

## Supporting Information

### Occupational Exposures to Phthalates Among Black and Latina U.S. Hairdressers Serving an Ethnically Diverse Clientele: A Pilot Study

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**Table S1.** Description of Hair Salon Services.<sup>a</sup>

Name of Process	Description of Style	Description of Hair Care Process
Permanent waves or texturizing	Process that creates permanent curls or waves in hair	Using hands or a brush, a permanent waving solution is applied to the hair. The solution breaks down existing disulfide bonds within the hair, enabling it to be molded into curls or waves. After a set amount of time, the solution is rinsed off and a neutralizing solution is used to restore normal hair pH. The waves or curls last until new hair grows which needs to then be permed.
Chemical straightening or relaxing	Process that permanently straightens hair	Using hands or a brush, relaxer cream is applied to the hair. The solution breaks down existing disulfide bonds within the hair. Once the cream is applied, the hair is smoothed section by section in order to straighten it. After a set amount of time, the cream is rinsed off and a neutralizing shampoo is used to restore normal hair pH. The straightening lasts until new hair grows which needs to then be relaxed.
Bleaching and highlights	Process that partially or completely de-colors hair by stripping it of existing melanin	An alkaline solution of hydrogen peroxide (usually up to a concentration of 12%) mixed with a thickening agent is applied to the hair. In highlights, this solution is applied only to isolated sections of hair. After a set amount of time, the solution is rinsed off. The bleaching/highlights last until new hair grows which needs to be bleached.
Semi-permanent hair coloring	Process that semi-permanently dyes hair a different color	Using hands or a brush, hair dye is added to the hair. After a set amount of time, the dye is rinsed off. Semi-permanent hair dye will last for about 4 or 6 weeks, at which point it can be washed out.
Permanent hair coloring	Process that permanently dyes hair a different color	Using hands or a brush, hair dye is added to the hair. After a set amount of time, the dye is rinsed off. Permanent hair dye will last until new hair grows out.
Hair extensions (no glue or chemicals)	Process that non-chemically attaches synthetic or artificial hair to existing hair for the purpose of increasing hair length or volume	Hair extensions are attached to existing hair or afixed to head using clips, braids, sewing or other methods. Extensions will last days or month depending on style, condition and maintenance.
Hair extensions (with glue or other chemicals)	Process that chemically attaches synthetic or artificial hair to existing hair for the purpose of increasing hair length or volume	Hair extensions are attached to existing hair or afixed to head using glue or other chemicals. Extensions will last days or month depending on style, condition and maintenance.

Name of Process	Description of Style	Description of Hair Care Process
Hair drying with a blow dryer	Process that dries hair with hair or blow dryer	A commercial hair or blow dryer is used to dry the hair. Drying temperatures vary greatly depending on the model of blow dryer, distance at which blow-drying is performed, and other factors.
Flat ironing or curling with a curling iron	Process that creates curls in hair with curling iron or straightens hair with flat iron	Hair is straightened with a flat iron or styled with a curling iron.
Putting hair in rollers	Process that permanently or semi-permanently waves or curls hair by wrapping it around rollers	Hair is wrapped around rollers, usually in the process of permanent waving or curling. Rollers are often used in conjunction with permanent waving solutions.
Brazilian blowout or keratin treatment	Process that semi-permanently straightening hair	Keratin, a sealing liquid, and a preservative solution is applied to the hair. The hair is then straightened with a flat iron. This style lasts several months and is then reapplied.
Braids on afro hair	A hairstyle formed by intertwining three or more strands of hair	Hair is divided into even sections of three or more. The hair is then braided together. Hair extensions can be added to the elongate the braid.
Twists	A hairstyle formed by the intertwining of two strands of hair	Hair is divided into two even sections and twisted together. Hair extensions can be added to elongate the braid.
Sister locs or locs	A hairstyle in which the hair is twisted into medium or small strands	Strands of hair are section and twisted together. The hair will then loc forming thicker ropes of hair. The hair is re-twisted every few weeks to months.
Afros	Afros are a hairstyle in which the natural hair is combed out and styled	Treatment and care for loose natural kinky or curly hair.
Haircut	Process of cutting and shaping the hair	The hair is first sectioned. Cutting shears are then used to cut the ends of the hair to a desired length.
Hair washing	Process of cleaning the scalp and hair through the use of shampoo or soap	The hair is first rinsed with lukewarm water and then shampoo is applied to the scalp and hair. After lathering, the shampoo is then rinsed out.
Deep conditioner	Hair treatment to restore the softness, manageability, and glossiness of the hair.	Deep conditioner is applied and left on hair for 20 to 30 minutes. Heat may be used to increase penetration. The deep conditioner is then washed out after the allotted time. Usually used for extremely dry or chemically treated hair.

