female

Supplementary Material

Is the default of 2 liters for daily per-capita water consumption appropriate? A nationwide survey reveals water intake in Japan

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Table S1. Adult subpopulations in terms of region, gender, and age group created by editing the 2010 Population Census (Statistics Bureau 2011)

	Population [Thousand persons]								
	Male				Female				Total
Region / Age	20–39	40–59	60–79	Subtotal	20–39	40–59	60–79	Subtotal	
Northeast	1687	1948	1748	5383	1670	2017	2068	5755	11138
East	6714	6527	5426	18667	6255	6202	5900	18357	37024
Middle	4978	4954	4581	14513	5365	5013	5114	15492	30005
West	2986	3260	3005	9251	3039	3403	3542	9984	19235
Subtotal	16365	16689	14760	47814	16329	16635	16624	49588	**97402**

Table S2. Distribution of respondents for the water intake surveys

a) Winter, 2012

Region / Age	Male				Female				Total
	20–39	40–59	60–79	Subtotal	20–39	40–59	60–79	Subtotal	
Northeast	45	52	52	149	54	59	36	149	298
East	50	49	46	145	59	57	45	161	306
Middle	46	49	45	140	51	56	49	156	296
West	46	43	48	137	49	58	44	151	288
Subtotal	187	193	191	571	213	230	174	617	**1188**

b) Summer, 2012

Region / Age	Male				Female				Total
	20–39	40–59	60–79	Subtotal	20–39	40–59	60–79	Subtotal	
Northeast	54	55	52	161	53	59	50	162	323
East	55	51	51	157	54	55	55	164	321
Middle	57	53	52	162	57	57	53	167	329
West	49	51	49	149	51	54	51	156	305
Subtotal	215	210	204	629	215	225	209	649	**1278**

Table S3. Sample numbers of new dataset used to estimate demographically adjusted water intakes

a) Winter, 2012

	Male				Female				Total
Region / Age	20–39	40–59	60–79	Subtotal	20–39	40–59	60–79	Subtotal	
Northeast	45x37=1665	52x37=1924	52x34=1768	5357	54x31=1674	59x34=2006	36x57=2052	5732	11089
East	50x134=6700	49x136=6528	46x115=5405	18633	59x106=6254	57x109=6202	45x131=5900	18362	36995
Middle	46x106=4982	49x101=4949	45x104=4576	14507	51x105=5355	56x90=5013	49x104=5114	15491	29998
West	46x65=2990	43x76=3268	48x63=3024	9282	49x62=3038	58x59=3403	44x81=3542	10024	19306
:Subtotal	16337	16669	14773	47779	16321	16681	16607	49609	**97388**

b) Summer, 2012

	Male				Female				Total
Region / Age	20–39	40–59	60–79	Subtotal	20–39	40–59	60–79	Subtotal	
Northeast	54x31=1674	55x35=1925	52x34=1768	5367	53x32=1696	59x34=2006	50x41=2050	5752	11119
East	55x122=6710	51x128=6528	51x106=5406	18644	54x116=6264	55x113=6215	55x107=5885	18364	37008
Middle	57x87=4959	53x93=4929	52x88=4576	14464	57x94=5358	57x88=5016	53x96=5088	15462	29926
West	49x61=2989	51x64=3264	49x61=2989	9242	51x60=3060	54x63=3402	51x69=3519	9981	19223
Subtotal	16332	16646	14739	47717	16378	16639	16542	49559	**97276**

* Equation in the table: (original sample number in subpopulation) x (replication number) = sample number of the new dataset
** Replication number is the rounded quotient of the population (in thousands) of each subpopulation divided by the corresponding sample numbers.

Table S4. Results of the winter survey: weekly-averaged water intake (n = 1188)

Code	Item	Mean (mL/day)	Number of subjects with zero intake	Number of consumer	Mean intake by consumers only (mL/day)
	A. Tap water including drinks and ices made with tap water				
W01	Tap water, and drinks made with tap water (Without household water purifier)	104	802	386	321
W02	Tap water after filtered through household water purifier, and drinks made with the water	98	873	315	370
W03	Boiled tap water, and drinks made with boiled water (without water purifier)	376	508	680	657
W04	Boiled tap water, and drinks made with boiled water (with water purifier)	215	759	429	595
W05	Ice cubes made with tap water (without water purifier)	8	1071	117	82
W06	Ice cubes made with tap water (with water purifier)	4	1124	64	78
	B. Commercial drinks				
W07	Cold water, cold tea (free drinks supplied in an earety)	44	732	456	116
W08	Commercial bottled water, and drinks made with bottled water.	40	1009	179	268
W09	Boiled commercial bottled water, and drinks made with boiled bottledwater.	35	1048	140	295
W10	Ice cubes made with commercial bottled water, and commercial ice cubes.	2	1128	60	46
W11	Non-alcoholic commercial beverages including soft drinks, juices, teas, coffees etc.	201	317	871	274
W12	Milk	82	546	642	152
W13	Alcoholic drinks	169	633	555	361
W14	Other drinks	17	1033	155	128
	C. Rice and soup made in home (includes home-made lunch box)				
W15	Rice, rice gruel (g/day)	232	50	1138	242
W16	Soups includings soups in noodles such as ramen.	213	96	1092	232
	D. Rice and soup eaten outside the home, or purchased in the marketplace.				
W17	Rice, rice gruel (g/day)	52	634	554	112
W18	Soups includings soups in noodles such as ramen.	54	667	521	112

Table S5. Results of the summer survey: weekly-averaged water intake (*n* = 1278)

Code	Item	Mean (mL/day)	Number of subjects with zero intake	Number of consumer	Mean intake by consumers only (mL/day)
	A. Tap water including drinks and ices made with tap water				
W01	Tap water, and drinks made with tap water (Without household water purifier)	212	741	537	504
W02	Tap water after filtered through household water purifier, and drinks made with the water	153	913	365	537
W03	Boiled tap water, and drinks made with boiled water (without water purifier)	286	636	642	569
W04	Boiled tap water, and drinks made with boiled water (with water purifier)	130	956	322	518
W05	Ice cubes made with tap water (without water purifier)	76	732	546	179
W06	Ice cubes made with tap water (with water purifier)	37	1007	271	173
	B. Commercial drinks				
W07	Cold water, cold tea (free drinks supplied in an earety)	66	704	574	147
W08	Commercial bottled water, and drinks made with bottled water.	101	948	330	393
W09	Boiled commercial bottled water, and drinks made with boiled bottledwater.	19	1179	99	251
W10	Ice cubes made with commercial bottled water, and commercial ice cubes.	20	1066	212	122
W11	Non-alcoholic commercial beverages including soft drinks, juices, teas, coffees etc.	316	259	1019	396
W12	Milk	103	500	778	168
W13	Alcoholic drinks	215	623	655	419
W14	Other drinks	34	1053	225	192
	C. Rice and soup made in home (includes home-made lunch box)				
W15	Rice, rice gruel	226	70	1208	239
W16	Soups includings soups in noodles such as ramen.	152	246	1032	188
	D. Rice and soup eaten outside the home, or purchased in the marketplace.				
W17	Rice, rice gruel	56	679	599	118
W18	Soups includings soups in noodles such as ramen.	43	773	505	110

