

Supporting Information

A Survey of Phthalates and Parabens in Personal Care Products from the United States and its Implications for Human Exposure

Ying Guo ¹, Kurunthachalam Kannan ^{1*}

¹ Wadsworth Center, New York State Department of Health, and Department of Environmental Health Sciences, School of Public Health, State University of New York at Albany, Empire State Plaza, P.O. Box 509, Albany, New York 12201-0509, USA

***Corresponding author: Kurunthachalam Kannan**

Wadsworth Center

Empire State Plaza, PO Box 509

Albany, NY 12201-0509

Tel: 1-528-474-0015

Fax: 1-582-473-2895

E-mail: kkanan@wadsworth.org

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TABLE S1. Concentrations (µg/g, wet weight) of Phthalates and Parabens in Personal Care Products from New York State, U.S. (n = 170)

		DMP	DEP	DIBP	DBP	DNHP	BzBP	DEHP	MeP	EtP	PrP	BuP	BzP	HepP
Rinse-off products (n = 41)														
body wash (n = 11)	mean	0.01	270	0.07	0.07	0.07	0.01	0.48	757	94.5	47.2	65.0	0.01	0.01
	median	- ^a	-	-	-	-	-	0.21	-	-	-	-	-	-
	max	0.09	2420	0.39	0.36	0.49	0.13	1.92	8200	1040	488	714	0.11	0.07
	df ^b	1	5	5	3	3	1	10	5	2	5	1	1	1
shampoo (n = 9)	mean	0.07	393	0.02	0.02	-	0.03	0.35	133	0.24	1.77	0.41	-	0.08
	median	-	-	-	-	-	-	-	-	-	-	-	-	-
	max	0.32	3530	0.21	0.14	-	0.18	1.87	1180	2.14	14.0	1.88	-	0.69
	df	2	3	1	1	0	2	4	3	1	3	2	0	1
hair conditioner (n = 7)	mean	-	0.16	0.03	0.05	-	0.02	0.18	603	-	194	3.40	0.31	-
	median	-	-	-	-	-	-	0.14	-	-	0.59	-	-	-
	max	-	1.09	0.19	0.34	-	0.14	0.39	2610	-	1350	23.8	2.19	-
	df	0	1	1	1	0	1	7	3	0	4	1	1	0
face cleanser (n = 9)	mean	0.01	0.05	0.07	0.10	-	0.01	0.82	668	-	440	267	-	-
	median	-	-	-	-	-	-	0.15	-	-	0.46	-	-	-
	max	0.06	0.43	0.33	0.69	-	0.10	6.15	3730	-	1670	2090	-	-
	df	1	1	4	2	0	1	7	2	0	5	3	0	0
shaving gel (n = 5)	mean	-	-	-	-	-	-	0.69	2.12	0.02	0.45	0.05	-	-
	median	-	-	-	-	-	-	0.16	0.03	-	-	-	-	-
	max	-	-	-	-	-	-	2.70	10.5	0.11	2.26	0.26	0.01	-
	df	0	0	0	0	0	0	3	3	1	1	1	1	0
<i>Total</i>	<i>mean</i>	<i>0.02</i>	<i>159</i>	<i>0.04</i>	<i>0.05</i>	<i>0.02</i>	<i>0.02</i>	<i>0.50</i>	<i>482</i>	<i>25.4</i>	<i>143</i>	<i>76.7</i>	<i>0.06</i>	<i>0.02</i>
	<i>median</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>0.16</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>
	<i>max</i>	<i>0.32</i>	<i>3530</i>	<i>0.39</i>	<i>0.69</i>	<i>0.49</i>	<i>0.18</i>	<i>6.15</i>	<i>8200</i>	<i>1040</i>	<i>1670</i>	<i>2090</i>	<i>2.19</i>	<i>0.69</i>
	<i>Frequency</i>	<i>10%</i>	<i>24%</i>	<i>27%</i>	<i>17%</i>	<i>7%</i>	<i>12%</i>	<i>76%</i>	<i>39%</i>	<i>10%</i>	<i>44%</i>	<i>20%</i>	<i>7%</i>	<i>5%</i>
Leave-on products (n = 109)														
skin lotion (n = 23)	mean	0.39	2.47	0.17	0.29	0.13	0.03	0.96	912	81.3	489	109	-	-
	median	-	-	-	0.05	-	-	0.09	554	-	207	-	-	-
	max	5.68	52.3	1.45	2.40	2.96	0.56	11.3	2880	620	2030	845	0.06	-
	df	3	9	8	13	1	3	13	21	11	22	11	6	1
hair care (n = 6)	mean	3.71	179	-	-	0.14	-	0.12	561	1.61	0.16	0.01	-	-
	median	-	0.05	-	-	-	-	0.04	0.04	-	-	-	-	-
	max	12.1	897	-	0.01	0.86	-	0.56	3370	9.65	0.98	0.07	-	-
	df	2	5	0	1	1	0	4	3	2	1	1	0	0