<sup>a</sup>. References: Adewumi-Gunn TA, Ponce E, Flint N, Robbins W. A Preliminary Community-Based Occupational Health Survey of Black Hair Salon Workers in South Los Angeles. J Immigr Minor Heal. 2016;0: 0. doi:10.1007/s10903-016-0521-0; Bolduc C, Shapiro J. Hair care products: waving, straightening, conditioning, and coloring. Clin Dermatol. 2001;19: 431–6. doi:10.1016/s0738-081x(01)00201-2; Kobayashi M, Ito K, Sugita T, Murakami Y, Yamashita R, Matsunaka H, et al. Physiological and microbiological verification of the benefit of hair washing in patients with skin conditions of the scalp. J Cosmet Dermatol. 2016;15: e1–e8. doi:10.1111/jocd.12228

**Table S2.** Summary statistics for uncorrected phthalate metabolite concentrations in ng/mL among study participants (n=40, 2018-2019).

Metabolite	LOD	Hairdressers (n=23)				Office Controls (n=17)				p-value <sup>b</sup>
		DF %	GM	P50 (P25, P75)	Range	DF %	GM	P50 (P25, P75)	Range	
MEP	0.237	100	143.9	122.7 (60.8, 320.2)	17.5-1193.3	100	12.1	20.4 (2.8, 24.9)	1.5-220.1	<b>&lt;0.001</b>
MCP	0.187	60.9	0.5	0.3 (0.1, 1.2)	0-5.6	35.3	0.2	0.1 (0.1, 0.3)	0.1 -2.1	--
MECP	0.156	100	6.7	5.3 (3.1, 21.5)	1.3-63.4	100	1.6	1.6 (0.8, 2.5)	0.3-9.5	<b>&lt;0.001</b>
MEHP	0.197	100	6.4	5.7 (2.7, 12.4)	1.3-109.0	100	1.7	1.2 (1.2, 2.4)	0.4-5.6	<b>&lt;0.001</b>
MEHP	0.291	52.2	0.8	1.4 (0.1, 4.2)	0.1-11.9	23.5	0.2	0.1 (0.1, 0.1)	0.1-1.2	--
MEOHP	0.089	100	3.7	3.6 (1.6, 7.3)	0.8-23.8	94.1	0.9	0.9 (0.6, 1.9)	0.04-4.7	<b>&lt;0.001</b>
MnBP	0.246	100	8.4	11.8 (2.8, 18.6)	0.8-111.9	100	3.0	3.7 (1.2, 6.5)	0.6-10.0	<b>0.004</b>
MiBP	0.542	91.3	3.0	3.1 (1.3, 9.0)	0.3-26.8	47.1	0.6	0.3 (0.3, 1.2)	0.3-3.7	--
MBzP	0.063	91.3	0.8	1.2 (0.4, 2.6)	0.3-6.8	94.1	0.7	1.1 (0.2, 1.7)	0.03-4.6	0.753
Σ DEHP <sup>a</sup>	--	--	19.6	16.8 (9.0, 43.0)	3.6-173.5	--	4.7	4.1 (3.1, 6.3)	0.9-15.7	<b>&lt;0.001</b>

<sup>a</sup>. Σ DEHP represents the molar sum of MEHP, MEHP, MEOHP, MECP metabolites (ng/mL).