Table S6. Percentiles and averages of water intakes from the original dataset

(a) Winter (from the raw data: n=1188)

Category Number	Designation	Percentiles (mL/day) 1%	5%	10%	25%	**50%**	75%	90%	95%	99%	**Mean**
	(Combined Category)										
C1-8	All-water Intake	618	891	1046	1339	**1710**	2158	2664	3063	4176	**1812**
C1-5	pTWI	486	743	859	1132	**1453**	1856	2299	2621	3518	**1545**
C1-4	Tap+bottled Water Intake	362	545	675	944	**1253**	1647	2102	2441	3193	**1344**
C1, 3, 4	Tap Water Intake	240	443	579	883	**1190**	1574	1987	2324	3030	**1266**
C1, 2	Tap+bottled Drink Intake	98	229	329	563	**843**	1190	1586	1888	2551	**928**
	(Category included in pTWI)										
C1	Tap Water Drink	0	124	250	500	**786**	1107	1505	1800	2497	**850**
C2	Bottled Water	0	0	0	0	**0**	26	265	469	975	**77**
C3	Water-in-rice	0	47	56	91	**130**	183	264	316	455	**150**
C4	Soup	0	29	71	146	**236**	357	500	576	803	**267**
C5	Soft Drink	0	0	0	0	**129**	312	500	633	1000	**201**
	(Category not included in pTWI)										
C6	Milk	0	0	0	0	**36**	149	200	300	457	**82**
C7	Alcohol	0	0	0	0	**0**	251	507	700	1250	**169**
C8	Miscellaneous	0	0	0	0	**0**	0	57	129	280	**17**

(b) Summer (from the raw data: n=1278)

Category Number	Designation	Percentiles (mL/day) 1%	5%	10%	25%	**50%**	75%	90%	95%	99%	**Mean**
	(Combined Category)										
C1-8	All-water Intake	618	989	1185	1521	**1959**	2515	3205	3757	4985	**2112**
C1-5	pTWI	486	822	960	1257	**1643**	2102	2704	3123	4316	**1761**
C1-4	Tap+bottled Water Intake	362	505	692	957	**1330**	1800	2344	2779	3551	**1446**
C1, 3, 4	Tap Water Intake	240	383	547	836	**1205**	1643	2176	2582	3182	**1304**
C1, 2	Tap+bottled Drink Intake	98	274	329	657	**980**	1425	1980	2318	3158	**1102**
	(Category included in pTWI)										
C1	Tap Water Drink	0	71	271	537	**867**	1271	1772	2115	2780	**961**
C2	Bottled Water	0	0	0	0	**0**	114	500	756	1596	**141**
C3	Water-in-rice	0	38	53	87	**130**	186	276	316	447	**148**
C4	Soup	0	0	0	71	**171**	271	400	486	715	**195**
C5	Soft Drink	0	0	0	65	**236**	471	741	972	1472	**316**
	(Category not included in pTWI)										
C6	Milk	0	0	0	0	**64**	200	248	300	500	**103**
C7	Alcohol	0	0	0	0	**33**	350	646	824	1310	**215**
C8	Miscellaneous	0	0	0	0	**0**	0	100	200	500	**34**

Table S7. Estimated percentiles and averages of water intakes after the demographic adjustment

(a) Winter (estimated value)

Category Number	Designation	Percentiles (mL/day) 1%	5%	10%	25%	**50%**	75%	90%	95%	99%	**Mean**
	(Combined Category)										
C1-8	All-water Intake	619	889	1036	1343	**1708**	2177	2673	3024	4107	**1814**
C1-5	pTWI	468	744	860	1133	**1452**	1872	2333	2637	3498	**1548**
C1-4	Tap+bottled Water Intake	358	529	668	939	**1259**	1659	2122	2466	3053	**1346**
C1, 3, 4	Tap Water Intake	213	434	567	882	**1185**	1577	2019	2365	3018	**1266**
C1, 2	Tap+bottled Drink Intake	66	225	329	564	**857**	1200	1636	1907	2550	**936**
	(Category included in pTWI)										
C1	Tap Water Drink	0	111	236	500	**789**	1118	1536	1814	2496	**856**
C2	Bottled Water	0	0	0	0	**0**	29	268	471	1000	**79**
C3	Water-in-rice	0	45	56	90	**128**	181	264	316	440	**148**
C4	Soup	0	32	71	143	**232**	357	479	564	771	**262**
C5	Soft Drink	0	0	0	0	**129**	314	500	636	1000	**203**
	(Category not included in pTWI)										
C6	Milk	0	0	0	0	**36**	148	200	293	457	**81**
C7	Alcohol	0	0	0	0	**0**	250	500	700	1250	**167**
C8	Miscellaneous	0	0	0	0	**0**	0	57	129	280	**17**

(b) Summer (estimated value)

Category Number	Designation	Percentiles (mL/day) 1%	5%	10%	25%	**50%**	75%	90%	95%	99%	**Mean**
	(Combined Category)										
C1-8	All-water Intake	631	990	1185	1522	**1959**	2513	3174	3635	4758	**2100**
C1-5	pTWI	525	822	974	1260	**1641**	2103	2672	3122	4349	**1758**
C1-4	Tap+bottled Water Intake	285	515	703	959	**1332**	1779	2331	2739	3614	**1445**
C1, 3, 4	Tap Water Intake	215	395	563	844	**1210**	1643	2182	2581	3179	**1308**
C1, 2	Tap+bottled Drink Intake	48	275	407	666	**982**	1429	1961	2321	3161	**1107**
	(Category included in pTWI)										
C1	Tap Water Drink	0	86	286	550	**878**	1271	1795	2133	2821	**970**
C2	Bottled Water	0	0	0	0	**0**	114	464	752	1579	**137**
C3	Water-in-rice	0	38	53	87	**128**	184	267	316	429	**146**
C4	Soup	0	0	0	71	**171**	264	400	486	657	**192**
C5	Soft Drink	0	0	0	71	**229**	464	725	921	1461	**313**
	(Category not included in pTWI)										
C6	Milk	0	0	0	0	**71**	200	250	300	443	**103**
C7	Alcohol	0	0	0	0	**43**	350	630	796	1286	**208**
C8	Miscellaneous	0	0	0	0	0	0	100	200	500	31

Table S8. Estimated percentiles and averages of water intakes for male and female in winter

(a) Male (estimated values, winter)

