Supplementary Material

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Table S1. Distribution of urinary phenols, pesticides, and phthalates in NHANES 2005–2016 (N = 2163).

Chemicals	Detection frequency (%)	GM	Mean	Percentiles				
				P5	P25	P50	P75	P95
Phenols (ug/L)								
BPA	96.1	2.82	3.44	0.30	1.00	1.90	3.70	10.39
BP3	99.3	137.72	228.27	1.60	5.35	13.90	47.60	553.42
Pesticides (ug/L)								
2,4-DCP	93.8	0.63	5.70	0.14	0.40	0.90	2.60	19.89
2,5-DCP	98.8	5.79	202.34	0.40	2.30	8.40	39.15	781.91
Phthalates (ug/L)								
MEP	99.8	193.59	238.96	7.30	27.09	71.10	201.73	1025.95
MBP	99.1	19.51	33.01	2.61	9.43	19.90	40.00	103.07
MCOP	99.2	6.47	35.86	1.50	4.70	10.70	28.44	154.99
MECPP	99.9	26.41	68.56	3.50	10.44	22.80	51.60	257.51
MEHHP	99.6	20.47	51.13	1.80	5.90	14.10	34.35	191.54
MCPP	94.2	1.70	6.81	0.28	1.20	2.60	5.50	20.80
MBzP	99.3	6.46	20.41	1.08	4.20	10.26	22.26	70.98
MiBP	99.4	13.25	19.50	1.40	5.10	10.40	19.88	49.48
MCNP	96.8	6.62	5.61	0.42	1.50	2.80	5.10	15.55
MEOHP	99.7	12.42	31.21	1.20	3.90	9.50	21.95	120.89

Note: GM, geometric mean. BPA, bisphenol-A; BP3, benzophenone-3; 2,4-DCP, 2,4-dichlorophenol; 2,5-DCP, 2,5-dichlorophenol; MEP,Mono-ethyl phthalate; MBP, Mono-n-butyl phthalate; MCOP, mono (carboxyoctyl) phthalate; MECPP, mono (2-ethyl-5-carboxypentyl)phthalate; MEHHP, mono (2-ethyl-5-hydroxyhexyl) phthalate; MCPP, mono-(3-carbox ypropyl) phthalate; MBzP, mono benzyl phthalate; MiBP, mono-isobutyl phthalate; MCNP, mono-(carboxynonyl) phthalate; MEOHP, mono-(2-ethyl-5-oxohexyl) phthalate.

Table S2. Subgroup analysis of the association between single chemical exposure and HSI stratified by sex.

Chemicals	Continuous	Q1	Q2	Q3	Q4	P_{trend}
	β (95% CI)		β (95% CI)	β (95% CI)	β (95% CI)	
Phenols						
BPA						
Male	-0.136 (-0.370, 0.098)	Ref.	0.631 (-0.002, 1.264)	**0.705 (0.103, 1.306) ***	-0.185 (-0.816, 0.445)	0.087
Female	0.007 (-0.341, 0.355)	Ref.	0.133 (-0.630, 0.896)	-0.066 (-0.797, 0.666)	0.231 (-0.746, 1.209)	0.655
BP3						
Male	-0.028 (-0.188, 0.132)	Ref.	0.111 (-0.514, 0.735)	-0.057 (-0.753, 0.64)	-0.015 (-0.814, 0.784)	0.889
Female	-0.109 (-0.279, 0.061)	Ref.	0.501 (-0.461, 1.463)	0.635 (-0.201, 1.471)	0.053 (-0.714, 0.821)	0.157
Pesticides						
2,4-DCP						
Male	-0.028 (-0.189, 0.132)	Ref.	-0.385 (-1.141, 0.371)	-0.579 (-1.242, 0.085)	0.008 (-0.715, 0.731)	0.491
Female	0.007 (-0.208, 0.222)	Ref.	0.592 (-0.149, 1.334)	-0.124 (-0.734, 0.485)	0.314 (-0.459, 1.086)	0.774
2,5-DCP						
Male	-0.032 (-0.129, 0.064)	Ref.	-0.242 (-0.854, 0.370)	-0.341 (-0.963, 0.280)	-0.246 (-0.876, 0.384)	0.685
Female	0.043 (-0.132, 0.219)	Ref.	0.215 (-0.623, 1.053)	-0.280 (-1.017, 0.458)	0.413 (-0.500, 1.327)	0.344
Phthalates						
MEP						
Male	0.070 (-0.135, 0.275)	Ref.	0.519 (-0.004, 1.043)	0.200 (-0.354, 0.754)	0.348 (-0.398, 1.095)	0.681
Female	-0.047 (-0.214, 0.121)	Ref.	0.310 (-0.527, 1.146)	0.170 (-0.574, 0.915)	-0.195 (-0.913, 0.522)	0.148
MBP						
Male	0.015 (-0.299, 0.329)	Ref.	0.188 (-0.436, 0.811)	0.247 (-0.444, 0.937)	-0.373 (-1.117, 0.371)	0.152
Female	-0.190 (-0.473, 0.092)	Ref.	-0.400 (-1.236, 0.436)	0.404 (-0.420, 1.227)	-0.622 (-1.283, 0.039)	0.016
MCOP						
Male	0.074 (-0.139, 0.287)	Ref.	0.372 (-0.252, 0.996)	0.509 (-0.108, 1.126)	0.413 (-0.183, 1.009)	0.526
Female	0.190 (-0.107, 0.487)	Ref.	0.431 (-0.283, 1.145)	0.453 (-0.124, 1.029)	0.593 (-0.055, 1.241)	0.265
MECPP						
Male	-0.126 (-0.321, 0.068)	Ref.	-0.298 (-0.916, 0.320)	-0.271 (-0.804, 0.263)	-0.481 (-1.090, 0.127)	0.253
Female	-0.122 (-0.429, 0.185)	Ref.	0.056 (-0.670, 0.782)	-0.023 (-0.646, 0.601)	0.164 (-0.731, 1.059)	0.705
MEHHP						
Male	-0.098 (-0.270, 0.075)	Ref.	-0.053 (-0.835, 0.728)	-0.362 (-0.851, 0.127)	-0.177 (-0.772, 0.417)	0.706
Female	-0.067 (-0.296, 0.161)	Ref.	0.738 (-0.156, 1.633)	0.055 (-0.583, 0.692)	0.221 (-0.467, 0.910)	0.829
MCPP						
Male	0.064 (-0.143, 0.271)	Ref.	**0.684 (0.081, 1.287) ***	0.212 (-0.387, 0.810)	0.544 (-0.111, 1.198)	0.397
Female	0.079 (-0.268, 0.425)	Ref.	-0.494 (-1.269, 0.282)	-0.374 (-1.154, 0.407)	-0.190 (-1.051, 0.671)	0.734
MBzP						
Male	0.166 (-0.099, 0.431)	Ref.	-0.019 (-0.686, 0.648)	0.011 (-0.724, 0.746)	0.371 (-0.384, 1.126)	0.219
Female	0.241 (-0.074, 0.555)	Ref.	-0.421 (-1.114, 0.272)	0.029 (-0.629, 0.686)	0.160 (-0.728, 1.048)	0.440
MiBP						
Male	0.138 (-0.150, 0.425)	Ref.	0.119 (-0.470, 0.708)	0.125 (-0.494, 0.744)	0.419 (-0.248, 1.087)	0.239
Female	-0.007 (-0.335, 0.320)	Ref.	**0.906 (0.012, 1.800) ***	0.255 (-0.427, 0.936)	0.180 (-0.472, 0.832)	0.465
MCNP						
Male	-0.031 (-0.335, 0.273)	Ref.	0.278 (-0.319, 0.876)	-0.035 (-0.573, 0.503)	-0.055 (-0.811, 0.700)	0.614
Female	0.238 (-0.119, 0.595)	Ref.	0.029 (-0.608, 0.667)	0.086 (-0.738, 0.910)	0.111 (-0.709, 0.930)	0.803
MEOHP						
Male	-0.070 (-0.250, 0.111)	Ref.	0.275 (-0.461, 1.011)	-0.245 (-0.795, 0.305)	-0.084 (-0.722, 0.554)	0.573
Female	-0.072 (-0.311, 0.167)	Ref.	0.161 (-0.703, 1.025)	-0.042 (-0.897, 0.812)	-0.097 (-0.793, 0.599)	0.633

Note: * Presenting for $P < 0.05$. Models adjusted for age, race/ethnicity, BMI, PIR, total calories intake, diabetes and ln-transformed serum cotinine, ALT, ALP, and GGT levels. Continuous, Ln-transformed concentration of urinary chemicals. Q, quartile; BPA, bisphenol-A; BP3, benzophenone-3; 2,4-DCP, 2,4-dichlorophenol; 2,5-DCP, 2,5-dichlorophenol; MEP,Mono-ethyl phthalate; MBP, Mono-n-butyl phthalate; MCOP, mono (carboxyoctyl) phthalate; MECPP, mono (2-ethyl-5-carboxypentyl)phthalate; MEHHP, mono (2-ethyl-5-hydroxyhexyl) phthalate; MCPP, mono-(3-carbox ypropyl) phthalate; MBzP, mono benzyl phthalate; MiBP, mono-isobutyl phthalate; MCNP, mono-(carboxynonyl) phthalate; MEOHP, mono-(2-ethyl-5-oxohexyl) phthalate; HSI, hepatic steatosis index.