<sup>b</sup>. P-values from Wilcoxon rank sum test comparing phthalate biomarker concentrations between hairdressers and office controls; p-values (p<0.05) are bolded; MCP, MEHP, and MiBP had DF<70% for hairdressers and/or office workers and were not compared using statistical tests, the p-value is noted as -- .

Abbreviations: LOD: limit of detection; DF: detection frequency; GM: geometric mean; MEP: monoethyl phthalate; MCP: Mono-3-carboxypropyl phthalate; MECP: Mono(2-ethyl-5-carboxypentyl) phthalate; MEHP: Mono(2-ethyl-5-hydroxyhexyl) phthalate; MEHP: Mono(2-ethylhexyl) phthalate; MEOHP: Mono(2-ethyl-5-oxohexyl) phthalate; MnBP: Monobutyl phthalate; MiBP: Monoisobutyl phthalate; MBzP: Monobenzyl phthalate

**Table S3.** Summary statistics for phthalate metabolite concentrations in ng/mL among hairdressers stratified by type of salon (n=23, 2018-2019).<sup>a</sup>

Metabolite	LOD	Hairdressers from Black Salons (n=11)				Hairdressers from Dominican Salons (n=12)				p-value <sup>c</sup>
		Uncorrected				Uncorrected				
		Specific gravity-corrected				Specific gravity-corrected				
DF %	GM	P50 (P25, P75)	Range	DF %	GM	P50 (P25, P75)	Range			
MEP	0.237	100	130.9	98.2 (51.3, 317.8)	31.4-763.1	100	156.8	183.4 (61.0, 183.4)	17.5-1193.3	0.460
			136.4	103.7 (53.0, 475.2)	34.4-582.2		188.3	187.1 (68.5, 500.0)	36.5-897.1	
MCP	0.187	72.7	0.7	0.5 (0.1, 2.4)	0-5.6	50.0	0.3	0.1 (0.1, 0.9)	0-1.7	--
			0.6	0.5 (0.1, 2.1)	0-3.9		0.3	0.2 (0.1, 0.8)	0-1.2	
MECP	0.156	100	8.2	5.6 (4.0, 21.8)	1.8-63.4	100	5.5	4.5 (2.6, 15.9)	1.3-31.5	0.538
			8.6	5.3 (3.6, 23.8)	3.1-52.2		6.7	7.2 (3.1, 17.2)	1.2-22.6	
MEHP	0.197	100	8.6	6.6 (4.8, 13.2)	2.5-109.0	100	4.9	4.4 (2.2, 9.5)	1.3-43.9	0.623
			8.9	6.8 (3.5, 16.2)	2.8-89.8		5.9	6.8 (2.7, 12.9)	1.4-31.5	
MEHP	0.291	45.5	0.7	0.1 (0.1, 4.2)	0.1-11.9	58.3	0.9	1.7 (0.1, 4.7)	0.1-8.1	--
			0.8	0.2 (0.1, 6.4)	0.1-30.7		1.1	2.0 (0.1, 5.5)	0.1-11.1	
MEOHP	0.089	100	4.6	4.6 (3.1, 7.5)	1.5-15.8	100	3.1	2.8 (1.4, 5.9)	0.8-23.8	0.538
			4.8	4.8 (2.5, 6.7)	1.8-20.1		3.7	3.8 (2.0, 7.2)	0.9-17.1	
MnBP	0.246	100	13.6	15.2 (8.7, 20.2)	2.8-46.3	100	5.4	5.7 (1.9, 13.3)	0.8-111.9	0.124
			14.2	12.8 (9.0, 37.5)	4.5-41.6		6.5	8.1 (3.4, 13.4)	0.7-102.0	
MiBP	0.542	100	3.9	3.9 (1.4, 11.2)	0.7-19.3	83.3	2.4	2.3 (0.9, 7.9)	0.3-26.8	0.538
			4.1	4.3 (1.8, 9.9)	0.9-17.3		2.9	4.4 (1.4, 6.8)	0.2-24.5	
MBzP	0.063	100	1.1	1.2 (0.5, 3.0)	0.1-6.8	83.3	0.6	1.0 (0.3, 1.8)	0.03-5.6	0.758
			1.2	1.4 (0.4, 2.7)	0.3-4.8		0.7	0.9 (0.8, 1.8)	0.02-5.0	
Σ DEHP <sup>b</sup>	--	--	25.0	16.9 (12.7, 58.7)	7.0-173.5	--	15.7	14.9 (8.4, 29.7)	3.6-102.4	0.623
			26.1	22.0 (9.8, 48.9)	7.7-142.9		18.9	22.3 (10.2, 41.8)	3.5-73.5	

