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Research Article

Health Risk Assessment of BPA Exposure via Multiple Exposure Pathways on Teenagers and Adults in Taiwan

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Abstract

Background: There are not many studies on the various pathways of BPA exposure in Taiwan, such as through non-canned food, canned food, bottled water, and tap water. This study therefore aims to calculate the Average Daily Dose (ADD) and Hazard Quotient (HQ) of BPA exposure *via* multiple pathways in teenagers and adults in Taiwan.

Methods: BPA intake *via* non-canned food consumption was estimated by using data from a long-term dietary intake of BPA. The BPA intake from seven types of canned food was studied based on a Food-Frequency Questionnaire (FFQ) combined with Taiwanese food BPA concentrations. We also reanalyzed the BPA concentrations in food products, canned foods, and drinking water.

Results: For the ADDs for male and female subjects aged 19–30, the BPA concentrations that males were exposed to *via* non-canned food, canned food, bottled water, and tap water were 921.7, 248.8, 157.1, and 58.3 ng/kg/day, respectively. Non-canned food thus contributed for 66.5% of total BPA intake; The BPA concentrations females were exposed to were 841.4, 151.2, 167.7, and 62.2 ng/kg/day, respectively, with non-canned food contributed for 68.8% of total BPA intake. Results show that the ADD from non-canned food was the highest *via* multiple exposure pathways.

Conclusion: The HQ values were all below one, whether from a single pathway or all pathways combined, suggesting that there was no predicted risk from these levels of exposure to BPA *via* these pathways.

Keywords: Average daily dose; Bisphenol A; Dietary exposure; Hazard quotient; Ingestion risk; Probability

Introduction

Bisphenol A (BPA) is the monomer used in the synthesis of Polycarbonate (PC) and epoxy resins. Polycarbonate is clear, transparent and tough, and is therefore widely used in packaging materials for food and drinks. Epoxy resins are chemically stable, flexible, tough, and show good adherence and thermal resistance, and are thus often used in the internal coatings of cans [1,2]. Humans can be exposed to BPA through respiration, skin contact, and ingestion, and ingestion is the predominant of these sources of exposure [2,3].

By combining data from the long-term Nutrition and Health Survey in Taiwan (NHSIT) and BPA concentrations reported from various food-testing projects, a previous study calculated the average daily dose (ADD; µg/kg/day) of BPA in the Taiwan population and compared this with the maximum acceptable dose of BPA was established at 0.05 mg/kg/day [4], whereas Health Canada established to Tolerable Daily Intakes (TDI) for BPA at 0.025 mg/kg/day [5]. Recently, the European Food Safety Authority (EFSA) has established a TDI value set at 0.004 mg/kg/day [6]. Our previous study had established the BPAexposure risk from long-term dietary intakes [7]. An important finding of that study was that the BPA concentrations of Taiwanese food were 10–100 times those in the other countries. Estimates of the ADDs of different male and female age groups indicated that the 97.5 percentile HQ of BPA intake in different age-sex groups were all below than one, suggesting that there was no risk from BPA exposure through general food consumption. Nevertheless, other sources of exposure, such as canned food, drinking water, bottled water, and thermal paper should not be ignored.

Liao and Kannan [8] measured the average BPA concentrations in food and canned food sold at grocery stores in the US and found that the ADDs for babies, toddlers, children, teenagers, and adults were 0.114, 0.195, 0.0912, 0.0485, and 0.0446 µg/kg/day, respectively. Barnes et al. [9] mentioned that the US Geological Survey collected untreated water samples from different areas, from drinking, surface, and underground water sources, and found an average BPA concentration of 1 µg/L, and the peak average concentration recorded was 1.9 µg/L.