Table S3. Subgroup analysis of the association between single chemical exposure and MASLD risk stratified by sex.

Chemicals	Continuous	Q1	Q2	Q3	Q4	P_{trend}
	OR (95% CI)		OR (95% CI)	OR (95% CI)	OR (95% CI)	
Phenols						
BPA						
Male	**2.025 (1.285, 3.190) ***	Ref.	**5.790 (1.697, 19.752) ***	**5.188 (1.276, 21.102) ***	**7.063 (2.322, 21.484) ***	**0.010**
Female	0.991 (0.664, 1.481)	Ref.	0.575 (0.172, 1.918)	0.791 (0.225, 2.782)	1.001 (0.354, 2.830)	0.548
BP3						
Male	0.895 (0.664, 1.206)	Ref.	0.979 (0.437, 2.193)	0.599 (0.161, 2.228)	0.616 (0.170, 2.227)	0.534
Female	0.799 (0.612, 1.045)	Ref.	0.630 (0.119, 3.343)	0.531 (0.121, 2.324)	0.336 (0.079, 1.424)	0.149
Pesticides						
2,4-DCP						
Male	0.974 (0.755, 1.255)	Ref.	1.179 (0.279, 4.974)	1.021 (0.320, 3.250)	0.837 (0.311, 2.250)	0.518
Female	1.213 (0.874, 1.683)	Ref.	0.920 (0.206, 4.121)	1.803 (0.401, 8.117)	1.850 (0.473, 7.240)	0.250
2,5-DCP						
Male	1.014 (0.875, 1.174)	Ref.	0.484 (0.199, 1.180)	1.250 (0.510, 3.065)	0.573 (0.229, 1.431)	0.389
Female	1.101 (0.884, 1.371)	Ref.	1.073 (0.352, 3.273)	0.650 (0.200, 2.107)	1.992 (0.616, 6.441)	0.106
Phthalates						
MEP						
Male	1.111 (0.871, 1.419)	Ref.	1.622 (0.485, 5.427)	0.537 (0.153, 1.878)	2.106 (0.827, 5.363)	0.099
Female	1.189 (0.862, 1.639)	Ref.	**4.703 (1.672, 13.227) ***	2.997 (0.901, 9.970)	**4.486 (1.165, 17.268) ***	0.228
MBP						
Male	1.456 (0.962, 2.203)	Ref.	0.978 (0.308, 3.111)	2.092 (0.712, 6.148)	1.499 (0.569, 3.947)	0.494
Female	0.981 (0.586, 1.644)	Ref.	1.491 (0.391, 5.677)	1.427 (0.420, 4.845)	1.235 (0.336, 4.542)	0.991
MCOP						
Male	0.962 (0.679, 1.363)	Ref.	1.054 (0.514, 2.161)	0.669 (0.240, 1.864)	1.096 (0.400, 3.005)	0.673
Female	1.011 (0.725, 1.409)	Ref.	**4.004 (1.229, 13.043) ***	3.283 (0.962, 11.212)	2.045 (0.660, 6.333)	0.651
MECPP						
Male	0.952 (0.664, 1.364)	Ref.	0.983 (0.331, 2.918)	2.347 (0.884, 6.230)	0.569 (0.216, 1.501)	0.122
Female	1.014 (0.736, 1.397)	Ref.	0.389 (0.124, 1.219)	0.784 (0.176, 3.490)	0.925 (0.291, 2.942)	0.546
MEHHP						
Male	1.008 (0.731, 1.390)	Ref.	**3.907 (1.135, 13.448) ***	1.978 (0.772, 5.068)	2.222 (0.735, 6.715)	0.974
Female	1.105 (0.774, 1.579)	Ref.	0.998 (0.227, 4.398)	1.118 (0.327, 3.826)	1.691 (0.569, 5.026)	0.332
MCPP						
Male	1.026 (0.665, 1.583)	Ref.	0.483 (0.204, 1.148)	0.750 (0.295, 1.911)	0.859 (0.254, 2.899)	0.702
Female	1.068 (0.705, 1.619)	Ref.	1.365 (0.407, 4.580)	1.272 (0.349, 4.635)	0.506 (0.121, 2.115)	0.144
MBzP						
Male	**1.891 (1.327, 2.695) ***	Ref.	2.296 (0.782, 6.741)	2.319 (0.755, 7.122)	**4.173 (1.787, 9.746) ***	**0.022**
Female	1.222 (0.818, 1.826)	Ref.	0.545 (0.178, 1.668)	0.711 (0.250, 2.023)	1.752 (0.496, 6.189)	0.110
MiBP						
Male	1.133 (0.761, 1.687)	Ref.	0.647 (0.199, 2.102)	0.918 (0.306, 2.755)	0.997 (0.389, 2.552)	0.690
Female	1.088 (0.630, 1.879)	Ref.	1.286 (0.375, 4.413)	1.024 (0.240, 4.375)	1.161 (0.264, 5.100)	0.917
MCNP						
Male	1.169 (0.698, 1.958)	Ref.	2.895 (0.891, 9.403)	0.773 (0.204, 2.935)	2.178 (0.741, 6.401)	0.513
Female	**1.682 (1.042, 2.716) ***	Ref.	1.345 (0.447, 4.048)	0.861 (0.264, 2.810)	1.883 (0.466, 7.619)	0.302
MEOHP						
Male	1.038 (0.736, 1.464)	Ref.	**3.814 (1.206, 12.064) ***	**3.270 (1.067, 10.022) ***	1.896 (0.656, 5.483)	0.715
Female	1.150 (0.785, 1.684)	Ref.	0.436 (0.124, 1.533)	0.716 (0.184, 2.785)	1.098 (0.323, 3.736)	0.387

Note: * Presenting for $P < 0.05$. Models adjusted for age, race/ethnicity, BMI, PIR, total calories intake, diabetes and ln-transformed serum cotinine, ALT, ALP, and GGT levels. Continuous, Ln-transformed concentration of urinary chemicals. Q, quartile; BPA, bisphenol-A; BP3, benzophenone-3; 2,4-DCP, 2,4-dichlorophenol; 2,5-DCP, 2,5-dichlorophenol; MEP,Mono-ethyl phthalate; MBP, Mono-n-butyl phthalate; MCOP, mono (carboxyoctyl) phthalate; MECPP, mono (2-ethyl-5-carboxypentyl)phthalate; MEHHP, mono (2-ethyl-5-hydroxyhexyl) phthalate; MCPP, mono-(3-carbox ypropyl) phthalate; MBzP, mono benzyl phthalate; MiBP, mono-isobutyl phthalate; MCNP, mono-(carboxynonyl) phthalate; MEOHP, mono-(2-ethyl-5-oxohexyl) phthalate; MASLD, metabolic dysfunction-associated steatotic liver disease.

Table S4. BKMR model to estimate posterior inclusion probabilities (PIPs).

Chemicals	Group	HSI		MASLD	
		Group PIP	Cond PIP	Group PIP	Cond PIP
Phenols					
BPA	1	0.157	0.487	0.186	0.989
BP3	1	0.157	0.513	0.186	0.011
Pesticides					
2,4-DCP	2	0.078	0.518	0.023	0.400
2,5-DCP	2	0.078	0.482	0.023	0.600
Phthalates					
MEP	3	0.303	0.001	0.072	0.006
MBP	3	0.303	0.063	0.072	0.022
MCOP	3	0.303	0.117	0.072	0.092
MECPP	3	0.303	0.026	0.072	-
MEHHP	3	0.303	0.029	0.072	0.017
MCPP	3	0.303	0.098	0.072	-
MBzP	3	0.303	0.564	0.072	-
MiBP	3	0.303	0.034	0.072	-
MCNP	3	0.303	0.051	0.072	0.863
MEOHP	3	0.303	0.017	0.072	-

Note: Models adjusted for age, gender, race/ethnicity, BMI, PIR, total calories intake, diabetes and ln-transformed serum cotinine, ALT, ALP, and GGT levels. BPA, bisphenol-A; BP3, benzophenone-3; 2,4-DCP, 2,4-dichlorophenol; 2,5-DCP, 2,5-dichlorophenol; MEP, mono-ethyl phthalate; MBP, Mono-n-butyl phthalate; MCOP, mono (carboxyoctyl) phthalate; MECPP, mono (2-ethyl-5-carboxypentyl)phthalate; MEHHP, mono (2-ethyl-5-hydroxyhexyl) phthalate; MCPP, mono-(3-carbox ypropyl) phthalate; MBzP, mono benzyl phthalate; MiBP, mono-isobutyl phthalate; MCNP, mono-(carboxynonyl) phthalate; MEOHP, mono-(2-ethyl-5-oxohexyl) phthalate; HSI, hepatic steatosis index; MASLD, metabolic dysfunction-associated steatotic liver disease.