Category		Percentiles (mL/day)									
Number	Designation	1%	5%	10%	25%	**50%**	75%	90%	95%	99%	**Mean**
	(Combined Category)										
C1-8	All-water Intake	718	1050	1168	1487	**1822**	2288	2859	3425	4354	**1952**
C1-5	pTWI	511	777	915	1241	**1506**	1911	2396	2811	3531	**1608**
C1-4	Tap+bottled Water Intake	329	500	635	946	**1265**	1624	2123	2520	3176	**1345**
C1, 3, 4	Tap Water Intake	213	443	578	882	**1193**	1570	1959	2427	3053	**1269**
C1, 2	Tap+bottled Drink Intake	36	207	271	500	**807**	1146	1536	1836	2721	**885**
	(Category included in pTWI)										
C1	Tap Water Drink	0	111	218	443	**746**	1071	1479	1657	2500	**809**
C2	Bottled Water	0	0	0	0	**0**	29	289	493	857	**76**
C3	Water-in-rice	0	53	77	105	**158**	215	309	339	572	**177**
C4	Soup	0	54	86	157	**257**	382	529	600	821	**283**
C5	Soft Drink	0	0	0	36	**200**	400	586	786	1243	**263**
	(Category not included in pTWI)										
C6	Milk	0	0	0	0	**0**	129	200	294	429	**69**
C7	Alcohol	0	0	0	0	**109**	404	682	894	1679	**260**
C8	Miscellaneous	0	0	0	0	**0**	0	43	129	271	**16**

(b) Female (estimated values, winter)

Category		Percentiles (mL/day)									
Number	Designation	1%	5%	10%	25%	**50%**	75%	90%	95%	99%	**Mean**
	(Combined Category)										
C1-8	All-water Intake	453	799	953	1207	**1614**	2055	2467	2787	3572	**1680**
C1-5	pTWI	453	708	831	1061	**1387**	1807	2255	2570	3286	**1491**
C1-4	Tap+bottled Water Intake	401	550	699	930	**1245**	1681	2122	2419	2808	**1346**
C1, 3, 4	Tap Water Intake	208	411	562	883	**1166**	1603	2051	2363	2808	**1264**
C1, 2	Tap+bottled Drink Intake	100	271	407	625	**914**	1243	1689	1921	2464	**985**
	(Category included in pTWI)										
C1	Tap Water Drink	0	114	286	561	**821**	1169	1600	1893	2464	**902**
C2	Bottled Water	0	0	0	0	**0**	27	229	464	1791	**83**
C3	Water-in-rice	0	38	53	79	**105**	149	196	222	335	**120**
C4	Soup	0	29	71	143	**214**	329	443	521	664	**242**
C5	Soft Drink	0	0	0	0	**86**	200	400	500	732	**145**
	(Category not included in pTWI)										
C6	Milk	0	0	0	0	**64**	171	218	286	457	**93**
C7	Alcohol	0	0	0	0	**0**	100	321	400	700	**79**
C8	Miscellaneous	0	0	0	0	**0**	0	64	129	280	**18**

Table S9. Estimated percentiles and averages of water intakes for male and female in summer

(a) Male (estimated values, summer)

Catergory		Percentiles (mL/day)									
Number	Designation	1%	5%	10%	25%	**50%**	75%	90%	95%	99%	**Mean**
	(Combined Category)										
C1-8	All-water Intake	789	1054	1289	1690	**2167**	2703	3403	4011	5272	**2298**
C1-5	pTWI	525	870	1050	1327	**1743**	2229	2851	3385	4582	**1868**
C1-4	Tap+bottled Water Intake	245	487	666	979	**1373**	1819	2427	2863	3775	**1487**
C1, 3, 4	Tap Water Intake	220	403	562	888	**1256**	1698	2276	2658	3375	**1355**
C1, 2	Tap+bottled Drink Intake	0	236	331	619	**950**	1400	2061	2457	3571	**1097**
	(Category included in pTWI)										
C1	Tap Water Drink	0	86	279	507	**841**	1263	1857	2164	2850	**965**
C2	Bottled Water	0	0	0	0	**0**	100	443	714	1686	**132**
C3	Water-in-rice	26	53	72	105	**158**	226	316	344	489	**176**
C4	Soup	0	0	18	100	**200**	286	424	521	743	**214**
C5	Soft Drink	0	0	0	100	**286**	571	857	1057	1500	**381**
	(Category not included in pTWI)										
C6	Milk	0	0	0	0	**36**	200	250	321	500	**96**
C7	Alcohol	0	0	0	0	**179**	500	764	1050	1429	**306**
C8	Miscellaneous	0	0	0	0	**0**	0	71	200	421	**28**

(b) Female (estimated values, summer)

Catergory		Percentiles (mL/day)									
Number	Designation	1%	5%	10%	25%	**50%**	75%	90%	95%	99%	**Mean**
	(Combined Category)										
C1-8	All-water Intake	529	905	1111	1434	**1787**	2257	2831	3365	4384	**1911**
C1-5	pTWI	525	801	926	1189	**1553**	1979	2524	2888	3889	**1652**
C1-4	Tap+bottled Water Intake	302	575	724	933	**1303**	1758	2241	2639	3523	**1404**
C1, 3, 4	Tap Water Intake	186	380	573	811	**1187**	1593	2068	2453	3145	**1263**
C1, 2	Tap+bottled Drink Intake	93	361	475	691	**1017**	1429	1884	2232	3093	**1117**
	(Category included in pTWI)										
C1	Tap Water Drink	0	71	307	575	**915**	1293	1739	2061	2700	**975**
C2	Bottled Water	0	0	0	0	**0**	129	496	779	1557	**142**
C3	Water-in-rice	0	30	45	72	**105**	152	196	248	339	**116**
C4	Soup	0	0	0	68	**150**	236	361	436	543	**171**
C5	Soft Drink	0	0	0	53	**200**	357	575	771	1011	**248**
	(Category not included in pTWI)										
C6	Milk	0	0	0	0	**93**	200	250	300	436	**110**
C7	Alcohol	0	0	0	0	**0**	168	364	529	800	**114**
C8	Miscellaneous	0	0	0	0	**0**	0	107	200	500	**34**

Table S10. Estimated percentiles and averages of water intakes for male, female, and the entire population (winter and summer data were merged)