In Taiwanese BPA study, Chen [10] estimated the BPA concentrations of 126 samples taken from beverages sold at various convenience stores. The beverages were sold in either PET bottles. The average BPA concentration with Standard Deviation (SD) of the bottled carbonated drinks (n = 108, with detection rate of 54% of the bottled samples) was 0.34 ± 0.11 µg/L. The bottled black-tea beverages, green-tea beverages, and fruit juices were estimated to be 1.92 ± 0.63 µg/L, 2.33 ± 1.05 µg/L, and 3.32 ± 0.41 µg/L, respectively. Lin [11] also assess the average BPA concentrations in canned food. The results shows that the average BPA concentrations in non-canned food were

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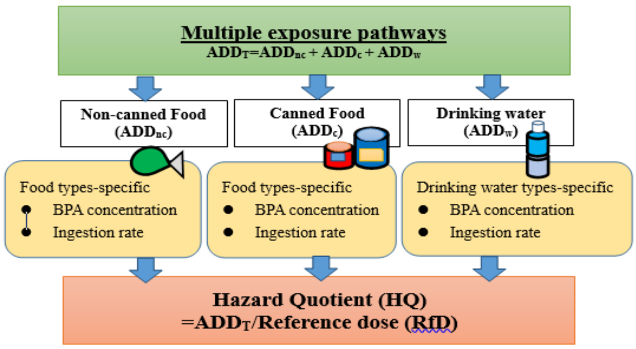

Figure 1: Conceptual framework of this present study.

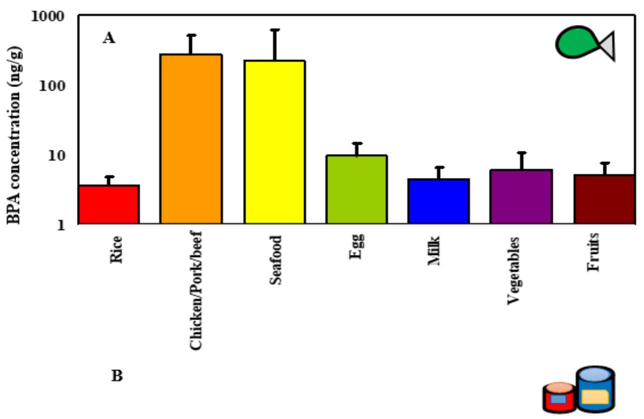

Figure 2: (A) Average level of Bisphenol A (BPA) concentration in different food categories (ng/g wet weight) in Taiwan regions (adopted from Lin [11]). (B) Average level of BPA concentration in canned food categories (ng/g) in Taiwan regions (adopted from Lin [11]).

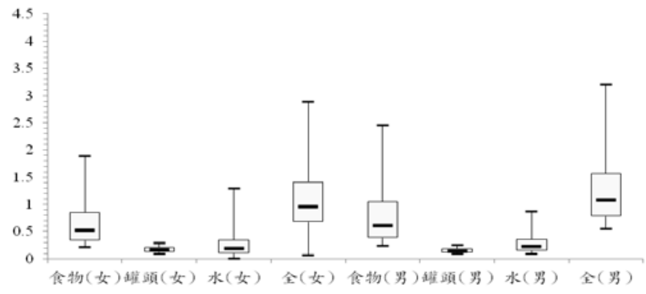

Figure 3: Box-and-whisker plot of estimated average daily dose (mg/kg/day) of BPA concentration by sex in different age groups of (A) 13-18 years, (B) 19-30 years, and (C) ≥31 years.

271.73 ng/g for poultry, 174.71 ng/g for fish and seafood, 6.15 ng/g for vegetables, 5.10 ng/g for fruits, 8.24 ng/g for eggs, 3.94 ng/g for milk, 1.23 ng/g for raw rice and 3.52 ng/g for cooked rice.

To sum up, this study aimed to calculate daily BPA exposure doses for various age and gender groups of the Taiwan population *via* multiple exposure pathways. We reanalyzed the published BPA concentration with ingestion rate for different age-gender groups. We also aimed to estimate the risk level of BPA exposure *via* non-canned food, canned food, and drinking water by combining the reference doses of several countries. Using HQ as a marker, which indicates the presence of non-carcinogenic health risks when it is higher than one and no risk when lower than one, we compared the effect of BPA exposure on the Taiwan population with the situation in other countries.