<sup>a</sup> Rows shaded in grey indicate specific gravity-corrected concentrations in ng/mL.

<sup>b</sup> Σ DEHP represents the molar sum of MEHP, MEHHP, MEOHP, MECPP metabolites in ng/mL.

<sup>c</sup> P-values from Wilcoxon rank sum test comparing specific gravity-corrected phthalate biomarker concentrations between hairdressers from Black and Dominican salons; p-values (p<0.05) are bolded; MCPP, MEHP, and MiBP had DF<70% for hairdressers and were not compared using statistical tests, the p-value is noted as --. Abbreviations: LOD: limit of detection; DF: detection frequency; GM: geometric mean; MEP: monoethyl phthalate; MCPP: Mono-3-carboxypropyl phthalate; MECPP: Mono(2-ethyl-5-carboxypentyl) phthalate; MEHHP: Mono(2-ethyl-5-hydroxyhexyl) phthalate; MEHP: Mono(2-ethylhexyl) phthalate; MEOHP: Mono(2-ethyl-5-oxohexyl) phthalate; MnBP: Monobutyl phthalate; MiBP: Monoisobutyl phthalate; MBzP: Monobenzyl phthalate

**Table S4.** Specific gravity-corrected geometric mean phthalate metabolite concentrations (ng/mL) for hair salon services provided on day of biospecimen collection (n=23, 2018-2019).

Services Provided	%	MEP	MCP	MECP	MEHP	MEHP	MEOHP	MnBP	MiBP	MBzP	$\Sigma$ DEHP <sup>a</sup>
Chemical straightening or relaxing											
Yes	21.7	222.9	1.0	15.1	8.3	0.9	6.0	7.8	4.1	0.7	35.0
No	78.3	147.6	0.3	6.2	6.9	0.9	3.8	10.0	3.2	1.0	19.4
Bleaching											
Yes	4.4	96.8	2.9	28.7	7.4	0.1	5.6	6.0	2.9	1.4	40.4
No	95.7	165.2	0.4	7.1	7.2	1.0	4.1	10.0	3.4	0.9	21.4
Semi-permanent hair color											
Yes	17.4	169.2	0.9	13.8	18.5	2.2	6.0	13.1	6.7	1.4	47.7
No	82.6	159.8	0.4	6.6	5.9	0.8	3.9	8.8	3.0	0.8	18.7
Permanent Hair Color											
Yes	21.7	295.6	0.9	8.6	10.2	2.6	6.1	16.0	5.1	1.2	29.3
No	78.3	136.4	0.4	7.3	6.5	0.7	3.8	8.2	3.0	0.8	20.4
Hair extensions (no glue)											
Yes	82.6	234.5	0.3	7.3	8.4	1.4	5.2	20.6	4.3	0.9	24.7
No	17.4	149.2	0.5	7.6	6.9	0.9	4.0	8.0	3.2	0.9	21.5
Hair extensions (with glue)											
Yes	8.7	105.9	0.4	12.4	4.2	1.1	3.2	8.3	4.1	0.3	27.0
No	91.3	168.0	0.4	7.2	7.5	0.9	4.3	9.6	3.3	1.0	21.6