Table S5. Association between single chemical exposure and inflammation markers.

Chemicals	WBC		Neu		NLR		SII	
	β (95% CI)	*P*	β (95% CI)	*P*	β (95% CI)	*P*	β (95% CI)	*P*
Phenols								
BPA	0.003 (-0.010, 0.016)	0.605	-0.005 (-0.024, 0.015)	0.629	-0.079 (-0.161, 0.002)	0.055	-0.414 (-0.859, 0.030)	0.068
BP3	-0.001 (-0.008, 0.006)	0.725	-0.001 (-0.011, 0.009)	0.855	-0.003 (-0.046, 0.040)	0.897	-0.015 (-0.250, 0.219)	0.897
Pesticides								
2,4-DCP	0.002 (-0.007, 0.011)	0.633	0.000 (-0.013, 0.013)	0.972	-0.008 (-0.063, 0.048)	0.786	-0.016 (-0.319, 0.287)	0.918
2,5-DCP	0.004 (-0.002, 0.010)	0.173	0.005 (-0.003, 0.014)	0.218	-0.004 (-0.040, 0.032)	0.829	0.002 (-0.194, 0.199)	0.982
Phthalates								
MEP	**0.013 (0.003, 0.022)**	**0.007**	**0.014 (0.000, 0.027)**	**0.044**	0.027 (-0.030, 0.084)	0.358	0.185 (-0.127, 0.497)	0.244
MBP	**0.024 (0.010, 0.038)**	**0.001**	**0.022 (0.001, 0.042)**	**0.036**	-0.012 (-0.098, 0.075)	0.793	-0.031 (-0.502, 0.440)	0.897
MCOP	0.004 (-0.005, 0.013)	0.384	-0.001 (-0.014, 0.013)	0.896	-0.022 (-0.078, 0.034)	0.443	-0.182 (-0.491, 0.127)	0.247
MECPP	**0.024 (0.014, 0.034)**	**< 0.001**	**0.021 (0.006, 0.037)**	**0.007**	-0.010 (-0.075, 0.055)	0.763	-0.011 (-0.365, 0.344)	0.953
MEHHP	**0.024 (0.014, 0.033)**	**< 0.001**	**0.020 (0.006, 0.034)**	**0.006**	-0.025 (-0.084, 0.035)	0.416	-0.095 (-0.421, 0.231)	0.567
MCPP	**0.019 (0.008, 0.029)**	**0.001**	0.013 (-0.003, 0.029)	0.101	-0.020 (-0.087, 0.048)	0.570	-0.117 (-0.486, 0.251)	0.532
MBzP	**0.012 (0.000, 0.023)**	**0.045**	0.012 (-0.006, 0.029)	0.183	0.019 (-0.053, 0.091)	0.608	0.114 (-0.280, 0.509)	0.570
MiBP	0.001 (-0.014, 0.015)	0.925	-0.009 (-0.031, 0.012)	0.396	-0.061 (-0.151, 0.030)	0.190	-0.346 (-0.842, 0.149)	0.171
MCNP	**0.016 (0.003, 0.029)**	**0.014**	0.011 (-0.009, 0.030)	0.282	-0.018 (-0.101, 0.064)	0.659	-0.126 (-0.576, 0.323)	0.582
MEOHP	**0.025 (0.015, 0.035)**	**< 0.001**	**0.022 (0.008, 0.037)**	**0.003**	-0.014 (-0.077, 0.048)	0.658	-0.034 (-0.375, 0.308)	0.848

Note: Models adjusted for age, gender, race/ethnicity, BMI, PIR, total calories intake, diabetes and ln-transformed serum cotinine, ALT, ALP, and GGT levels. BPA, bisphenol-A; BP3, benzophenone-3; 2,4-DCP, 2,4-dichlorophenol; 2,5-DCP, 2,5-dichlorophenol; MEP, mono-ethyl phthalate; MBP, Mono-n-butyl phthalate; MCOP, mono (carboxyoctyl) phthalate; MECPP, mono (2-ethyl-5-carboxypentyl)phthalate; MEHHP, mono (2-ethyl-5-hydroxyhexyl) phthalate; MCPP, mono-(3-carbox ypropyl) phthalate; MBzP, mono benzyl phthalate; MiBP, mono-isobutyl phthalate; MCNP, mono-(carboxynonyl) phthalate; MEOHP, mono-(2-ethyl-5-oxohexyl) phthalate; WBC, white blood cell counts; Neu, neutrophil; NLR, neutrophil-to lymphocyte; SII, systemic immune-inflammation index.

Table S6. Correlations between inflammation markers with HSI and MASLD risk.

Inflammation markers	HSI		MASLD	
	β (95% CI)	*P*	OR (95% CI)	*P*
WBC	**1.196 (0.652, 1.740)**	**< 0.001**	**3.400 (1.438, 8.193)**	**0.006**
Neu	**0.833 (0.470, 1.196)**	**< 0.001**	**2.247 (1.263, 4.040)**	**0.006**
NLR	0.051 (-0.036, 0.138)	0.252	0.993 (0.837, 1.152)	0.933
SII	0.010 (-0.006, 0.026)	0.214	0.999 (0.968, 1.026)	0.923

Note: Models adjusted for age, gender, race/ethnicity, BMI, PIR, total calories intake, diabetes and ln-transformed serum cotinine, ALT, ALP, and GGT levels. WBC, white blood cell counts; Neu, neutrophil; NLR, neutrophil-to lymphocyte; SII, systemic immune-inflammation index.

Table S7. The proportions and mediating effects of immune cells on relationship between phthalate and HSI.

Pathways	Indirect effect (IDE)		Direct effect (DE)		Total effect		Prop. Mediated	
	β (95% CI)	*P*	β (95% CI)	*P*	β (95% CI)	*P*	β (95% CI)	*P*
WBC								
MEP→WBC	**1.523% (0.415%, 2.896%)**	**0.010**	-7.393% (-18.708%, 3.961%)	0.198	-5.870% (-17.344%, 5.800%)	0.300	-25.945% (-201.822%, 220.529%)	0.310
MBP→WBC	**2.911% (1.165%, 5.120%)**	**< 0.001**	-10.083% (-28.610%, 8.769%)	0.290	-7.171% (-25.291%, 11.716%)	0.464	-40.597% (-300.450%, 387.131%)	0.464
MECPP→WBC	**3.003% (1.440%, 5.152%)**	**< 0.001**	-10.732% (-24.171%, 2.180%)	0.092	-7.729% (21.643%, 5.060%)	0.230	-38.855% (-392.201%, 289.686%)	0.230
MEHHP→WBC	**2.966% (1.399%, 4.876%)**	**< 0.001**	-9.830% (-22.215%, 1.509%)	0.092	-6.864% (-18.729%, 4.352%)	0.250	-43.220% (-409.460%, 522.224%)	0.250
MCPP→WBC	**2.226% (0.829%, 3.881%)**	**< 0.001**	2.996% (-10.969%, 17.300%)	0.686	5.222% (-9.059%, 19.490%)	0.488	42.631% (-237.707%, 465.447%)	0.448
MBzP→WBC	**1.369% (0.225%, 3.043%)**	**0.024**	**17.246% (0.489%, 34.160%)**	**0.040**	**18.615% (2.163%, 35.607%)**	**0.022**	**7.352% (0.731%, 53.966%)**	**0.046**
MCNP→WBC	**1.933% (0.433%, 3.818%)**	**0.004**	6.367% (-10.819%, 23.848%)	0.484	8.299% (-8.437%, 26.028%)	0.348	23.286% (-159.457%, 263.843%)	0.344
MEOHP→WBC	**3.107% (1.510%, 5.074%)**	**< 0.001**	-9.264% (-22.062%, 2.701%)	0.122	-6.156% (-18.752%, 6.026%)	0.318	-50.475% (-379.373%, 470.550%)	0.318
Neu								
MEP→Neu	**1.172% (0.064%, 2.489%)**	**0.030**	-7.014% (-18.929%, 4.413%)	0.230	-5.843% (-17.674%, 5.337%)	0.320	-20.050% (-227.544%, 220.037%)	0.350
MBP→Neu	**1.845% (0.311%, 3.789%)**	**0.022**	-8.948% (-26.933%, 9.565%)	0.458	-7.103% (-24.663%, 11.791%)	0.458	-25.973% (-207.934%, 229.210%)	0.480
MECPP→Neu	**1.815% (0.523%, 3.443%)**	**0.006**	-9.537% (-23.633%, 2.661%)	0.122	-7.722% (-21.410%, 4.108%)	0.210	-23.506% (-258.068%, 188.764%)	0.216
MEHHP→Neu	**1.681% (0.490%, 3.145%)**	**0.002**	-8.482% (-20.252%, 3.164%)	0.128	-6.800% (-18.728%, 4.650%)	0.216	-24.724% (-269.435%, 170.625%)	0.218
MCPP→Neu	1.111% (-0.215%, 2.583%)	0.092	4.042% (-9.549%, 18.124%)	0.546	5.153% (-8.294%, 19.521%)	0.450	21.552% (-150.141%, 158.416%)	0.498
MBzP→Neu	0.959% (-0.392%, 2.410%)	0.164	**17.568% (0.544%, 34.045%)**	**0.046**	**18.527% (1.129%, 35.121%)**	**0.044**	5.175% (-6.244%, 28.115%)	0.204
MCNP→Neu	0.891% (-0.803%, 2.757%)	0.300	7.286% (-9.836%, 23.938%)	0.430	8.177% (-9.004%, 24.830%)	0.380	10.897% (-95.168%, 122.634%)	0.550
MEOHP→Neu	**1.902% (0.641%, 3.467%)**	**0.002**	-7.994% (-20.623%, 3.802%)	0.180	-6.092% (-18.933%, 5.898%)	0.286	-31.223% (-367.143%, 195.741%)	0.288