Materials and Methods

Dietary intake from non-canned food (ADDnc)

Figure 1 illustrates the framework of this study. Firstly, we estimated the exposure *via* non canned-food consumption. The ADDnc, measured as daily exposure dose (mg/kg/day), was calculated using the BPA concentrations in non-canned food and the amount of food consumed daily by the Taiwan population, by dividing the sum of the BPA concentrations of each food type by the average body mass of subjects in each population group (Equation 1).

$$ADD_{nc,i} = \Sigma_{nj}=1c_j \times IR_{ij} \times 10^{-6}/BWi$$

In that, i(= 1–3) represents the population age group (13–18, 19–30, and ≥ 31); C_j (ng/g wet weight) represents the BPA concentration in each non-canned food source and j (= 1–8) represents the eight food categories mentioned above; *IR* (intake rate; g/day) is the frequency of consumption of each food type by each age group; and *BW* (kg) is the body mass of each age group.

The estimation of *IR* was adopted from the Nutrition and Health Survey in Taiwan (NHSIT). The 1993–1996 NHSIT was used to conduct an overall study on the dietary, nutritional, and health conditions of residents over the age of four. We used only subjects who were independent samples aged between 13 and 18. Second, the 2005–2008 NHSIT was used to investigate changes in the nutrition and food sources of the Taiwan adult and elderly population by analyzing family meal plans and subjects' 24-hour food-consumption recall. The data used comprised the total amount and calorie-content of food consumed, and the three primary nutrients sources consumed. Study subjects were grouped into males and females aged 19–30 and ≥ 31.

We referred to Lin [11] for BPA concentrations in various foodstuffs. In that study, 12 samples were taken from each of 15 different food categories, which were grouped into poultry, livestock, fish and seafood, vegetables, fruits, eggs/dairy, and grains. Samples were purchased from supermarkets in Northern, Central, Southern and Eastern Taiwan. We combined the data for the various food categories and used the average BPA concentrations for non-canned food from the four regions for further calculations.

Dietary intake from canned food (*ADDc*)

Exposure *via* canned-food consumption. $ADD_{c,j}$, measured as daily exposure dose (mg/kg/day), was calculated based on the BPA concentrations in canned food (C_k, ng/g), and the size and number of cans of food consumed (IR*i,k*, g/day) by the Taiwan population per week, which was then divided by seven to obtain daily consumption. The sum of the BPA concentrations of each canned-food type was then divided by the average body mass (*BW*, kg) of subjects in each age group (Equation 2).

$$ADD_{nc,i} = \Sigma_{nj}=1c_j \times IR_{ij} \times 10^{-6}/BWi$$

The canned food BPA concentrations (C_k) were taken from Lin

Table 1: Intake rate (g/day) by age and sex groups of each non-canned food source in the Nutrition and Health Survey in Taiwan (NAHSIT 2001-2002, NAHSIT 1993-1996, and NAHSIT 2005-2008) and canned food source in FFQ survey in 2017.

	Non-canned food consumption rate (g/day)							
Age groups (sex)	Rice	Chicken	Pork/beef	Seafood	Egg	Milk	Vegetables	Fruits
13–18 (M)	710.0	123.3	123.3	38.5	38.5	120.0	190.0	144.4
13–18 (F)	445.0	76.7	76.7	28.0	27.5	96.0	170.0	144.4
19–30 (M)	338.5	47.7	117.3	62.7	43.5	52.8	231.0	149.2
19–30 (F)	277.5	31.5	91.7	39.9	28.1	74.4	212.0	178.1
≥ 31 (M)	420.8	23.2	95.1	71.2	32.8	115.6	342.1	266.8
≥ 31 (F)	294.9	14.4	56.1	56.9	21.7	120.1	331.4	296.5
	Canned food consumption rate (g/day)							
Age groups (sex)	Fish	Meat	Vegetables	Beans	Fruits	Jam	Beverage	
13–18 (M)	7.8	3.5	10.1	12.9	6.3	5.0	99.0	
13–18 (F)	3.6	1.6	8.1	8.2	2.2	2.3	53.5	
19–30 (M)	7.9	4.9	11.3	16.1	10.2	8.1	111.0	
19–30 (F)	3.3	1.4	7.2	7.6	1.6	2.1	65.9	
≥ 31 (M)	8.9	2.3	9.3	9.3	2.5	1.4	70.4	
≥ 31 (F)	4.5	2.1	9.4	9.0	3.1	1.9	28.3	

[11], in that $k = 1–7$ represents the seven canned food categories. In that study, BPA concentrations were calculated for samples of canned fish, meat, vegetables, beans, fruits, jams, and beverages, and were averaged for each of the four regions of Taiwan.

