

## Preplanned Studies

## Exposure to Chlorinated Paraffins in the Sixth Total Diet Study — China, 2016–2019

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### Summary

#### What is already known about this topic?

Short-chain chlorinated paraffins (SCCPs) are persistent organic pollutants that are toxic to organisms. Medium-chain chlorinated paraffins (MCCPs) have similar properties. Chlorinated paraffins (CPs) may be biomagnified through the food chain, thereby threatening human health.

#### What is added by this report?

The concentrations of SCCP and MCCP in each food sample were 5–265 and 4–306 ng/g, respectively. The estimated dietary exposure to CPs was relatively lower than the threshold set in the current guidelines.

#### What are the implications for public health practice?

The production and use of SCCP and MCCP have not been prohibited in China yet. Further studies are needed to assess the health risks through dietary exposure to CPs.

Short-chain chlorinated paraffins (SCCPs) are persistent organic pollutants listed in the Stockholm Convention. Medium-chain chlorinated paraffins (MCCPs) structurally similar to SCCPs have similar toxicity. China is the largest producer and consumer of chlorinated paraffins (CPs) in the world. Dietary intake is considered the main route of human exposure to CPs (1).

The China National Center for Food Safety Risk Assessment launched the Sixth China Total Diet Study (TDS). The dietary survey methods, sample collection, and processing methods are referenced in the Foreword in this special issue (2). The concentrations of SCCP and MCCP in each food sample in the Sixth China TDS were 5–265 ng/g wet weight and 4–306 ng/g wet weight, respectively (Table 1). Among the 8 food categories, the highest average concentrations of SCCP and MCCP were found in meats at 63 ng/g wet weight and 70 ng/g wet weight, respectively. The average SCCP and MCCP concentrations in animal-origin foods were generally higher than those in plant-origin

foods. A possible reason could be that SCCPs and MCCPs are compounds with high octanol-water partition coefficients and tend to accumulate in the fatty tissues of animals. The highest total concentrations of SCCP in eight food categories were detected in the provincial-level administrative divisions (PLADs) of Hebei, Henan, and Shanxi, while those of MCCP were found in Henan, Hebei, and Ningxia. Overall, the total concentrations of SCCP and MCCP from the eight food samples in the northern PLADs were higher than those in the southern PLADs in this study. The total estimated dietary intakes (EDI) for SCCP and MCCP in eight food categories were listed in Table 2, which ranged from 270 to 2,844 ng/kg body weight per day (average: 1,041 ng/kg body weight per day) and 192 to 2,927 ng/kg body weight per day (average: 918 ng/kg body weight per day), respectively.

## DISCUSSION

In this study, the average concentrations of SCCP in the eight food categories ranged from 27 ng/g in potatoes to 63 ng/g in meats. The average MCCP concentrations in the present study ranged from 18 ng/g in potatoes to 70 ng/g in meats. The average levels of SCCP from dairy products, meats, eggs, and cereals in this study were much lower than those found in the Republic of Korea, whereas the average levels of SCCP from vegetables in this study were higher than those found from vegetables in the Republic of Korea (15.1 ng/g wet weight) (3). However, the average CP levels in the eight food categories in China were considerably higher than those in southern Germany (4), Sweden (5), and Japan (6), which may be attributed to the higher production and use of CP in China. In general, dietary exposure to CPs in China was equal or higher than that of other studies in the world. A decrease in the production and use of CPs may be helpful to reduce human dietary exposure to CPs.

In the Sixth TDS, the average concentrations of

TABLE 1. Concentrations of short-chain chlorinated paraffin (SCCP) and medium-chain chlorinated paraffin (MCCP) in ng/g wet weight in the Sixth Total Diet Study — China, 2016–2019.