Note: MEP, mono-ethyl phthalate; MBP, Mono-n-butyl phthalate; MCOP, mono (carboxyoctyl) phthalate; MECPP, mono (2-ethyl-5-carboxypentyl) phthalate; MEHHP, mono (2-ethyl-5-hydroxyhexyl) phthalate; MCPP, mono-(3-carbox ypropyl) phthalate; MBzP, mono benzyl phthalate; MiBP, mono-isobutyl phthalate; MCNP, mono-(carboxynonyl) phthalate; MEOHP, mono-(2-ethyl-5-oxohexyl) phthalate; WBC, white blood cell counts; Neu, neutrophil; HSI, hepatic steatosis index.

Table S8. The proportions and mediating effects of immune cells on relationship between phthalate and MASLD.

Pathways	Indirect effect (IDE)		Direct effect (DE)		Total effect		Prop. Mediated	
	β (95% CI)	*P*	β (95% CI)	*P*	β (95% CI)	*P*	β (95% CI)	*P*
WBC								
MEP→WBC	**0.057% (0.011%, 0.122%)**	**0.010**	-0.060% (-0.847%, 0.583%)	0.866	-0.003% (-0.765%, 0.641%)	0.992	-2285.491% (-292.648%, 340.393%)	0.990
MBP→WBC	**0.106% (0.027%, 0.223%)**	**0.002**	0.388% (-0.635%, 1.462%)	0.466	0.495% (-0.523%, 1.556%)	0.352	21.517% (-167.796%, 176.008%)	0.354
MECPP→WBC	**0.111% (0.032%, 0.222%)**	**< 0.001**	-0.105% (-0.915%, 0.575%)	0.696	0.006% (-0.805%, 0.708%)	0.922	2006.353% (-451.122%, 357.776%)	0.922
MEHHP→WBC	**0.109% (0.031%, 0.212%)**	**< 0.001**	-0.041% (-0.779%, 0.616%)	0.804	0.068% (-0.637%, 0.739%)	0.938	160.238% (-423.711%, 450.843%)	0.938
MCPP→WBC	**0.084% (0.020%, 0.171%)**	**0.002**	0.299% (-0.524%, 1.072%)	0.514	0.383% (-0.463%, 1.166%)	0.386	21.947% (-186.463%, 213.349%)	0.388
MBzP→WBC	**0.052% (0.006%, 0.126%)**	**0.030**	**1.137% (0.373%, 1.915%)**	**< 0.001**	**1.189% (0.423%, 1.966%)**	**< 0.001**	**4.349% (0.425%, 15.275%)**	**0.030**
MCNP→WBC	**0.074% (0.011%, 0.175%)**	**0.006**	**1.028% (0.011%, 2.017%)**	**0.048**	**1.102% (0.095%, 2.072%)**	**0.026**	**6.708% (0.491%, 48.788%)**	**0.032**
MEOHP→WBC	**0.114% (0.031%, 0.222%)**	**< 0.001**	0.061% (-0.693%, 0.758%)	0.930	0.174% (-0.546%, 0.877%)	0.682	65.267% (-382.332%, 481.855%)	0.682
Neu								
MEP→Neu	**0.043% (0.001%, 0.010%)**	**0.034**	-0.032% (-0.755%, 0.594%)	0.892	0.010% (-0.714%, 0.635%)	0.978	412.473% (-182.437%, 198.037%)	0.984
MBP→Neu	**0.066% (0.007%, 0.156%)**	**0.028**	0.427% (-0.545%, 1.432%)	0.420	0.493% (-0.502%, 1.469%)	0.352	13.361% (-133.974%, 137.329%)	0.368
MECPP→Neu	**0.066% (0.014%, 0.144%)**	**0.008**	-0.081% (-0.856%, 0.623%)	0.804	-0.016% (-0.797%, 0.712%)	0.960	-421.947% (-245.869%, 398.774%)	0.960
MEHHP→Neu	**0.061% (0.012%, 0.135%)**	**0.006**	0.005% (-0.731%, 0.640%)	0.972	0.056% (-0.670%, 0.728%)	0.916	108.287% (-175.094%, 203.723%）	0.914
MCPP→Neu	0.041% (-0.007%, 0.112%)	0.098	0.339% (-0.489%, 1.108%)	0.394	0.379% (-0.478%, 1.141%)	0.332	10.743% (-72.127%, 133.418%)	0.390
MBzP→Neu	0.034% (-0.014%, 0.102%)	0.170	**1.146% (0.348%, 1.890%)**	**0.004**	**1.180% (0.353%, 1.923%)**	**0.002**	2.891% (-1.294%, 12.981%)	0.172
MCNP→Neu	0.033% (-0.033%, 0.113%)	0.302	1.072% (-0.049%, 1.998%)	0.058	1.104% (-0.034%, 2.046%)	0.058	2.996% (-8.507%, 17.241%)	0.324
MEOHP→Neu	**0.068% (0.016%, 0.148%)**	**0.006**	0.097% (-0.666%, 0.798%)	0.850	0.165% (-0.598%, 0.887%)	0.702	41.430% (-254.135%, 373.191%)	0.704

Note: MEP, mono-ethyl phthalate; MBP, Mono-n-butyl phthalate; MCOP, mono (carboxyoctyl) phthalate; MECPP, mono (2-ethyl-5-carboxypentyl) phthalate; MEHHP, mono (2-ethyl-5-hydroxyhexyl) phthalate; MCPP, mono-(3-carbox ypropyl) phthalate; MBzP, mono benzyl phthalate; MiBP, mono-isobutyl phthalate; MCNP, mono-(carboxynonyl) phthalate; MEOHP, mono-(2-ethyl-5-oxohexyl) phthalate; WBC, white blood cell counts; Neu, neutrophil; MASLD, metabolic dysfunction-associated steatotic liver disease.

Table S9. Associations between single urinary chemicals and HSI and MASLD risk.