A computer-assisted online questionnaire survey for the period 2015–2016 conducted by Li et al. [12] was used to estimate the consumption rate in canned food $(IR_{i,k})$. The questionnaire in that survey was shared on major information platforms and contained questions about seven types of canned food (fish, meat, vegetables, beans, fruits, jams and beverages). Subjects in each age group (13–18, 19–30, and ≥ 31) were randomly selected. Each subject served as an independent sample. Questionnaires that contained unreasonable information (e.g., date of birth after the year in which the questionnaire was completed), that were received more than once, or that contained responses that made it impossible to judge the frequency and amount of food consumed (e.g., a response of "uncertain" to the question "How often do you consume this?") were excluded. In all, 1136 questionnaires were deemed valid.

Ingestion from drinking water (*ADDw*)

Exposure via drinking-water intake. This was estimated by calculating the daily exposure dose from water intake for the three age groups based on the BPA concentrations of different water sources (Equation 3).

$$ADD_{nc,i} = \Sigma_{nj} = 1 c_j \times IR_{ij} \times 10^{-3} / BWi$$

In the equation, IR (L/kg/day) represents water intake by different age groups from different water sources ($j=1, 2$). First, with respect to daily water intake (L/day), data from the Compilation of Exposure Factors in the General Taiwan Population [13] was used to provide an estimate of adult water intake for the four regions of Taiwan. The sample distribution was set according to the proportion of the population in each of the four regions of Taiwan. In total 2013 subjects, aged between 20 and 60, were randomly sampled from the population and treated as independent samples. Then, to calculate the daily water intake per kilogram body mass (L/kg/day), body mass data were taken from the Compilation of Exposure Factors in the General Taiwan Population [13].

Table 2: Sex-specific daily water intake and body weight. Exposure parameters were adopted from Compilation of Exposure Factors in the General Taiwan Population [13].

Age groups (sex)	Daily water intake (L/day) Mean ± SD	Body weight (kg) Mean ± SD
20–29 (M)	1.43±0.81	70.11±27.61
30–39 (M)	1.52±0.81	71.55±25.99
40–49 (M)	1.73±1.06	70.60±28.33
50+ (M)	1.58±0.97	69.30±44.22
20–29 (F)	1.24±0.73	56.73±59.19
30–39 (F)	1.35±0.72	56.99±40.57
40–49 (F)	1.31±0.92	59.04±43.35
50+ (F)	1.30±0.82	61.95±50.92

We referred to Chao [14] for BPA concentrations of bottled and tap water. That study used randomly selected samples of plastic-bottled water sold at major supermarkets. In total 48 bottles of water were sampled and analyzed. The mean concentration with Standard Deviation (SD) of BPA in the bottled and tap water was 7.70 ± 2.87 μg/L and 2.86 ± 3.72 μg/L, respectively.

Estimation of Hazard Quotations (HQ)

The HQ for all three pathways, HQT, was calculated by combining Equations (1–3) into Equation (4).

$$HQ_{T,I} = ADD_{nci} + ADD_{ci} + ADD_{wj} / RfD$$

An HQ value of < 1 indicates that the dose of exposure is lower than the reference doses, suggesting that no adverse effect on humans is expected. HQ values of > 1 suggest that some risk is expected. The exposure of each age group of the Taiwan population was calculated using the RfDs adopted by the US (0.05 mg/kg/day; [4]), Canada

Table 3: Average daily dose (ng/kg/day) by age and sex groups of each non-canned food source and canned food source.