Chlorinated paraffins	PLADs	Cereals	Vegetables	Potatoes	Legumes	Eggs	Dairy products	Meats	Aquatic foods	Total
SCCPs	Heilongjiang	265	50	12	44	22	28	31	44	496
	Hebei	39	73	15	162	36	83	39	55	502
	Shanxi	122	43	25	19	69	89	98	34	499
	Ningxia	30	70	28	89	55	85	35	23	415
	Guangdong	41	32	38	79	27	117	78	60	472
	Qinghai	38	69	40	35	73	71	78	72	476
	Shandong	63	40	36	18	27	72	71	142	469
	Shaanxi	36	18	14	28	101	82	58	62	399
	Sichuan	47	20	40	51	102	53	89	12	414
	Liaoning	71	46	44	52	11	50	81	12	367
	Beijing	29	18	30	50	28	35	25	22	237
	Jilin	22	27	36	50	53	18	84	86	376
	Inner Mongolia	43	20	28	51	54	14	49	77	336
	Gansu	24	66	40	43	81	9	27	34	324
	Henan	162	64	31	86	14	69	48	26	500
	Shanghai	21	13	17	16	28	13	39	40	187
	Fujian	26	21	35	75	69	34	81	75	416
	Jiangxi	5	12	14	12	53	46	32	42	216
	Jiangsu	9	113	17	44	65	22	116	56	442
	Zhejiang	23	55	27	76	70	43	98	71	463
Hubei	11	42	17	83	61	64	80	87	445	
Guangxi	9	24	19	69	74	30	45	47	317	
Hunan	38	19	23	12	81	39	80	36	328	
Guizhou	13	34	28	93	80	47	50	45	390	
Mean	49	41	27	56	56	51	63	53	395	
MCCPs	Heilongjiang	306	29	12	32	36	19	35	46	515
	Hebei	31	70	8	202	40	114	51	72	588
	Shanxi	66	30	14	14	51	70	147	40	432
	Ningxia	28	72	22	104	59	209	48	37	579
	Guangdong	40	21	15	111	31	104	81	82	485
	Qinghai	39	70	40	28	177	54	100	58	566
	Shandong	99	25	31	16	34	43	74	161	483
	Shaanxi	29	14	7	53	79	86	114	61	443
	Sichuan	47	18	20	78	47	39	76	12	337
	Liaoning	72	27	42	38	29	71	97	17	393
	Beijing	23	15	12	40	29	42	30	33	224
	Jilin	11	18	70	44	65	33	108	71	420
	Inner Mongolia	38	13	17	58	84	19	62	86	377
	Gansu	25	80	23	46	92	15	32	33	346
	Henan	141	69	24	110	97	111	58	16	626
	Shanghai	6	12	10	5	23	5	13	12	86
	Fujian	20	18	6	33	48	13	53	47	238
	Jiangxi	12	10	4	12	53	15	37	36	179
	Jiangsu	21	66	11	12	87	6	103	17	323
	Zhejiang	13	16	8	16	23	17	57	30	180
Hubei	10	27	10	36	51	23	95	72	324	
Guangxi	11	19	6	34	40	7	71	31	219	
Hunan	21	20	6	12	30	13	67	26	195	
Guizhou	13	20	8	35	62	11	71	53	273	
Mean	47	32	18	49	57	47	70	48	368	

Abbreviations: PLADs=provincial-level administrative divisions; SCCPs=short-chain chlorinated paraffins; MCCPs=medium-chain chlorinated paraffins.

TABLE 2. Estimated dietary intake in ng/kg body weight per day of short-chain chlorinated paraffin (SCCP) and medium-chain chlorinated paraffin (MCCP) in food samples in the Sixth Total Diet Study — China, 2016–2019.