Chemicals	Continuous	Quartile 1	Quartile 2	Quartile 3	Quartile 4	P_{trend}
HSI, Linear regression model, β (95% CI)						
Phenols						
BPA	-0.042 (-0.238, 0.153)	Ref.	0.306 (-0.196, 0.809)	0.462 (-0.037, 0.961)	0.099 (-0.490, 0.688)	0.781
BP3	-0.047 (-0.150, 0.056)	Ref.	0.063 (-0.468, 0.594)	0.273 (-0.286, 0.832)	-0.200 (-0.791, 0.391)	0.165
Pesticides						
2,4-DCP	0.049 (-0.081, 0.179)	Ref.	0.133 (-0.468, 0.733)	-0.374 (-0.838, 0.089)	0.354 (-0.158, 0.866)	0.124
2,5-DCP	0.008 (-0.088, 0.104)	Ref.	-0.236 (-0.736, 0.263)	-0.314 (-0.804, 0.175)	0.151 (-0.410, 0.711)	0.218
Phthalates						
MEP	0.057 (-0.094, 0.208)	Ref.	0.362 (-0.131, 0.855)	0.285 (-0.158, 0.727)	0.169 (-0.370, 0.709)	0.956
MBP	-0.029 (-0.253, 0.195)	Ref.	-0.003 (-0.490, 0.484)	0.541 (-0.025, 1.108)	-0.300 (-0.810, 0.211)	0.064
MCOP	0.001 (-0.169, 0.171)	Ref.	0.188 (-0.409, 0.785)	0.209 (-0.268, 0.685)	0.195 (-0.294, 0.683)	0.748
MECPP	-0.161 (-0.363, 0.041)	Ref.	-0.217 (-0.747, 0.313)	-0.231 (-0.700, 0.238)	-0.294 (-0.846, 0.258)	0.517
MEHHP	-0.074 (-0.237, 0.089)	Ref.	-0.006 (-0.608, 0.596)	-0.280 (-0.748, 0.188)	-0.017 (-0.549, 0.515)	0.850
MCPP	-0.032 (-0.209, 0.145)	Ref.	0.266 (-0.267, 0.799)	0.116 (-0.485, 0.716)	0.013 (-0.531, 0.557)	0.540
MBzP	**0.220 (0.035, 0.406)***	Ref.	-0.128 (-0.668, 0.412)	0.165 (-0.357, 0.687)	0.267 (-0.297, 0.830)	0.181
MiBP	0.145 (-0.084, 0.373)	Ref.	0.391 (-0.083, 0.865)	0.283 (-0.209, 0.774)	0.361 (-0.134, 0.856)	0.491
MCNP	-0.002 (-0.233, 0.230)	Ref.	0.000 (-0.516, 0.516)	-0.238 (-0.718, 0.241)	-0.257 (-0.835, 0.321)	0.328
MEOHP	-0.065 (-0.235, 0.104)	Ref.	-0.042 (-0.517, 0.434)	-0.238 (-0.703, 0.227)	-0.116 (-0.628, 0.395)	0.830
MASLD, Logistic regression model, OR (95% CI)						
Phenols						
BPA	1.143 (0.951, 1.375)	Ref.	2.169 (0.886, 5.306)	2.488 (0.944, 6.554)	**3.019 (1.312, 6.944)***	**0.032**
BP3	0.861 (0.681, 1.088)	Ref.	0.812 (0.390, 1.688)	0.610 (0.238, 1.563)	0.536 (0.186, 1.543)	0.394
Pesticides						
2,4-DCP	1.050 (0.848, 1.300)	Ref.	1.120 (0.402, 3.121)	1.323 (0.597, 2.934)	1.011 (0.476, 2.145)	0.852
2,5-DCP	1.042 (0.891, 1.220)	Ref.	0.602 (0.268, 1.352)	0.932 (0.397, 2.186)	0.868 (0.399, 1.889)	0.892
Phthalates						
MEP	1.156 (0.885, 1.511)	Ref.	2.017 (0.731, 5.567)	0.882 (0.318, 2.450)	2.464 (0.877, 6.924)	0.088
MBP	1.105 (0.750, 1.629)	Ref.	0.876 (0.356, 2.157)	1.635 (0.708, 3.776)	1.244 (0.529, 2.926)	0.651
MCOP	0.891 (0.678, 1.170)	Ref.	1.529 (0.712, 3.280)	1.065 (0.422, 2.691)	0.924 (0.389, 2.197)	0.482
MECPP	1.023 (0.804, 1.300)	Ref.	0.636 (0.255, 1.584)	1.849 (0.778, 4.395)	0.814 (0.352, 1.885)	0.589
MEHHP	1.060 (0.831, 1.354)	Ref.	1.796 (0.542, 5.954)	1.588 (0.705, 3.579)	1.792 (0.768, 4.181)	0.481
MCPP	0.947 (0.687, 1.305)	Ref.	0.819 (0.299, 2.243)	0.955 (0.381, 2.397)	0.594 (0.208, 1.698)	0.298
MBzP	**1.573 (1.195, 2.071)***	Ref.	1.202 (0.467, 3.097)	1.398 (0.497, 3.933)	**2.760 (1.287, 5.916)***	**0.018**
MiBP	1.121 (0.783, 1.604)	Ref.	0.632 (0.254, 1.575)	0.726 (0.329, 1.599)	1.070 (0.482, 2.377)	0.386
MCNP	1.392 (0.946, 2.049)	Ref.	**2.660 (1.003, 7.054)***	1.026 (0.325, 3.243)	2.461 (0.914, 6.630)	0.224
MEOHP	1.090 (0.850, 1.399)	Ref.	0.954 (0.384, 2.367)	1.688 (0.699, 4.077)	1.292 (0.581, 2.872)	0.635

Note: * Presenting for $P < 0.05$. Models adjusted for age, gender, race/ethnicity, BMI, PIR, total calories intake, diabetes and ln-transformed serum cotinine, ALT, ALP, and GGT levels, sedentary activity, physical activity, white blood cell counts, and neutrophil. Continuous, Ln-transformed concentration of urinary chemicals. BPA, bisphenol-A; BP3, benzophenone-3; 2,4-DCP, 2,4-dichlorophenol; 2,5-DCP, 2,5-dichlorophenol; MEP,Mono-ethyl phthalate; MBP, Mono-n-butyl phthalate; MCOP, mono (carboxyoctyl) phthalate; MECPP, mono (2-ethyl-5-carboxypentyl)phthalate; MEHHP, mono (2-ethyl-5-hydroxyhexyl) phthalate; MCPP, mono-(3-carbox ypropyl) phthalate; MBzP, mono benzyl phthalate; MiBP, mono-isobutyl phthalate; MCNP, mono-(carboxynonyl) phthalate; MEOHP, mono-(2-ethyl-5-oxohexyl) phthalate; HSI, hepatic steatosis index; MASLD, metabolic dysfunction-associated steatotic liver disease.

Table S10. The proportions and mediating effects of immune cells on relationship between phthalate and HSI.

Pathways	Indirect effect (IDE)		Direct effect (DE)		Total effect		Prop. Mediated	
	β (95% CI)	*P*	β (95% CI)	*P*	β (95% CI)	*P*	β (95% CI)	*P*
WBC								
MEP→WBC	**1.555% (0.384%, 3.167%)**	**< 0.001**	-3.381% (-16.811%, 9.407%)	0.612	-1.826% (-15.095%, 11.103%)	0.800	-85.186% (-334.140%, 710.591%)	0.800
MBP→WBC	**2.337% (0.690%, 4.604%)**	**0.004**	-9.879% (-29.953%, 10.423%)	0.334	-7.542% (26.885%, 13.121%)	0.462	-30.981% (-331.205%, 278.995%)	0.466
MECPP→WBC	**2.797% (1.025%, 5.223%)**	**< 0.001**	-8.867% (-22.757%, 5.445%)	0.228	-6.070% (-20.013%, 7.575%)	0.426	-46.072% (-534.076%, 501.682%)	0.426
MEHHP→WBC	**2.753% (1.001%, 5.030%)**	**< 0.001**	-9.004% (-21.345%, 4.244%)	0.184	-6.250% (-18.933%, 7.004%)	0.338	-44.048% (-541.752%, 367.241%)	0.338
MCPP→WBC	**1.948% (0.516%, 3.823%)**	**0.002**	0.047% (-14.962%, 15.699%)	0.946	1.994% (-13.315%, 17.502%)	0.862	97.648% (-449.717%, 421.534%)	0.860
MBzP→WBC	**1.310% (0.134%, 2.860%)**	**0.030**	**17.449% (0.851%, 36.012%)**	**0.042**	**18.759% (2.114%, 37.176%)**	**0.028**	**6.984% (-0.015%, 41.953%)**	**0.054**
MCNP→WBC	**1.579% (0.152%, 3.687%)**	**0.018**	10.704% (-8.698%, 29.396%)	0.294	12.282% (-6.988%, 3.096%)	0.238	12.854% (-124.197%, 108.509%)	0.252
MEOHP→WBC	**2.924% (1.119%, 5.329%)**	**< 0.001**	-8.298% (-21.431%, 5.854%)	0.236	-5.374% (-18.204%, 8.667%)	0.450	-54.414% (-470.376%, 586.834%)	0.450
Neu								
MEP→Neu	**1.263% (0.194%, 2.680%)**	**0.024**	-3.057% (-16.358%, 10.304%)	0.656	-1.795% (-14.887%, 11.513%)	0.772	70.370% (276.635%, 247.032%)	0.784
MBP→Neu	1.474% (-0.086%, 3.542%)	0.064	-8.530% (-29.496%, 12.184%)	0.408	-7.457% (-27.568%, 14.172%)	0.500	-19.763% (-155.933%, 156.109%)	0.532
MECPP→Neu	**1.480% (0.191%, 3.187%)**	**0.016**	-7.552% (-21.444%, 6.676%)	0.334	-6.072% (-20.035%, 8.349%)	0.402	-24.374% (-259.203%, 140.906%)	0.418
MEHHP→Neu	**1.456% (0.300%, 3.041%)**	**0.002**	-7.634% (-19.971%, 4.609%)	0.240	-6.178% (-18.560%, 6.030%)	0.380	-23.573% (-306.671%, 274.156%	0.382
MCPP→Neu	0.926% (-0.476%, 2.522%)	0.180	0.973% (-13.189%, 16.589%)	0.916	1.899% (-13.189%, 17.682%)	0.826	48.753% (-216.758%, 162.404%)	0.854
MBzP→Neu	0.911% (-0.425%, 2.446%)	0.194	17.742% (-1.816%, 37.997%)	0.076	18.653% (-0.831%, 38.547%)	0.066	4.886% (-13.038%, 29.521%)	0.240
MCNP→Neu	0.438% (-1.244%, 2.325%)	0.612	11.698% (-7.811%, 30.555%)	0.256	12.136% (-7.905%, 31.210%)	0.250	3.609% (-53.449%, 60.706%)	0.666
MEOHP→Neu	**1.705% (0.432%, 3.487%)**	**< 0.001**	-7.007% (-20.318%, 5.913%)	0.318	-5.302% (-18.810%, 7.769%)	0.478	-32.160% (-284.775%, 266.363%)	0.478

Note: Models excluded individuals who had recently taken prescription medications (n = 1674). MEP,Mono-ethyl phthalate; MBP, Mono-n-butyl phthalate; MCOP, mono (carboxyoctyl) phthalate; MECPP, mono (2-ethyl-5-carboxypentyl)phthalate; MEHHP, mono (2-ethyl-5-hydroxyhexyl) phthalate; MCPP, mono-(3-carbox ypropyl) phthalate; MBzP, mono benzyl phthalate; MiBP, mono-isobutyl phthalate; MCNP, mono-(carboxynonyl) phthalate; MEOHP, mono-(2-ethyl-5-oxohexyl) phthalate; WBC, white blood cell counts; Neu, neutrophil; HSI, hepatic steatosis index.