	Average daily dose from non-canned food (ng/kg/day)							
Age groups (sex)	**Rice**	**Chicken**	**Pork/beef**	**Seafood**	**Egg**	**Milk**	**Vegetables**	**Fruits**
13–18 (M)	47.33	610.38	610.38	154.38	6.86	9.81	21.26	13.40
13–18 (F)	31.98	409.05	409.05	121.04	5.28	8.46	20.51	14.44
19–30 (M)	18.18	183.51	475.82	202.43	6.24	3.48	20.83	11.16
19–30 (F)	18.48	150.28	461.46	159.87	4.99	6.08	23.71	16.51
≥ 31 (M)	22.30	88.11	380.59	227.98	4.64	7.51	30.43	19.68
≥ 31 (F)	18.97	66.45	272.89	220.10	3.73	9.48	35.80	24.13
	Average daily dose from canned food (ng/kg/day)							
Age groups (sex)	**Fish**	**Meat**	**Vegetables**	**Beans**	**Fruits**	**Jam**	**Beverage**	
13–18 (M)	8.94	8.01	13.78	195.17	0.18	0.44	11.62	
13–18 (F)	7.65	9.63	13.10	206.42	0.24	0.61	11.09	
19–30 (M)	8.57	4.45	10.70	118.36	0.06	0.11	6.95	
19–30 (F)	4.76	4.26	12.81	143.49	0.07	0.24	7.25	
≥ 31 (M)	4.16	3.44	10.74	124.14	0.05	0.20	8.42	
≥ 31 (F)	5.29	4.90	13.22	140.50	0.09	0.17	3.43	
	Average daily dose from water intake (ng/kg/day)							
Age groups (sex)	**Bottled water**	**Tap water**						
20–29 (M)	157.1	58.3						
20–29 (F)	167.7	62.2						
≥ 30 (M)	175.9	65.3						
≥ 30 (F)	171.5	63.6						

(0.025 mg/kg/day; [5]), and the EU (0.004 mg/kg/day; [6]).

To sun up, we calculated the ADDs of BPA exposure per kilogram body mass of male and female subjects in the following three age groups: 13–18 (pathways: non-canned food and canned food), and 19–30 and ≥ 30 (pathways: non-canned food, canned food, bottled water, and tap water).

Sensitivity analysis

Sensitivity analysis is an approach to studying and analyzing how the conditions and output of a model vary against changes in system parameters. It can be used to determine which parameters have the greatest impact on the system or model. We assumed that the variability in the BPA concentrations of bottled water and the water intakes of the different population groups all exhibited a lognormal (LN) distribution, and conducted 10,000 Monte Carlo simulations, using the Crystal Ball software (Version 2000.2, Decisioneering Inc., Denver, CO, USA). The results revealed the probability distributions of the daily exposure doses and the hazard risk indices of multiple exposure sources.

Results and Discussion

BPA concentration and intake rate for multiple exposure pathways

Figure 2A shows the BPA concentrations in eight non-canned food items. Results indicated that chicken/pork/beef contained the highest amount of BPA, with the mean concentration and Standard Deviation (SD) of 271.7 ± 231.4 ng/g wet weight. The BPA concentration (mean ± SD) in seafood was 220.2 ± 389.03. BPA was detected in both in rice, eggs, milk, vegetables and fruits, but the levels were low; 3.66 ± 1.09, 9.8 ± 4.76, 4.5 ± 2.05, 6.2 ± 4.4, and 5.10 ± 2.41 ng/g, respectively. Figure 2B shows the BPA concentration in canned food items. The canned beans and canned meats with an average concentration (mean ± SD), 893.86 ± 328.5 ng/g and 135.70±73.57 ng/g respectively, were the higher BPA content among the investigated canned foods.

Table 4: Age specific average daily dose (ng/day/kg) from multiple exposure pathways.