(a) Male

Category Number	Designation	Percentiles (mL/day) 1%	5%	10%	25%	**50%**	75%	90%	95%	99%	[mL/day] **Mean**
	(Combined Category)										
C1-8	All-water Intake	726	1051	1255	1555	**1959**	2552	3174	3678	4764	**2125**
C1-5	pTWI	512	800	975	1287	**1597**	2064	2597	3051	4349	**1738**
C1-4	Tap+bottled Water Intake	285	495	646	967	**1313**	1724	2312	2692	3533	**1416**
C1, 3, 4	Tap Water Intake	220	433	567	886	**1217**	1632	2163	2533	3302	**1312**
C1, 2	Tap+bottled Drink Intake	0	214	300	557	**868**	1271	1800	2170	3011	**991**
	(Category included in pTWI)										
C1	Tap Water Drink	0	100	243	466	**786**	1161	1621	2064	2821	**887**
C2	Bottled Water	0	0	0	0	**0**	71	357	536	1179	**104**
C3	Water-in-rice	0	53	72	105	**158**	219	309	340	489	**176**
C4	Soup	0	0	54	129	**214**	343	464	579	800	**249**
C5	Soft Drink	0	0	0	64	**243**	486	740	986	1500	**322**
	(Category not included in pTWI)										
C6	Milk	0	0	0	0	**0**	150	200	300	457	**82**
C7	Alcohol	0	0	0	0	**129**	450	714	964	1500	**283**
C8	Miscellaneous	0	0	0	0	**0**	0	64	171	375	**22**

(b) Female

Category Number	Designation	Percentiles (mL/day) 1%	5%	10%	25%	**50%**	75%	90%	95%	99%	[mL/day] **Mean**
	(Combined Category)										
C1-8	All-water Intake	529	841	1008	1308	**1690**	2183	2674	2994	4256	**1796**
C1-5	pTWI	468	744	867	1120	**1482**	1920	2364	2705	3806	**1572**
C1-4	Tap+bottled Water Intake	366	562	710	933	**1275**	1735	2149	2497	3351	**1375**
C1, 3, 4	Tap Water Intake	203	395	563	849	**1179**	1596	2058	2395	3011	**1263**
C1, 2	Tap+bottled Drink Intake	98	300	436	654	**954**	1364	1786	2071	3057	**1051**
	(Category included in pTWI)										
C1	Tap Water Drink	0	100	293	566	**868**	1232	1650	1939	2650	**939**
C2	Bottled Water	0	0	0	0	**0**	71	357	679	1579	**112**
C3	Water-in-rice	0	34	53	75	**105**	151	196	230	335	**118**
C4	Soup	0	0	29	100	**200**	286	407	486	600	**207**
C5	Soft Drink	0	0	0	0	**129**	293	500	643	921	**196**
	(Category not included in pTWI)										
C6	Milk	0	0	0	0	**71**	200	229	300	443	**102**
C7	Alcohol	0	0	0	0	**0**	125	350	475	743	**96**
C8	Miscellaneous	0	0	0	0	**0**	0	100	179	457	**26**

Table S10 (continued). Estimated percentiles and averages of water intakes for male, female and the entire population (winter and summer data were merged)

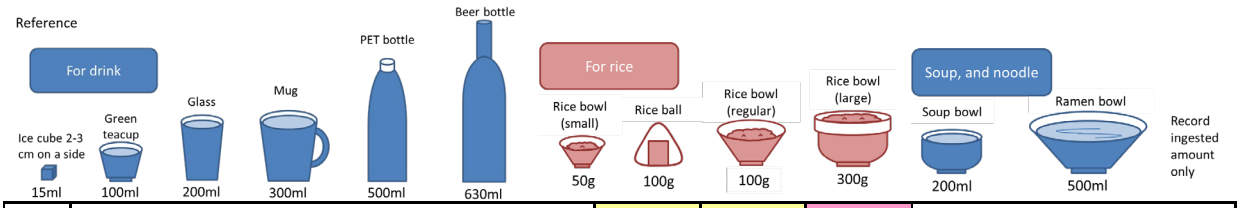
(c) The entire population

Catergory		Percentiles (mL/day)									[mL/day]
Number	Designation	1%	5%	10%	25%	**50%**	75%	90%	95%	99%	**Mean**
	(Combined Category)										
C1-8	All-water Intake	621	924	1084	1424	**1830**	2335	2914	3427	4639	**1957**
C1-5	pTWI	487	774	908	1196	**1546**	1979	2501	2913	3898	**1653**
C1-4	Tap+bottled Water Intake	305	520	687	951	**1292**	1732	2239	2592	3523	**1395**
C1, 3, 4	Tap Water Intake	213	406	567	861	**1202**	1614	2103	2465	3145	**1287**
C1, 2	Tap+bottled Drink Intake	57	243	364	616	**921**	1309	1793	2129	3011	**1022**
	(Category included in pTWI)										
C1	Tap Water Drink	0	100	257	511	**829**	1193	1643	1995	2734	**913**
C2	Bottled Water	0	0	0	0	**0**	71	357	588	1429	**108**
C3	Water-in-rice	0	38	53	90	**128**	181	264	316	429	**147**
C4	Soup	0	0	36	107	**200**	311	436	529	736	**227**
C5	Soft Drink	0	0	0	36	**179**	386	629	807	1268	**258**
	(Category not included in pTWI)										
C6	Milk	0	0	0	0	**50**	179	218	300	457	**92**
C7	Alcohol	0	0	0	0	**0**	301	571	743	1250	**188**
C8	Miscellaneous	0	0	0	0	**0**	0	71	179	400	**24**

Questionnaire (originally written in Japanese)

Record the approximate amounts of daily intake of each category in 2 work days and 1 non-work day during the survey period.

Note: Include the intake for eating and drinking out.



			Work day 1	Work day 2	Non-work day	
Code	Item	Unit	Date yy/mm/dd	Date yy/mm/dd	Date yy/mm/dd	Note & example
	A. Tap water including drinks and ice cubes made with tap water					
W01	Tap water, and drinks made with tap water (Without household water purifier)	mL				Ex. Fountain in school, tea or sports drinks made with tap water without boiling.
W02	Tap water after filtered through household water purifier, and drinks made with the water	mL				
W03	Boiled tap water, and drinks made with boiled water (without water purifier)	mL				Ex. Hot tea, hot coffee. Include cold drinks made with boiled water.
W04	Boiled tap water, and drinks made with boiled water (with water purifier)	mL				
W05	Ice cubes made with tap water (without water purifier)	**pieces**				Suppose ice cubes have sides of 2-3 cm. Suppose a normal cup of shaved ice contains 15 ice cubes.
W06	Ice cubes made with tap water (with water purifier)	**pieces**				
	B. Commercial drinks					
W07	Cold water, cold tea (free drinks supplied in an earety)	mL				Regarded as drinks made with tap water.
W08	Commercial bottled water, and drinks made with bottled water.	mL				Includes water from household water dispenser
W09	Boiled commercial bottled water, and drinks made with boiled bottledwater.	mL				
W10	Ice cubes made with commercial bottled water, and commercial ice cubes.	**pieces**				
W11	Non-alcoholic commercial beverages including soft drinks, juices, teas, coffees etc.	mL				Drinks purchased in the marketplace or consumed in an eating environment
W12	Milk	mL				
W13	Alcoholic drinks	mL				Includes alcoholic drinks diluted with water.
W14	Other drinks	mL				Drinks that are not defined by other categories.
	C. Rice and soup made at home (includes home-made lunch box)					
W15	Rice, rice gruel	g				Added tap water content is estimated as 52.7%. (See main text)
W16	Soups includings soups in noodles such as ramen.	mL				Only the ingested amount of soup should be recorded.
	D. Rice and soup eaten outside the home, or purchased in the marketplace.					
W17	Rice, rice gruel	g				Added tap water content is estimated as 52.7%. (See main text)
W18	Soups includings soups in noodles such as ramen.	mL				Only the ingested amount of soup should be recorded.