perfume (n = 12)	mean	-	3420	0.72	0.21	-	6.70	2.71	1.57	0.32	0.23	0.47	0.05	0.01
	median	-	3930	-	0.07	-	-	1.37	-	-	-	-	-	-
	max	-	7980	8.61	0.97	-	78.3	12.2	17.3	3.88	2.79	5.63	0.46	0.11
	df	0	12	2	8	0	3	12	4	1	1	1	2	2
skin toner (n = 9)	mean	0.03	2.14	-	-	-	0.01	0.18	159	1.34	41.0	0.76	-	-
	median	-	0.42	-	-	-	-	0.17	0.25	-	-	-	-	-
	max	0.28	13.1	-	-	-	0.06	0.60	1230	9.60	367	5.57	-	-
	df	1	8	0	0	0	1	6	5	2	4	2	0	0
deodorant (n = 14)	mean	1.51	0.20	0.02	0.03	2.69	0.01	4.98	0.08	0.04	0.13	0.02	-	-
	median	-	0.02	-	-	-	-	-	-	-	-	-	-	-
	max	20.6	1.15	0.14	0.26	37.7	0.14	65.3	0.92	0.61	1.45	0.27	-	-
	df	2	7	4	2	1	1	5	3	1	3	1	0	0
creams (n = 33)														
<i>face cream</i> (n = 21)	mean	0.52	0.01	0.08	0.03	-	-	0.40	885	246	221	81.6	-	-
	median	-	-	-	-	-	-	0.15	0.33	-	0.18	-	-	-
	max	10.7	1.64	1.48	0.31	-	-	2.45	3540	2270	2720	1500	-	-
	df	3	5	2	5	0	0	15	17	6	13	4	0	0
<i>eyeliner cream</i> (n = 4)	mean	-	0.12	-	-	-	-	0.64	5.83	1.11	1.01	-	-	-
	median	-	0.08	-	-	-	-	0.54	1.67	0.38	0.11	-	-	-
	max	-	0.30	-	-	-	-	1.46	20.0	3.69	3.81	-	-	-
	df	0	2	0	0	0	0	3	3	2	3	0	0	0
<i>hand cream</i> (n = 3)	mean	-	36.1	0.15	0.11	-	0.03	0.45	622	-	39.5	-	-	-
	median	-	-	-	-	-	-	0.48	443	-	-	-	-	-
	max	-	108	0.45	0.34	-	0.09	0.53	1420	-	119	-	-	-
	df	0	1	1	1	0	1	3	3	0	1	0	0	0
<i>sunscreen</i> (n = 5)	mean	-	0.02	-	0.02	-	-	-	908	419	607	0.05	0.62	-
	median	-	-	-	-	-	-	-	20.7	-	1.74	-	-	-
	max	-	0.08	-	0.98	-	-	-	2930	2100	2120	0.17	3.12	-
	df	0	1	0	2	0	0	0	5	1	5	2	1	0
lipstick (n = 4)	mean	0.04	1.95	0.30	0.55	-	0.05	1.79	3.92	0.12	98.7	318	0.01	-
	median	-	0.43	0.20	0.49	-	-	0.36	2.31	0.05	43.9	1.14	-	-
	max	0.18	6.92	0.80	1.22	-	0.20	6.45	11.0	0.37	307	1270	0.02	-
	df	1	3	3	3	0	1	3	4	3	4	4	3	0
nail polish (n = 8)	mean	0.03	1.28	11.0	5280	-	0.70	22.5	0.04	0.04	0.15	0.01	-	-
	median	-	0.18	0.14	6.41	-	0.05	6.92	-	-	-	-	-	-
	max	0.22	9.22	58.9	27400	-	2.20	135	0.26	0.33	1.16	0.11	-	-
	df	1	5	5	7	0	4	8	2	1	1	1	0	0
<i>Total</i>	mean	0.59	389	0.95	388	0.38	0.80	2.99	466	84.2	182	50.6	0.03	-
	median	-	0.04	-	-	-	-	0.16	0.25	-	0.06	-	-	-
	max	20.6	7980	58.9	27400	37.7	78.3	135	3540	2770	2720	1500	3.12	0.11
	Frequency	12%	53%	23%	39%	3%	13%	66%	64%	28%	53%	26%	11%	3%