Table S11. The proportions and mediating effects of immune cells on relationship between phthalate and MASLD.

Pathways	Indirect effect (IDE)		Direct effect (DE)		Total effect		Prop. Mediated	
	β (95% CI)	*P*	β (95% CI)	*P*	β (95% CI)	*P*	β (95% CI)	*P*
WBC								
MEP→WBC	**0.063% (0.004%, 0.145%)**	**0.032**	-0.441% (-1.222%, 0.357%)	0.266	-0.378% (-1.163%, 0.429%)	0.346	-16.726% (-197.897%, 194.750%)	0.378
MBP→WBC	**0.090% (0.006%, 0.211%)**	**0.038**	0.139% (-0.929%, 1.353%)	0.742	0.229% (-0.829%, 1.409%)	0.644	0.392% (-169.523%, 170.842%)	0.654
MECPP→WBC	**0.105% (0.010%, 0.222%)**	**0.036**	0.086% (-0.737%, 0.853%)	0.798	0.191% (-0.620%, 0.955%)	0.592	55.104% (-306.172%, 421.583%)	0.588
MEHHP→WBC	**0.103% (0.011%, 0.219%)**	**0.036**	0.059% (-0.707%, 0.807%)	0.800	0.162% (-0.622%, 0.910%)	0.628	63.827% (-360.050%, 410.674%)	0.620
MCPP→WBC	**0.076% (0.004%, 0.171%)**	**0.036**	0.363% (-0.651%, 1.246%)	0.458	0.440% (-0.571%, 1.332%)	0.364	17.196% (-154.620%, 208.389%)	0.380
MBzP→WBC	0.050% (-0.001%, 0.124%)	0.070	**1.157% (0.363%, 2.963%)**	**0.010**	**1.207% (0.382%, 2.109%)**	**0.010**	4.132% (-0.264%, 14.878%)	0.080
MCNP→WBC	**0.063% (0.001%, 0.171%)**	**0.044**	**1.319% (0.304%, 2.308%)**	**0.010**	**1.383% (0.369%, 2.391%)**	**0.010**	**4.569% (0.013%, 19.969%)**	**0.050**
MEOHP→WBC	**0.109% (0.011%, 0.232%)**	**0.036**	0.134% (-0.647%, 0.909%)	0.688	0.243% (-0.575%, 1.022%)	0.498	44.978% (-244.519%, 336.519%)	0.502
Neu								
MEP→Neu	**0.049% (0.003%, 0.122%)**	**0.030**	-0.401% (-1.147%, 0.407%)	0.274	-0.352% (-1.098%, 0.453%)	0.344	-13.929% (-210.056%, 132.814%)	0.366
MBP→Neu	0.056% (-0.002%, 0.165%)	0.072	0.151% (-0.925%, 1.292%)	0.730	0.207% (-0.865%, 1.331%)	0.666	27.038% (-176.633%, 118.553%)	0.702
MECPP→Neu	**0.056% (0.004%, 0.142%)**	**0.020**	0.114% (-0.691%, 0.934%)	0.826	0.170% (-0.647%, 1.003%)	0.716	32.997% (-225.820%, 193.911%)	0.720
MEHHP→Neu	**0.055% (0.005%, 0.141%)**	**0.006**	0.096% (-0.653%, 0.886%)	0.796	0.511% (-0.618%, 0.920%)	0.706	36.479% (-280.490%, 157.944%)	0.708
MCPP→Neu	0.036% (-0.018%, 0.108%)	0.188	0.388% (-0.575%, 1.254%)	0.418	0.423% (-0.528%, 1.306%)	0.374	8.391% (-65.770%, 121.970%)	0.450
MBzP→Neu	0.034% (-0.016%, 0.106%)	0.202	**1.158% (0.406%, 2.065%)**	**0.004**	**1.192% (0.436%, 2.101%)**	**0.004**	2.849% (-1.468%, 11.873%)	0.206
MCNP→Neu	0.017% (-0.048%, 0.102%)	0.616	**1.341% (0.280%, 2.263%)**	**0.018**	**1.358% (0.268%, 2.310%)**	**0.018**	1.281% (-5.553%, 9.145%)	0.626
MEOHP→Neu	**0.064% (0.008%, 0.156%)**	**0.004**	0.167% (-0.594%, 0.971%)	0.676	0.232% (-0.532%, 1.040%)	0.556	27.706% (-156.125%, 267.470%)	0.556

Note: Models excluded individuals who had recently taken prescription medications (n = 1674). MEP,Mono-ethyl phthalate; MBP, Mono-n-butyl phthalate; MCOP, mono (carboxyoctyl) phthalate; MECPP, mono (2-ethyl-5-carboxypentyl)phthalate; MEHHP, mono (2-ethyl-5-hydroxyhexyl) phthalate; MCPP, mono-(3-carbox ypropyl) phthalate; MBzP, mono benzyl phthalate; MiBP, mono-isobutyl phthalate; MCNP, mono-(carboxynonyl) phthalate; MEOHP, mono-(2-ethyl-5-oxohexyl) phthalate; WBC, white blood cell counts; Neu, neutrophil; MASLD, metabolic dysfunction-associated steatotic liver disease.

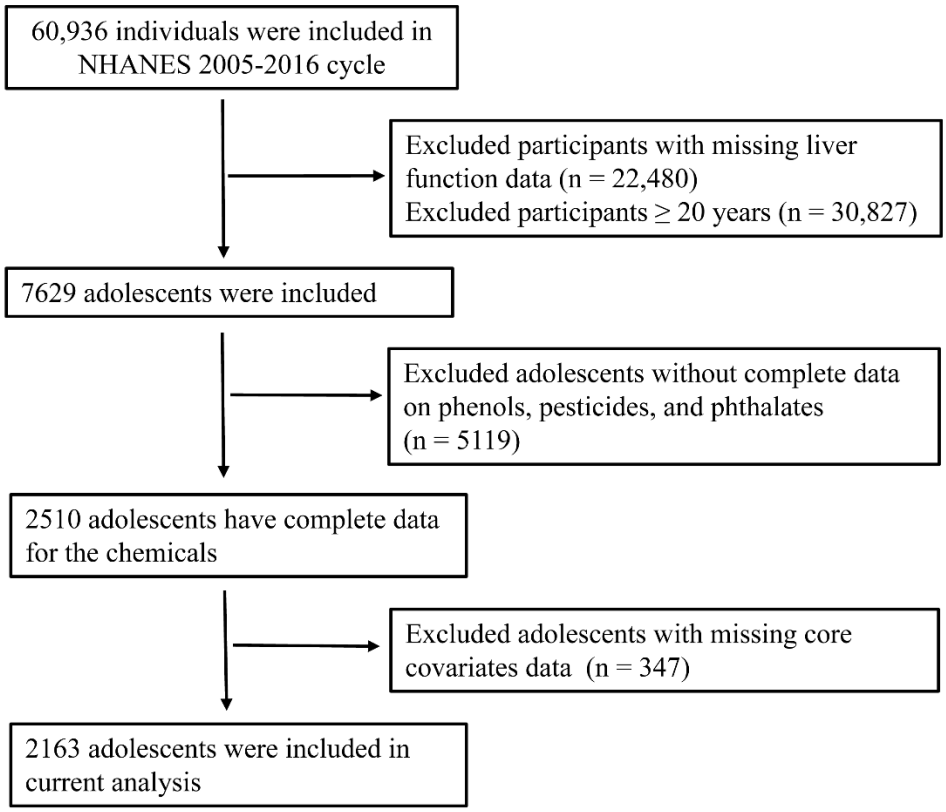

Fig. S1. Flowchart of participant selection.