Figure S1. Questionnaire sheet for recording the amount of water ingested

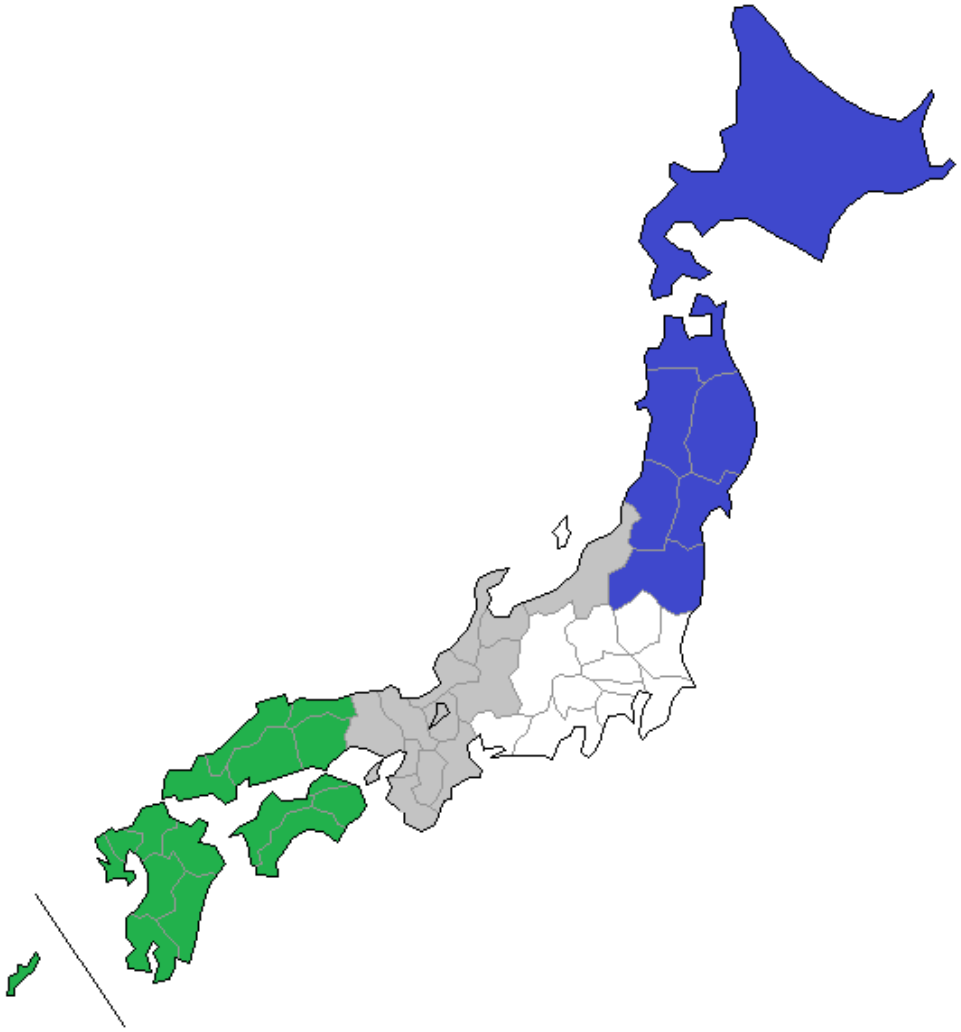


Figure S2. Map of Japan and the four regions divided in this study (Northeast, East, Middle, and West)