Baby care products (n = 20)														
shampoo (n = 4)	mean	0.17	0.02	0.03	0.02	-	0,04	0.09	0.01	-	-	-	-	-
	median	-	-	0.02	0.02	-	-	0.05	-	-	-	-	-	-
	max	0.68	0.08	0.09	0.05	-	0.14	0.26	0.05	-	-	-	-	-
	df	1	1	2	2	0	1	2	1	0	0	0	0	0
lotion and oil (n = 4)	mean	-	-	-	-	-	-	0.33	392	113	89.2	0.03	-	-
	median	-	-	-	-	-	-	0.05	0.04	-	0.41	0.02	-	-
	max	-	-	-	-	-	-	1.22	1570	453	356	0.07	-	-
	df	0	0	0	0	0	0	2	2	2	3	2	0	0
sunscreen (n = 6)	mean	-	12.1	-	0.02	-	-	0.02	1360	376	849	36.9	2.56	-
	median	-	-	-	-	-	-	-	1260	1.71	887	0.04	1.20	-
	max	-	42.4	0	0.11	-	-	0.10	2800	2020	2020	221	8.18	-
	df	0	2	0	1	0	0	1	6	4	6	3	3	0
diaper cream (n = 3)	mean	0.17	-	-	0.07	-	-	3.87	591	0.11	211	-	-	-
	median	-	-	-	-	-	-	2.41	0.30	-	0.1	-	-	-
	max	0.51	-	-	0.22	-	-	8.22	1770	0.32	632	-	-	-
	df	1	0	0	1	0	0	3	3	1	2	0	0	0
powder (n = 1)		-	1.57	-	-	-	-	-	-	-	-	-	0.03	-
<i>Total</i>	<i>mean</i>	<i>0.06</i>	<i>4.12</i>	<i>0.01</i>	<i>0.02</i>	<i>-</i>	<i>0.01</i>	<i>0.74</i>	<i>640</i>	<i>151</i>	<i>338</i>	<i>12.3</i>	<i>0.86</i>	<i>-</i>
	<i>median</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>0.20</i>	<i>-</i>	<i>0.13</i>	<i>-</i>	<i>-</i>	<i>-</i>
	<i>max</i>	<i>0.68</i>	<i>42.4</i>	<i>0.09</i>	<i>0.22</i>	<i>-</i>	<i>0.14</i>	<i>8.22</i>	<i>2800</i>	<i>2020</i>	<i>2020</i>	<i>221</i>	<i>8.18</i>	<i>-</i>
	<i>Frequency</i>	<i>10%</i>	<i>20%</i>	<i>10%</i>	<i>20%</i>	<i>0</i>	<i>5%</i>	<i>40%</i>	<i>60%</i>	<i>35%</i>	<i>55%</i>	<i>25%</i>	<i>15%</i>	<i>0</i>

^a - = not detected or concentrations below 0.01 µg/g; ^b detection frequency or number of sample with concentrations above 0.01 ng/g

Table S2. Parameters Used to Estimate Human Exposure of Phthalates and Parabens from PCPs for U.S. Female and Baby (1-3);

	M , Amount applied per day (g)	f_l , retention factors average
body wash (n = 11)	12.9	0.001
hair shampoo (n = 9)	10.75	0.01
hair conditioner (n = 7)	10.62	0.01
face cleanser (n = 9)	3.33	0.01
body lotion (n = 23)	7.63	1
hair care (n = 6)	3.74	0.01
perfume (n = 12)	0.34	1
toner (n = 9)	0.45	1
deodorant (n = 14)	0.59	1
face cream	1.53	1
lip stick (n = 4)	0.013	1
nail polish (n = 8)	0.589	0.25
baby shampoo (n = 4)	0.1377	0.01
baby lotion or oil (n = 4)	2.041	1
baby diaper cream (n = 34)	2.408	1
baby powder (n = 1)	1.2	0.5
f_2 , human skin absorption factor	For female adults, 0.0096, 0.0207, 0.0121, 0.0157, 0.0071 and 0.0011 was used for DMP, DEP, DIBP, DBP, BzBP and DEHP, respectively. For baby, the value for each individual phthalate was two times to that used for female adults.	

TABLE S3. Parameters and Sources Used to Estimate Human exposure to phthalates through inhalation uptake

$$DI_{inhalation} = \frac{C_{air} f_1 f_2}{M_1} r_{uptake}$$

	Indoor air (ng/m ³)					Outdoor air (ng/m ³)				
	DEP	DIBP	DBP	BzBP	DEHP	DEP	DIBP	DBP	BzBP	DEHP
infants	330	130	140	6.8	68	3.9	3.6	22.3	1.1	10
toddlers	330	130	140	6.8	68	3.9	3.6	22.3	1.1	10
adults	2330	130	140	6.8	68	3.9	3.6	22.3	1.1	10

Where, C_{air} is phthalate concentration (mg/m³), f_1 is the indoor exposure fraction (hours spent over a day), f_2 is the inhalation rate (m³/day), M_1 is the body weight (kg), r_{uptake} is the uptake rate.