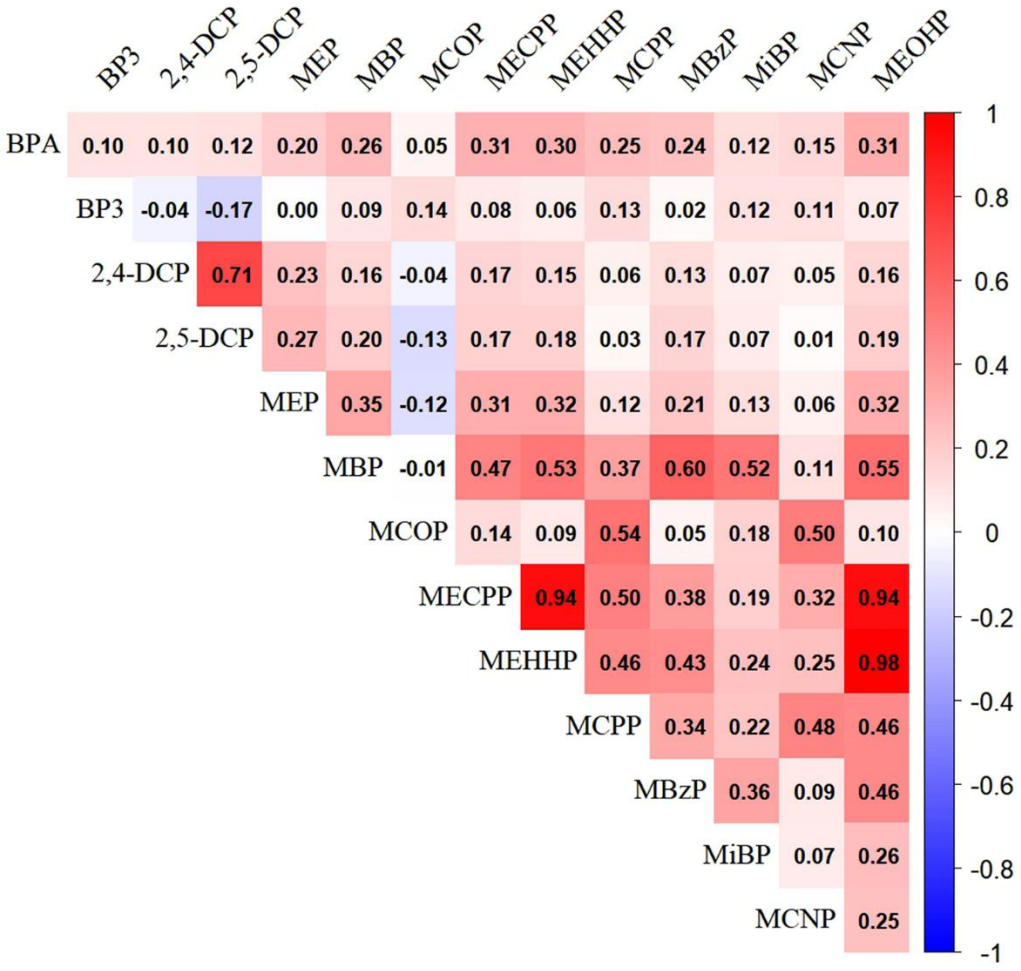

Fig. S2. Spearman correlations between urinary chemicals.

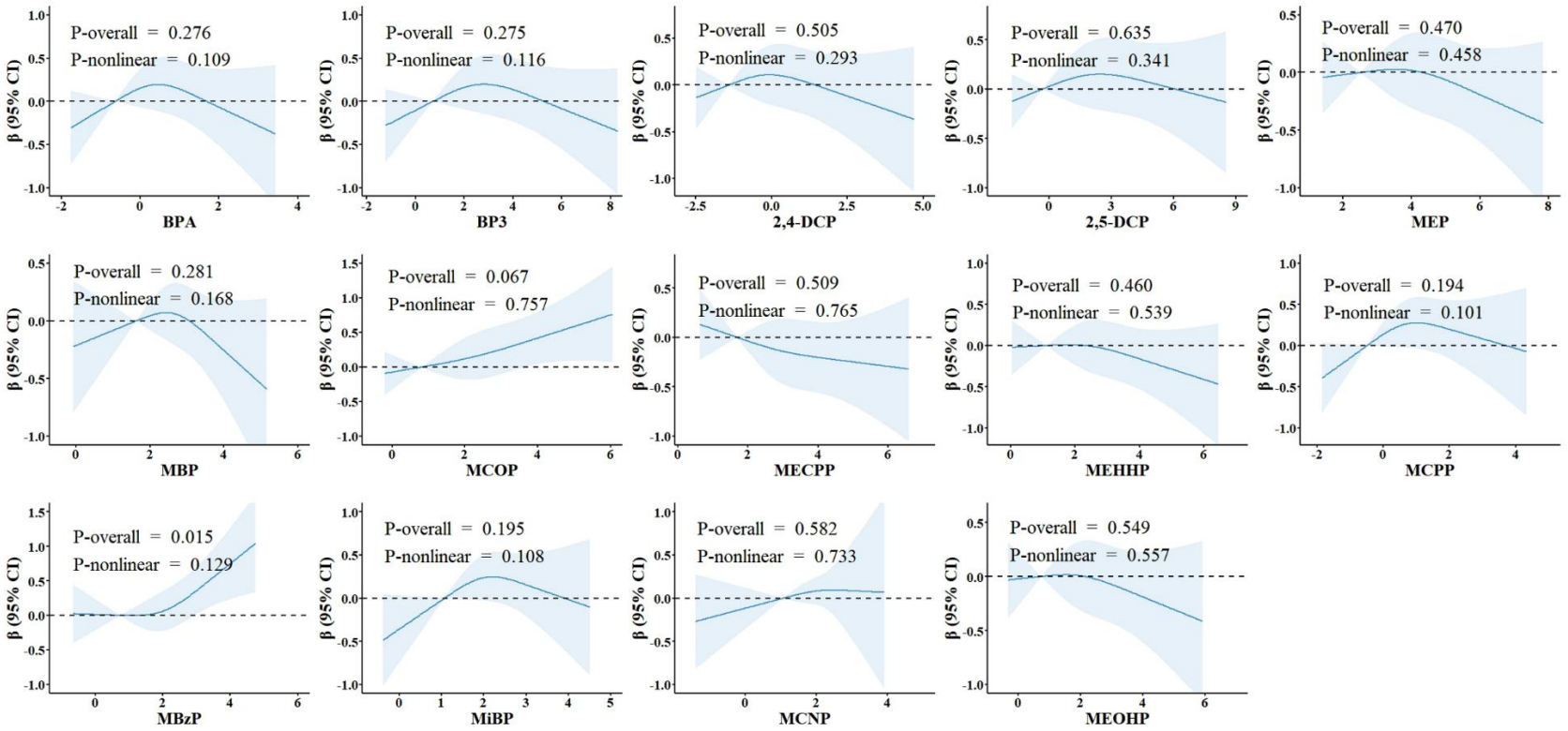

Fig. S3. Restricted cubic splines for the associations between individual chemicals and HSI. Models adjusted for age, gender, race/ethnicity, BMI, PIR, total calories intake, diabetes and ln-transformed serum cotinine, ALT, ALP, and GGT levels.