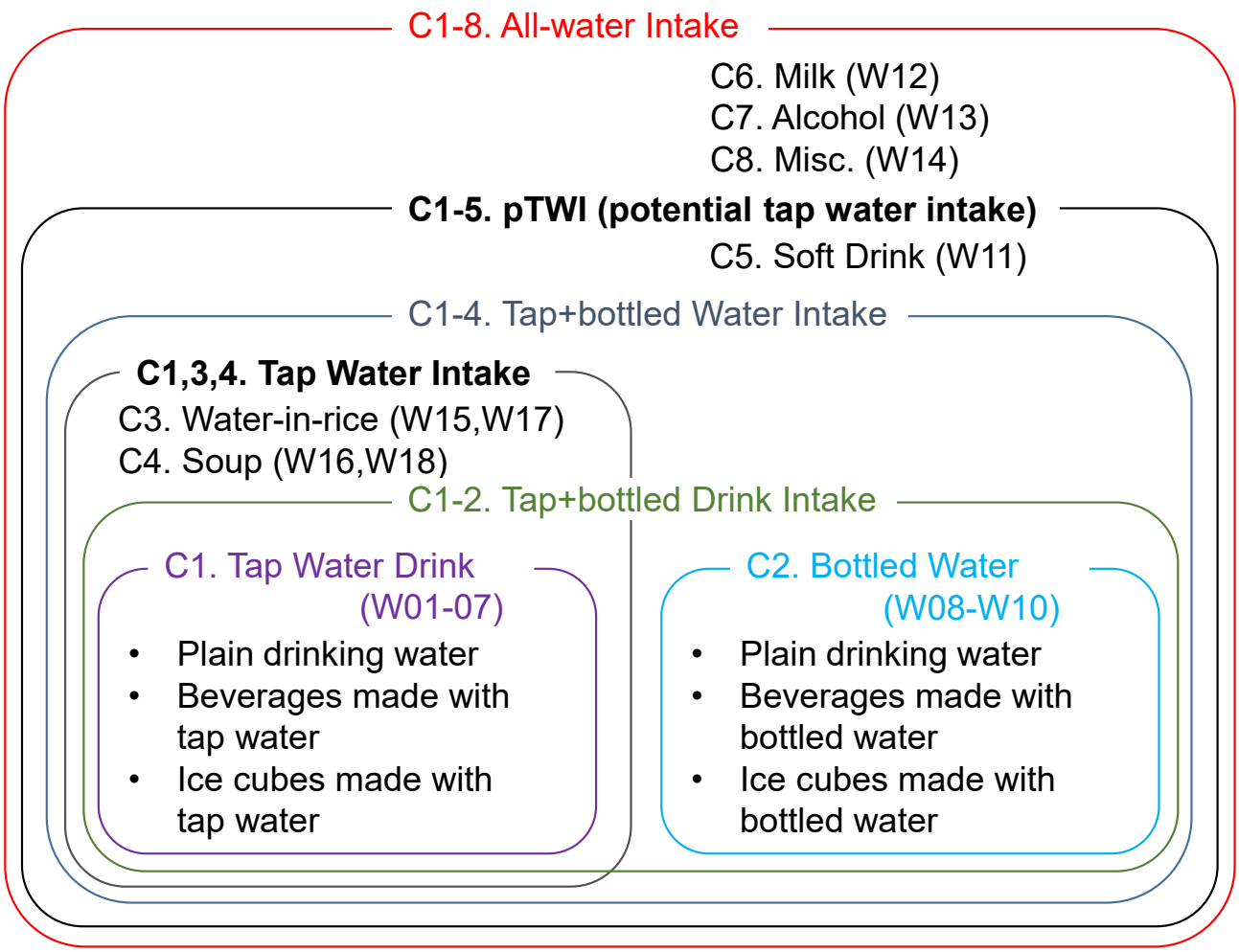


Figure S3. Relationship between water categories from C1 to C8 and combined categories defined in this study. Details of the water code (W01-18) can be seen in Figure S1.

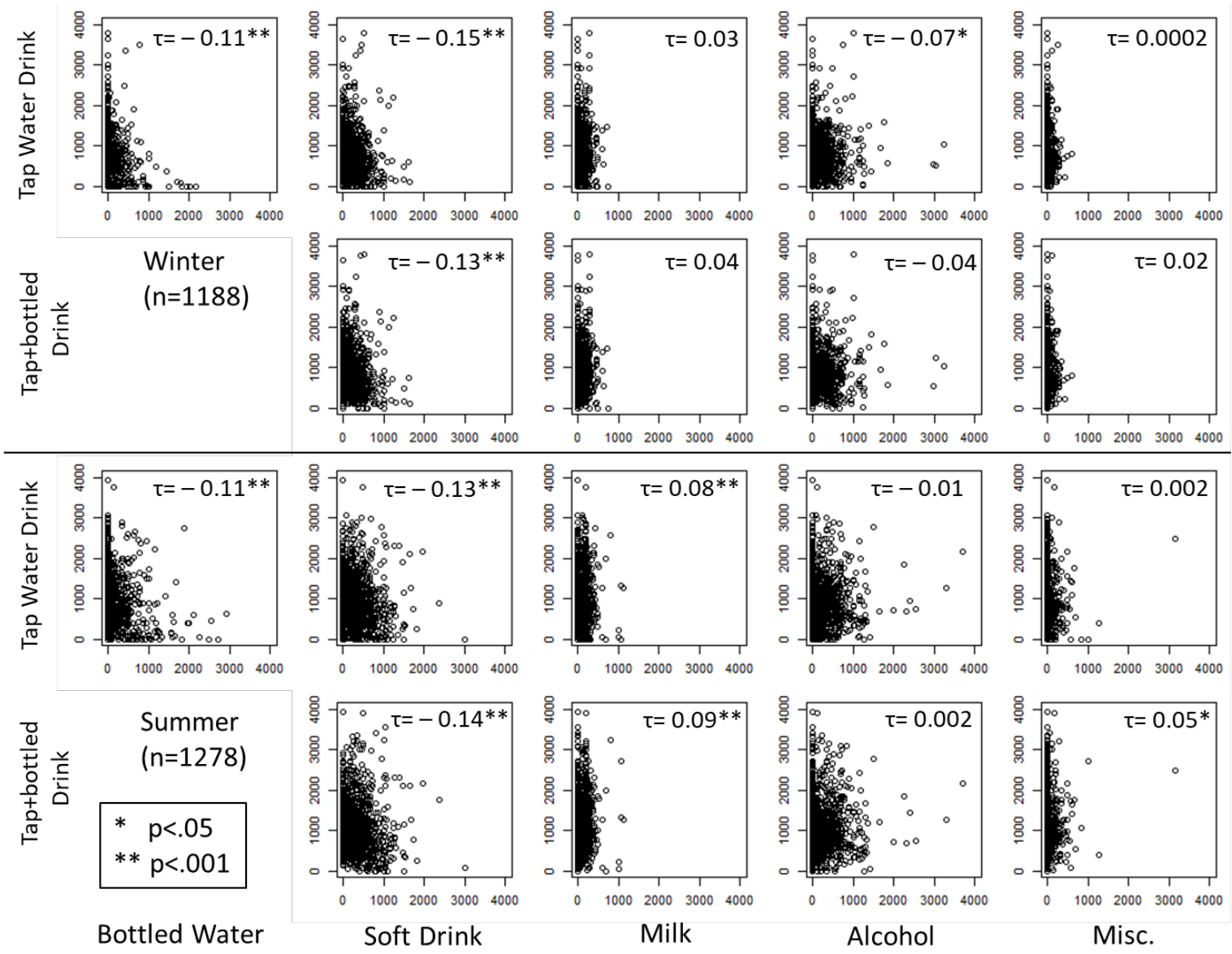
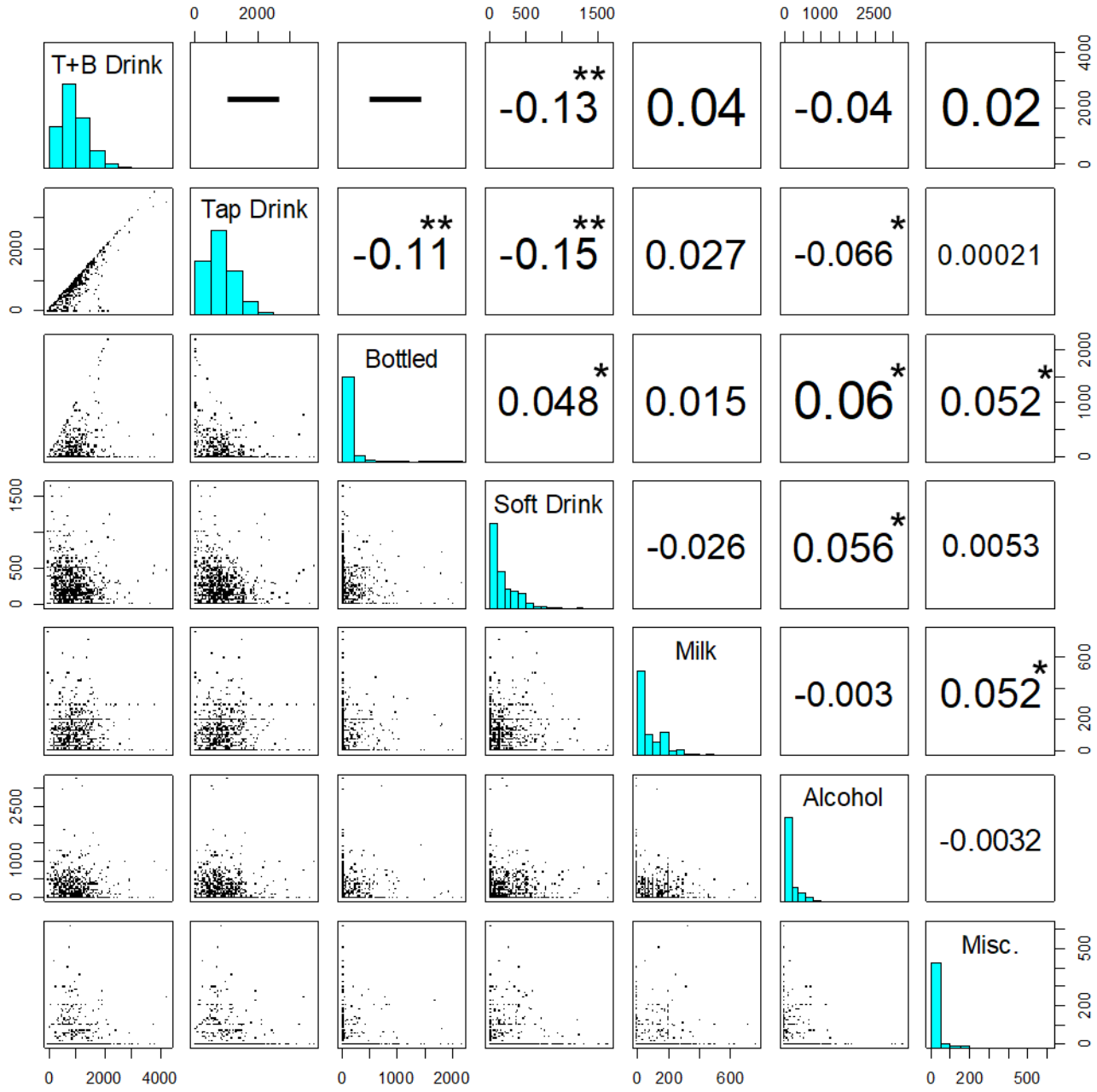