Services Provided	%	MEP	MCP	MECP	MEHP	MEHP	MEOP	MnBP	MiBP	MBzP	Σ DEHP <sup>a</sup>
Hair drying with blow dryer											
Yes	34.8	163.6	0.3	5.9	6.4	0.9	4.0	8.3	2.9	0.7	17.9
No	65.2	160.3	0.6	8.6	7.7	1.0	4.3	10.2	3.7	1.0	24.6
Flat iron											
Yes	21.7	198.7	0.2	10.7	5.6	0.3	4.2	7.2	2.6	0.5	24.2
No	78.3	152.3	0.5	6.8	7.7	1.3	4.2	10.2	3.7	1.1	21.5
Putting hair in rollers											
Yes	26.1	261.3	0.4	4.5	5.8	1.0	3.7	7.3	3.2	1.3	15.4
No	73.9	136.2	0.4	9.0	7.7	0.9	4.3	10.4	3.5	0.8	25.0
Brazilian blowout or keratin											
Yes	4.4	243.6	0.7	7.9	9.5	3.1	5.5	8.7	6.9	0.9	25.7
No	95.7	158.4	0.4	7.5	7.1	0.9	4.1	9.5	3.3	0.9	21.9
Braids											
Yes	13.0	49.0	0.2	3.3	3.5	0.1	2.3	12.8	1.5	0.6	9.1
No	87.0	193.0	0.5	8.5	8.0	1.3	4.6	9.1	3.8	1.0	25.2
Sister locs/locs											
Yes	4.4	103.7	1.4	5.3	6.7	4.0	6.1	38.2	12.9	3.4	22.0
No	95.7	164.7	0.4	7.6	7.2	0.9	4.1	8.9	3.2	0.9	22.0
Haircut											
Yes	43.5	204.1	0.7	15.9	11.8	1.4	5.8	9.5	4.4	0.9	40.7
No	56.5	134.7	0.3	4.2	4.9	0.7	3.2	9.4	2.8	0.9	13.7
Hair washing											
Yes	60.9	119.3	0.4	5.6	5.6	0.6	3.7	8.1	2.8	1.0	16.2
No	39.1	258.2	0.5	12.0	10.5	2.0	5.0	12.2	4.6	0.8	35.7

Services Provided	%	MEP	MCP	MECP	MEHP	MEHP	MEHP	MnBP	MiBP	MBzP	$\Sigma$ DEHP <sup>a</sup>
Deep conditioning											
Yes	4.4	64.4	0.3	3.6	4.3	0.1	3.2	10.0	0.9	2.1	11.1
No	95.7	168.3	0.4	7.8	7.3	1.0	4.2	9.4	3.6	0.9	22.7
Gloves worn on day of biospecimen collection											
Yes	63.6	148.6	0.4	7.5	6.6	0.6	3.5	7.4	2.5	0.6	20.7
No	36.4	178.8	0.5	6.9	7.5	1.5	4.9	14.3	5.1	1.4	22.2

<sup>a</sup>.  $\Sigma$  DEHP represents the molar sum of MEHP, MEHHP, MEOHP, MECPP metabolites (ng/mL).

Abbreviations: GM: geometric mean; MEP: monoethyl phthalate; MCP: Mono-3-carboxypropyl phthalate; MECPP: Mono(2-ethyl-5-carboxypentyl) phthalate; MEHHP: Mono(2-ethyl-5-hydroxyhexyl) phthalate; MEHP: Mono(2-ethylhexyl) phthalate; MEOHP: Mono(2-ethyl-5-oxohexyl) phthalate; MnBP: Monobutyl phthalate; MiBP: Monoisobutyl phthalate; MBzP: Monobenzyl phthalate