Age groups (yrs)	Pathways	Female		Male	
		ADD	**%**	**ADD**	**%**
13–18	Non-canned food	863.4	**79%**	610.8	**78%**
	Canned food	238.1	21%	172.9	22%
19–30 20–29	Non-canned food	921.7	**66.51%**	841.4	**68.82%**
	Canned food	248.8	17.95%	151.2	12.36%
	Bottled water	157.1	11.33%	167.7	13.72%
	Tap water	58.3	4.21%	62.2	5.09%
≥ 31 ≥ 30	Non-canned food	781.2	**66.68%**	651.6	**61.80%**
	Canned food	149.2	12.73%	167.6	15.90%
	Bottled water	175.9	15.02%	171.5	16.27%
	Tap water	65.3	5.57%	63.6	6.04%

Table 1 lists the intake rate (g/day) in different age-sex groups from the NAHSIT 2001-2002, NAHSIT 1993-1996, and NAHSIT

Table 5: Age specific and sex specific Hazard Quotient (HQs).

Age groups (yrs)	Sex	Exposure pathways	*RfD* = 50 (ng/kg/day)		*RfD* = 25 (ng/kg/day)		*RfD* = 4 (ng/kg/day)	
13–18	M	Non-canned food	0.0173	0.022a	0.0345	0.044[a]	0.2159	0.275[a]
		Canned food	0.0048		0.0095		0.0595	
	F	Non-canned food	0.0122	0.016[a]	0.0244	0.031[a]	0.1527	0.196[a]
		Canned food	0.0035		0.0069		0.0432	
19–30	M	Non-canned food	0.0184	0.028[a]	0.0370	0.055[a]	0.2304	0.346[a]
		Canned food	0.0050		0.0099		0.0622	
		Water intake	0.0043		0.0086		0.0538	
	F	Non-canned food	0.0168	0.024[a]	0.0337	0.049[a]	0.2103	0.306[a]
		Canned food	0.0030		0.0060		0.0378	
		Water intake	0.0046		0.0092		0.0575	
≥ 31	M	Non-canned food	0.0156	0.023[a]	0.0312	0.047[a]	0.1953	0.293[a]
		Canned food	0.0030		0.0060		0.0373	
		Water intake	0.0048		0.0096		0.0603	
	F	Non-canned food	0.0130	0.021[a]	0.0261	0.042[a]	0.1629	0.264[a]
		Canned food	0.0034		0.0067		0.0419	
		Water intake	0.0047		0.0094		0.0588	

2005-2008 survey. Results show that the consumption of rice, vegetables, and fruits for all age-sex groups contributed the highest percentage. Besides, the intake rate for canned beverage contributed the predominate source, with the mean of 71.4 ng/day for all age-sex groups. Table 2 gives the age-specific body weight with mean and Standard Deviation (SD) which was adopted from Compilation of Exposure Factors in the General Taiwan Population [13].

Average daily dose for multiple exposure pathways

Table 3 shows that BPA exposure from livestock products was the highest of that from all types of non-canned food consumed. The exposure doses for the 13–18, 19–30, and ≥ 31 age groups were 610.4, 475.8, and 380.6 ng/kg/day respectively for males, and 409.1, 461.5, and 272.9 ng/kg/day respectively for females. Among the seven types of canned food considered, the BPA exposure from canned beans was the highest, and the average ADD of males aged 19–30 was 206.42 ng/kg/day; this was the highest of all the groups. The ADDs from the canned fruits and jams did not exceed 1 ng/kg/day for any group, and those from the canned fruits were the lowest of all the types of canned food. With respect to adult water intake, as shown in Table 3, the BPA exposure from bottled water was more than double that from tap water for all groups.

The Monte Carlo simulation results were plotted in box-plots, indicating the 5^{th}, 25^{th}, 50^{th}, 75^{th} and 95^{th} percentiles of the distributions (Figure 3). The 50^{th} percentiles of the ADDs from all exposure pathways were higher for males of all age groups (0.98, 1.28, and 1.08 μg/kg/day respectively for males, in age-group order from youngest to oldest, and 0.70, 1.04, and 0.96 μg/kg/day respectively for females).