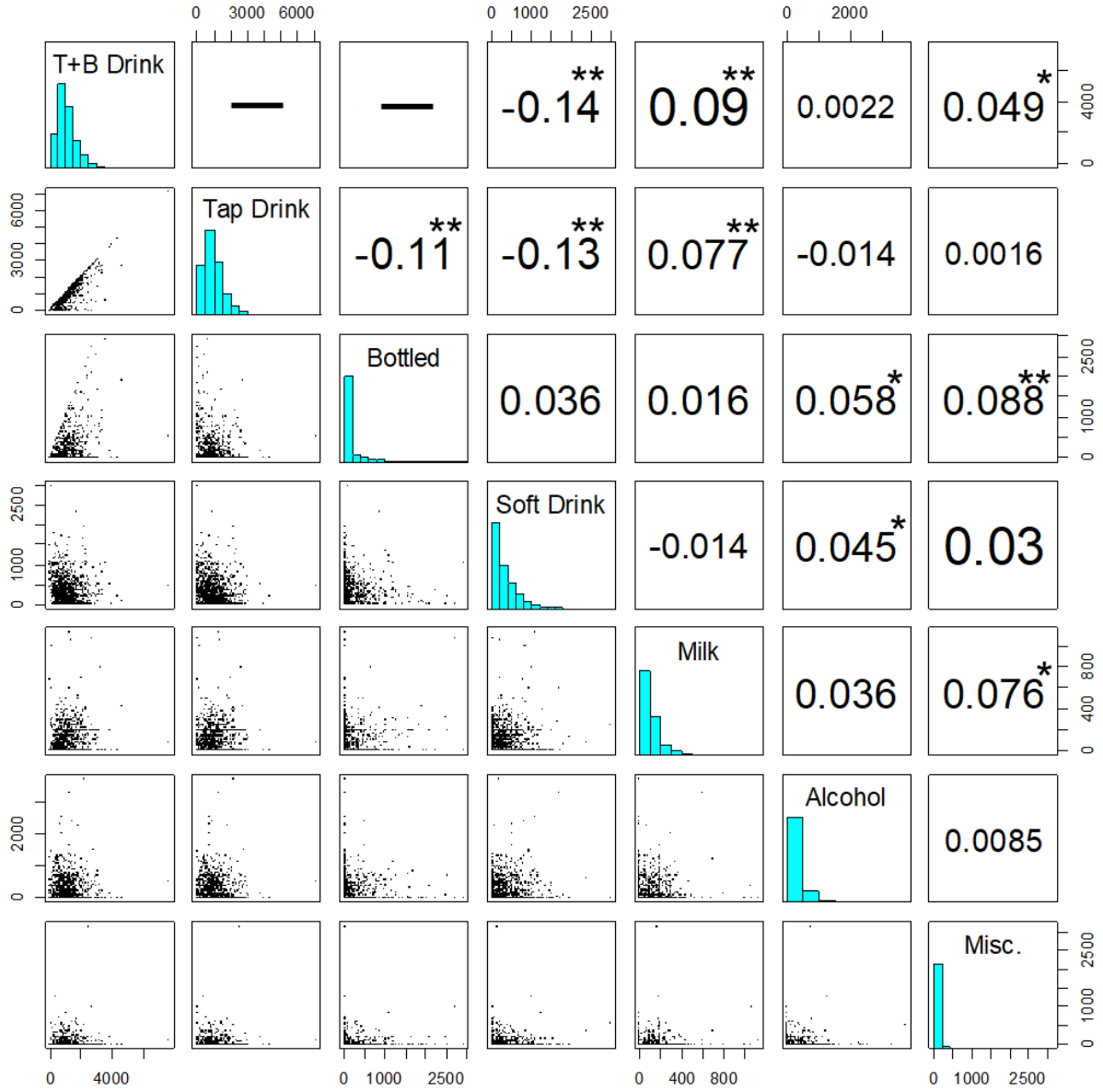
Figure S4. Scatter plots with Kendall's tau coefficients of the relationship between Tap Water Drink (or Tap+bottled Drink) and other kinds of beverages



* p<.05

** p<.001

Figure S5. Matrix of scatter plots and Kendall's tau coefficient in the winter survey



* p<.05

** p<.001

Figure S6. Matrix of scatter plots and Kendall's tau coefficient in the summer survey.