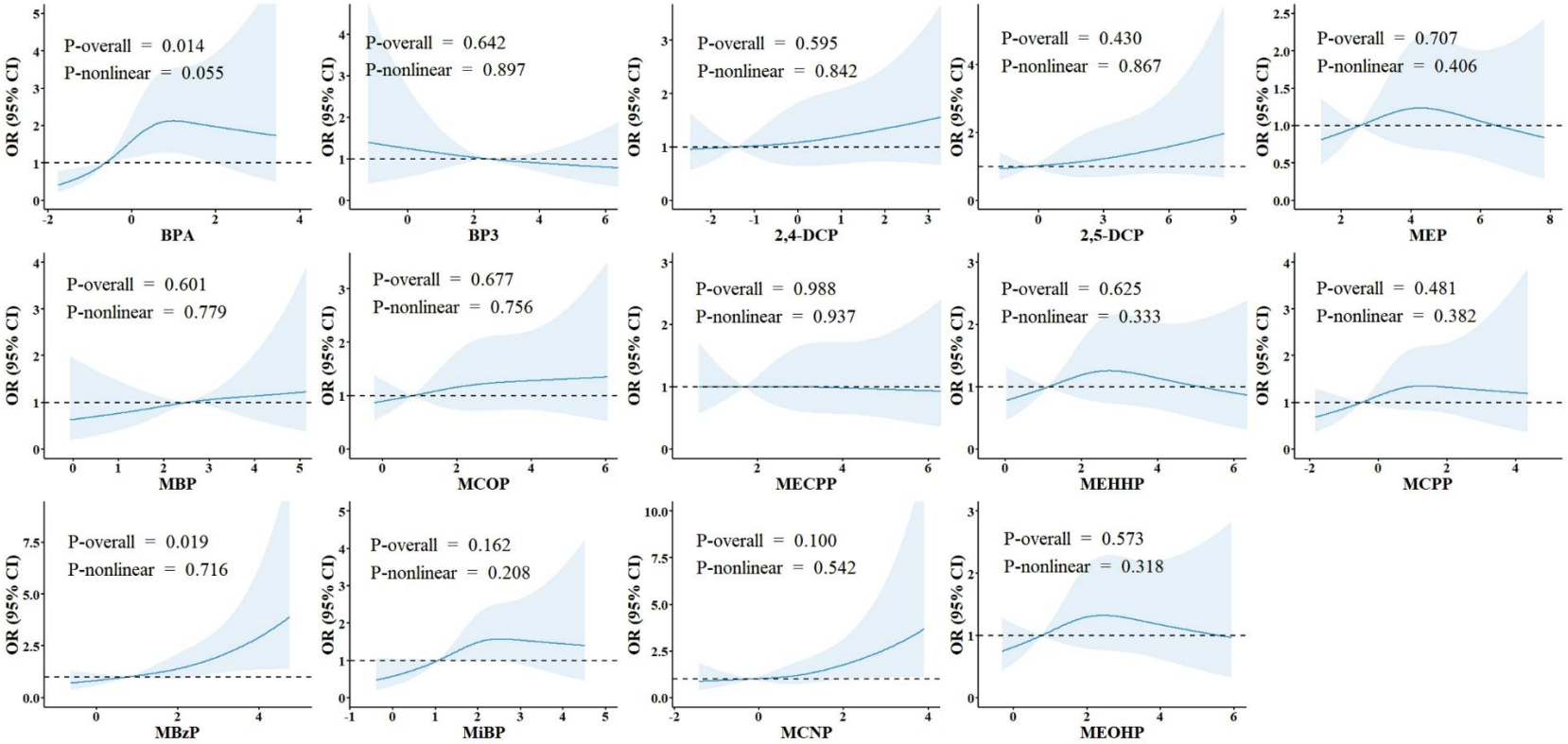

Fig. S4. Restricted cubic splines for the associations between individual chemicals and MASLD. Models adjusted for age, gender, race/ethnicity, BMI, PIR, total calories intake, diabetes and ln-transformed serum cotinine, ALT, ALP, and GGT levels.

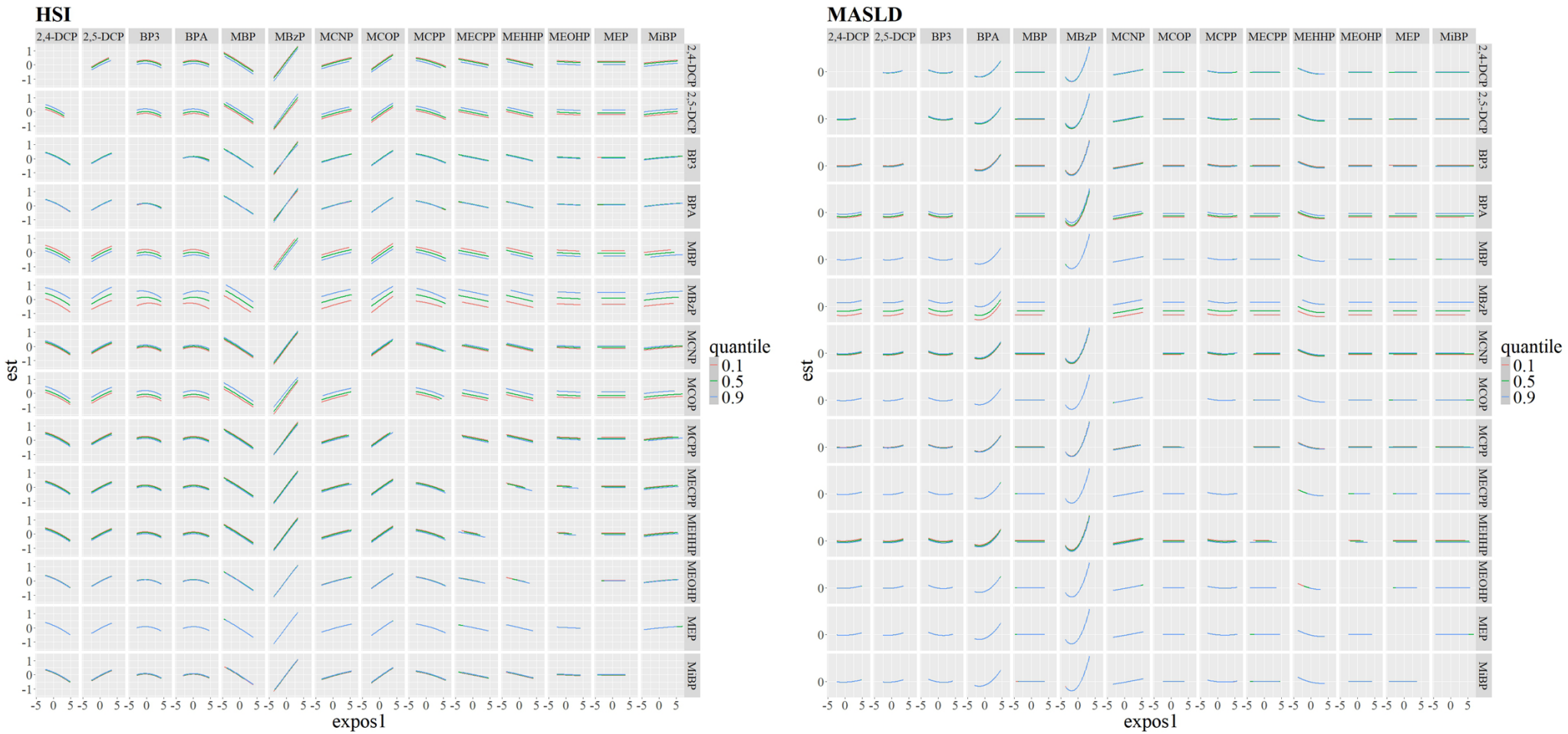

Fig. S5. Bivariate exposure-response functions of a single chemical for the second chemical of mixtures. The second chemical was fixed at its 25th, 50th and 75th percentiles, respectively (and the remaining metals were fixed to the 50th percentile). Models adjusted for age, gender, race/ethnicity, BMI, PIR, total calories intake, diabetes and ln-transformed serum cotinine, ALT, ALP, and GGT levels.

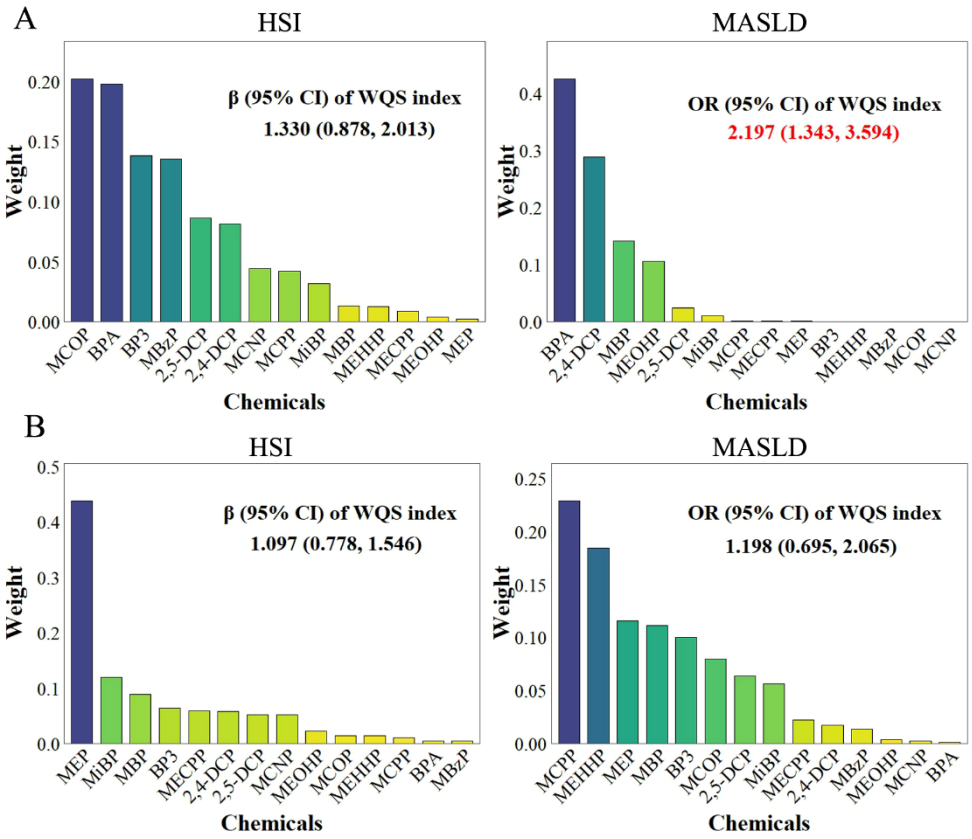

Fig. S6. Associations and component weights of WQS index with HSI and MASLD based on the positive (A) and negative (B) WQS models. Models adjusted for age, gender, race/ethnicity, BMI, PIR, total calories intake, diabetes and ln-transformed serum cotinine, ALT, ALP, GGT levels, sedentary activity, physical activity, white blood cell counts, and neutrophil.