Chlorinated paraffins	PLADs	Cereals	Vegetables	Potatoes	Legumes	Eggs	Dairy products	Meats	Aquatic foods	Total
SCCPs	Heilongjiang	2,305	254	15	32	14	6	29	19	2,675
	Hebei	468	340	15	147	18	32	29	8	1,057
	Shanxi	2,009	211	47	21	23	59	213	3	2,587
	Ningxia	315	174	44	50	11	21	26	1	642
	Guangdong	297	120	15	35	10	68	129	49	723
	Qinghai	462	340	64	4	15	60	88	4	1,038
	Shandong	633	282	21	40	10	38	133	113	1,271
	Shaanxi	436	82	25	37	35	25	33	4	678
	Sichuan	724	96	40	55	24	11	182	2	1,132
	Liaoning	694	238	50	101	7	35	86	3	1,215
	Beijing	366	112	28	81	17	48	27	6	684
	Jilin	204	166	69	60	34	9	89	15	646
	Inner Mongolia	493	82	54	32	25	8	57	13	765
	Gansu	261	260	91	28	29	2	13	2	686
	Henan	2,377	282	40	74	7	21	42	2	2,844
	Shanghai	150	83	10	30	17	15	69	44	417
	Fujian	261	132	23	94	21	19	111	76	738
	Jiangxi	52	86	7	14	18	16	48	29	270
	Jiangsu	115	762	9	58	29	10	169	35	1,187
	Zhejiang	231	388	16	170	27	23	184	56	1,094
Hubei	92	276	24	88	24	7	69	57	637	
Guangxi	136	134	4	46	16	9	108	72	526	
Hunan	348	161	20	14	30	11	190	38	812	
Guizhou	139	220	15	151	20	21	84	3	653	
	Mean	565	220	31	61	20	24	92	27	1,041
MCCPs	Heilongjiang	2,662	148	15	23	23	4	33	20	2,927
	Hebei	372	326	8	183	20	44	38	11	1,002
	Shanxi	1,087	147	26	15	17	46	320	4	1,663
	Ningxia	294	179	35	58	12	51	36	1	666
	Guangdong	290	79	6	49	12	60	134	67	696
	Qinghai	474	345	64	3	37	46	113	3	1,085
	Shandong	994	176	18	36	13	23	139	129	1,527
	Shaanxi	351	64	13	70	28	26	65	4	620
	Sichuan	724	86	20	84	11	8	155	2	1,089
	Liaoning	703	140	48	74	19	50	103	4	1,141
	Beijing	290	93	11	65	18	57	32	9	575
	Jilin	102	111	133	53	41	17	114	13	584
	Inner Mongolia	436	53	33	37	40	10	72	14	695
	Gansu	272	315	53	30	32	3	16	1	723
	Henan	2,068	304	31	94	46	35	51	1	2,630
	Shanghai	45	76	6	9	14	6	23	13	192
	Fujian	201	113	4	41	14	7	72	48	502
	Jiangxi	120	72	2	14	18	5	55	25	311
	Jiangsu	259	445	6	16	39	2	150	11	928
	Zhejiang	131	113	4	36	9	9	107	24	432
Hubei	84	177	14	38	20	2	81	47	465	
Guangxi	164	106	1	23	9	2	170	48	524	
Hunan	192	170	5	14	11	4	160	27	583	
Guizhou	139	130	4	57	16	5	119	3	473	
	Mean	519	165	23	47	22	22	98	22	918

Abbreviations: PLADs=provincial-level administrative divisions; SCCPs=short-chain chlorinated paraffins; MCCPs=medium-chain chlorinated paraffins.

SCCP and MCCP were significantly lower than those in the Fifth Total Diet Study except the increased concentrations of MCCP in meats (7–9). The highest average concentrations of SCCP and MCCP were found in meats in the present study, while in the Fifth China TDS, the average concentrations of SCCP and MCCP in aquatic foods were the highest. The ratio of MCCP to SCCP in each food category exhibited an increase from the Fifth to the Sixth TDS. This indicated that MCCPs may have become alternative products of SCCPs since SCCPs were listed as initial persistent organic pollutants of the Stockholm Convention.

The highest EDI values of SCCP and MCCP in the present study were much lower than the tolerable daily intake proposed by the International Programme on Chemical Safety (100 µg/kg body weight per day) (10). The European Food Safety Authority margins of exposure for total SCCP and total MCCP in eight food categories were  $2 \times 10^3$  and  $4 \times 10^4$  (11), respectively, which were much higher than 1,000, indicating that SCCPs and MCCPs ingested from food may not pose a significant risk to human health in China. The EDI of SCCP and MCCP in cereals was the highest among eight food categories, but cereals did not have the highest concentration of SCCP and MCCP. This could be due to the dietary habits in China, where there was higher daily consumption of cereals than meats.

Some limitations of this study include how apparatus for the food sample collection and storage could have been contaminated by chlorinated paraffins and how the complexity of CP mixtures posed a challenge for analysts. Complete separation or purification of individual isomers or congeners was also difficult. Also, there was a lack of standard methods for analysis of chlorinated paraffins.

The dietary exposure and health risk assessment of CP in 8 food categories of 24 PLADs were investigated in this study. Levels of SCCP and MCCP in legumes, cereals, meats, and aquatic foods exhibited a decrease from the Fifth to the Sixth China TDS, except the increased concentrations of MCCP in meats. The ratio of MCCP to SCCP in the foods investigated in this study tended to increase. The estimated dietary exposure to CPs was lower than the threshold set in the current guidelines. Further studies need to be performed to evaluate the health risks through dietary exposure to CPs and the results would be helpful for the development of chlorinated paraffin regulations.

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