Figure 3 shows that the ADD from non-canned food for age group 13–18 (0.72 μg/kg/day for males and 0.51 μg/kg/day for females) was higher than that from canned food (0.23 μg/kg/day for males and 0.20 μg/kg/day for females). The ADDs for males in age group 19–30 from all three exposure pathways were higher than those for females. The doses from non-canned food, canned food, and drinking water were 0.74 μg/kg/day, 0.24 μg/kg/day, and 0.20 μg/kg/day respectively for males, and 0.67 μg/kg/day, 0.146 μg/kg/day, and 0.148 μg/kg/day respectively for females. Note that the males received more BPA from canned food than from drinking water, but the reverse was true for females. The ADDs for males aged > 30 from non-canned food and drinking water (0.61 μg/kg/day and 0.23 μg/kg/day, respectively) were higher than those for females of that age group (0.53 μg/kg/day and 0.19 μg/kg/day, respectively). However, the opposite was true for the ADDs from canned food for this age group (0.14 μg/kg/day for males and 0.16 μg/kg/day for females).

BPA exposure doses compared between groups

For the comparisons of the total BPA ADDs from all three exposure pathways, the data were pooled into the age groups 19–30 and > 30 to facilitate comparison between different limited datasets. As shown in Table 4, BPA exposure from non-canned food was higher than from other pathways for all groups. The total ADDs from this pathway, from the youngest to the oldest age group, were 863.4, 921.7, and 781.2 ng/kg/day respectively for males, and 610.8, 841.38, and 651.55 ng/kg/day respectively for females. This accounted for over 60% of the total BPA ADD. The ADD from tap water was the lowest, not exceeding 7% for any group.

The ratios of the ADDs of BPA from non-canned food to canned food, for the three age groups in order of age, were 863.4/238.1, 921.7/248.8, and 781.2/149.2 ng/kg/day respectively for males, and 610.8/172.9, 841.4/151.2, and 651.6/167.6 ng/kg/day respectively for females. Liao and Kannan [8] combined fresh and canned food and divided them into nine categories (beverages; dairy; fat; fish and seafood; grains and cereal products; meat and meat products; fruits and canned fruits; vegetables and canned vegetables; and soup, eggs, and others) and found that the average exposure doses for different age groups (infants, toddlers, children, teenagers, and adults) were

144, 195, 91.2, 48.5, and 44.6 ng/kg /day, respectively. Our results revealed much higher ADDs, possibly due to the differences in the age groups used, or differences in the geological environment and measurement methods used.

Age- and sex-specific HQs

As shown in Table 5, the ratios between the exposure doses for each pathway and age group and the RfD values for the USA, EU, and Canada were all < 1, meaning that these exposure doses were lower than the reference doses. This was the case even for non-canned food, for which the exposure doses was the highest among the exposure pathways. This suggests that the BPA doses that humans are exposed to *via* any single pathway would not have significant adverse effects on their health. The HQ was < 1 even when the EFSA reference dose, 4 μg/kg/day (EFSA, 2015), which was the lowest, was used as the quotient, suggesting that the BPA exposure from each of the pathways considered does not carry any non-carcinogenic health risk.

However, due to the inconsistency in the age distributions of subjects in the data sources, the present study used relatively broad age groups. A more complete dataset, containing more precise age information and consumption data for all exposure pathways, would help to achieve better data uniformity and stronger statistical results.

Conclusion

From this study of the doses and risk levels of human exposure to BPA *via* multiple pathways (non-canned food, canned food, and drinking water), two preliminary research conclusions can be made. Firstly, of the three pathways, the BPA exposure from non-canned food was the highest for all gender–age groups. Secondly, the hazard quotient values, calculated using the reference BPA doses for the USA, EFSA, and Canada, were all < 1, even using the strictest reference dose (that for the EFSA, 4 μg/kg/day). This suggests that the BPA doses that the Taiwan population is currently exposed to through the three pathways considered will not result in any adverse health effects.

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Authors Contributions

SC initiated the study and WH conducted the calculation process. SC drafted the manuscript and writing of the manuscript, contributed the interpretation of the study results, and approved the final version of the manuscript submitted for publication.

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