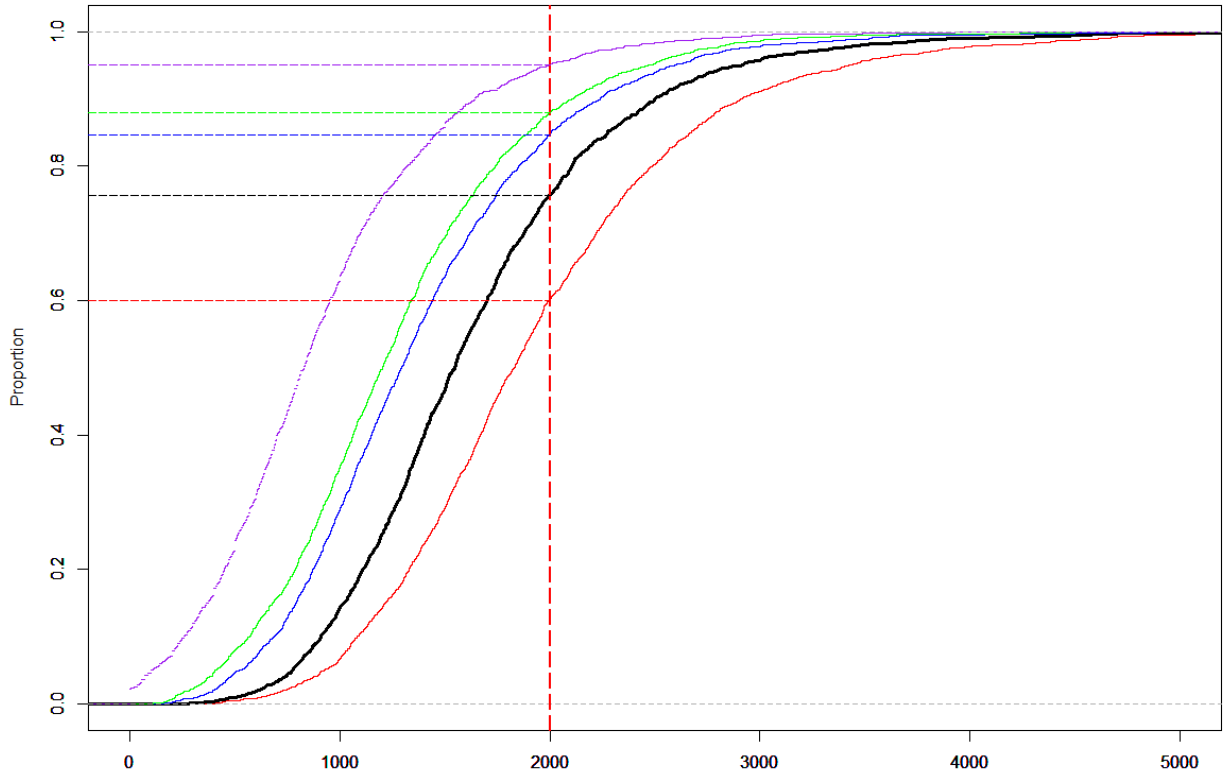


Figure S7. Cumulative distribution of water intakes of the combined categories and the category of Tap Water Drink. Red: All-water Intake, Black: pTWI, Blue: Tap+bottled Water Intake, Green: Tap Water Intake, Purple: Tap Water Drink Intake.

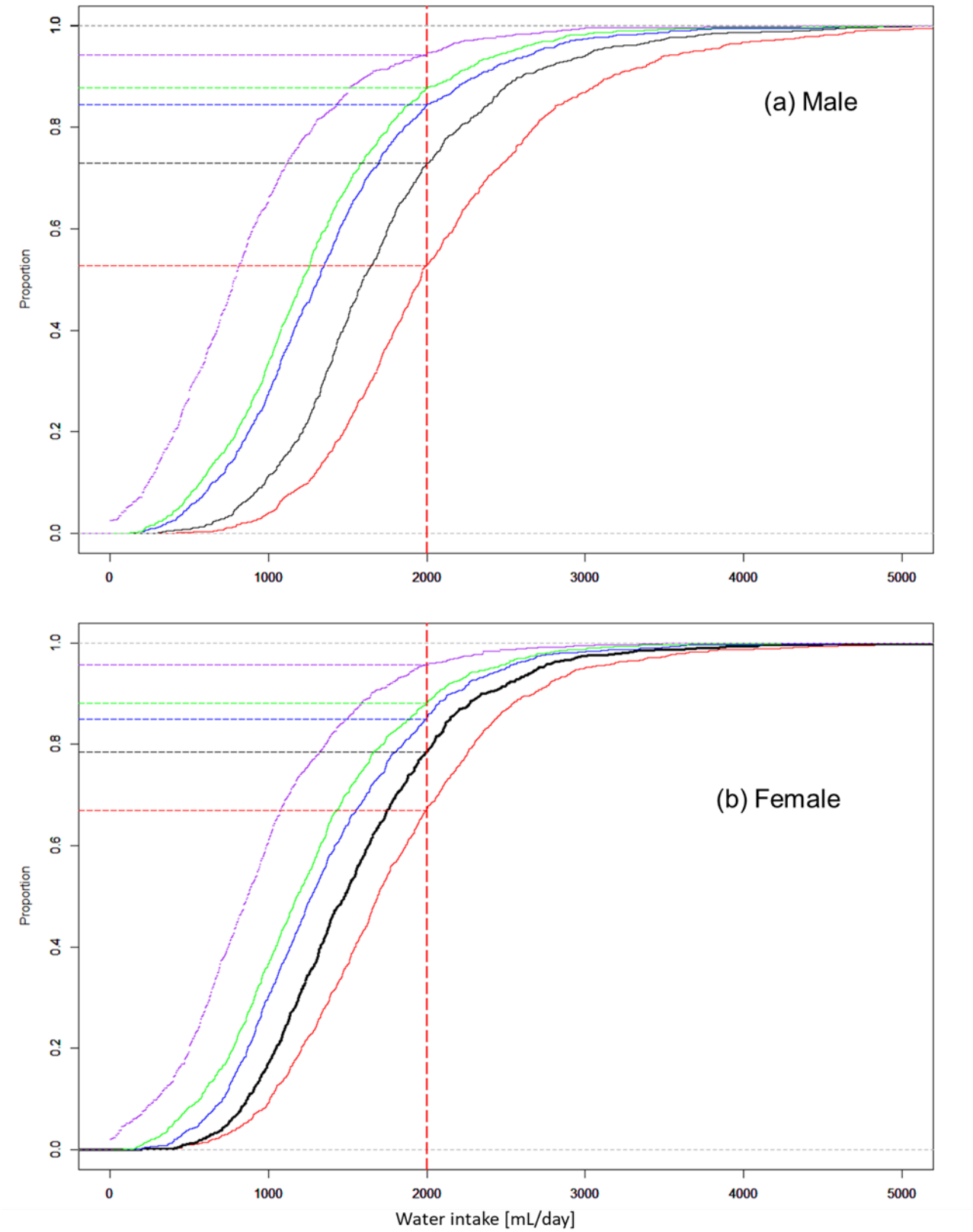


Figure S8. Cumulative distribution of water intakes of the combined categories and the category of Tap Water Drink (a: male, b: female). Red: All-water Intake, Black: pTWI, Blue: Tap+bottled Water Intake, Green: Tap Water Intake, Purple: Tap Water Drink Intake.