Phthalate concentrations of indoor air were the median values from north California (4) and of outdoor air were from references of (1,4); values of f_1 for infants, toddlers, and adults are 0.88, 0.79 and 0.88 (5); f_2 is 4.5, 7.6 and 13.3 m³/day for infants, toddlers, and adults from USEPA (5,6); for M_1 , a average value of 75.0 kg of U.S. females (adults, 20-60 years), 7.8 kg of infants and 12.6 kg of toddlers was used (2) and for r_{uptake} , 1 and 0.75 was used for infants and toddlers and adults, respectively.

TABLE S4. Estimated Total Human Daily Intakes of Phthalates from Urinary Metabolites (µg/kg-bw/day)

Based on the concentrations of phthalate metabolites in urine, a simple steady-state exposure model, as shown in eqn (1) was used to estimate human exposure levels:

$$DI = CV \times \frac{M_1}{M_2} \times \frac{1}{f} \times \frac{1}{W} \text{----- (1)}$$

where, DI is the total daily intake of phthalate (µg/kg bw/day), *C* is the urinary phthalate metabolite concentration (µg/L), *V* is human daily excretion volume of urine (L/day), *M*₁ and *M*₂ are the respective molecular weights of parent phthalate and its metabolite (g/mol), *W* is body weight (kg), and *f* is the molar fraction of the urinary monoester metabolite excreted in relation to the ingested amount of phthalate.

For *V*, we assumed a volume of 0.5 L for ages < 10 and 2.0 L for other age groups; for *f*, the values for mMP, mBP, mEP, mBzP, mEHHP, mEOHP, and mEHP were 0.69, 0.69, 0.70, 0.73, 0.23, 0.15, and 0.059, respectively (7,8).

		DMP	DEP	DIBP	DBP	BzBP	DEHP
USA	infants	—	1.7	0.1	0.8	0.5	2.6
	toddlers	—	1.7	0.1	0.8	0.5	2.6
	adults	—	5.5	0.1	0.8	0.5	2.1

value of DEP of infants and toddlers is estimated from 328 children 6-11 years of age by reference (9) , and of adults is estimated from 2772 persons 6 to > 20 years of age by reference (9); value of DEHP of infants and toddlers is estimated from 392 children 6-11 years of age by reference (9), and of adults is estimated from 2772 persons 6 to > 20 years of age by reference (9); value of DIBP, DBP and BzBP for all age group is estimated from 214 pregnant woman by reference (7).

TABLE S5. Cumulative Exposure Doses of Phthalates from Various Pathways for the U.S. Populations (µg/kg-bw/day)

	Inhalation uptake ^a		Oral uptake ^b		Dermal uptake ^c		Total 1 ^d	Total 2 ^e	Ratio (total 1/total 2)
	indoor	outdoor	food	dust	PCPs	dust			
<i>Infants</i>									
DEP	0.17	0.0003	0.020	0.0071	0.0050	— ^f	0.20	1.7	12%
DIBP	0.066	0.0002	0.043	0.0134	—	—	0.12	0.1	123%
DBP	0.071	0.0015	0.064	0.046	0.0007	0.0003	0.18	0.8	23%
BzBP	0.0035	0.0001	0.188	0.0743	—	0.0002	0.27	0.5	53%
DEHP	0.035	0.0007	4.203	1.07	0.0028	0.0004	5.31	2.6	204%
<i>Toddlers</i>									
DEP	0.16	0.0005	0.020	0.0100	0.0041	—	0.19	1.7	11%
DIBP	0.062	0.0005	0.043	0.0188	—	—	0.12	0.1	124%
DBP	0.067	0.0028	0.064	0.0645	0.0004	0.0002	0.20	0.8	25%
BzBP	0.0032	0.0001	0.188	0.104	—	0.0002	0.30	0.5	59%
DEHP	0.032	0.0013	4.203	1.50	0.0017	0.0003	5.74	2.6	221%
<i>Adult Females</i>									
DEP	0.039	0.0001	0.033	0.0014	0.35	—	0.42	5.5	8.0%
DIBP	0.015	—	0.020	0.0026	0.0005	—	0.038	0.1	38%
DBP	0.016	0.0004	0.184	0.0088	0.16	—	0.37	0.8	46%
BzBP	0.0008	—	0.085	0.0143	0.0003	—	0.10	0.5	20%
DEHP	0.0080	0.0002	0.673	0.206	0.0002	0.0001	0.89	2.1	42%

^a see Table S2; ^b data for food were from *ref*(10) and for dust were from *ref*(11); ^c data for dust were from *ref*(11); ^d sum of inhalation, oral intake and dermal intake; ^e total exposure doses estimated from biomonitoring studies, see Table S3; and ^f exposure dose was below 0.0001 µg/kg-bw/day.

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