

Supplementary Materials

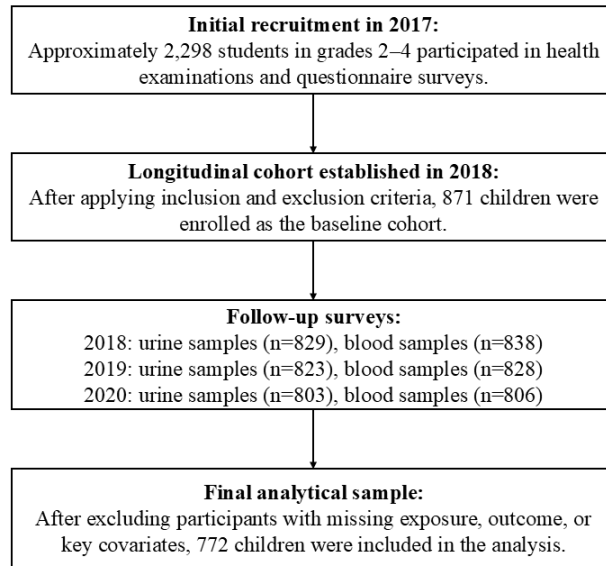
The impact of phthalate exposure on cardiometabolic risk progression in children and the modifying role of movement behaviors

Ruolin Wang¹, Di Gao², Xinli Song¹, Jianuo Jiang¹, Yi Zhang¹, Jieyu Liu¹, Ziqi Dong¹, Yang Qin¹, Dengcheng Zhang¹, Zhenting Lu¹, Li Chen¹, Jinghong Liang¹, Zhiying Song¹, Yi Song¹, Jun Ma¹, Yanhui Dong¹

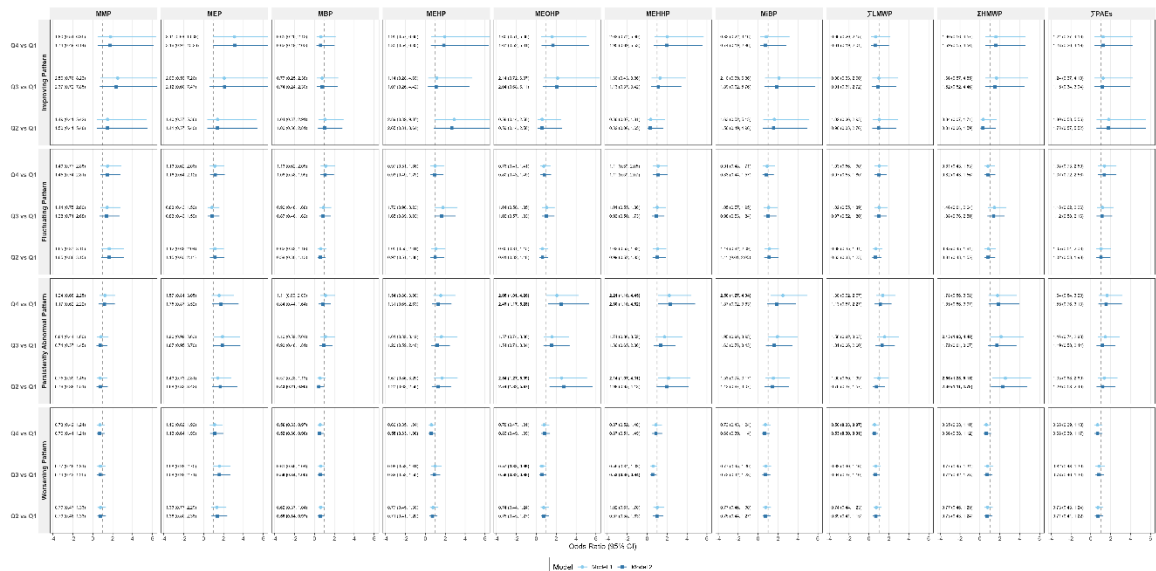
¹Institute of Child and Adolescent Health, School of Public Health, Peking University; National Health Commission Key Laboratory of Reproductive Health, Beijing 100191, China.

²Department of Obstetrics and Gynecology, Peking University First Hospital, Beijing 100034, China.

Correspondence to: Prof. Yanhui Dong, Institute of Child and Adolescent Health, School of Public Health, Peking University; National Health Commission Key Laboratory of Reproductive Health, Beijing 100191, China. E-mail: dongyanhui@bjmu.edu.cn



Supplementary Figure S1. Flowchart of participant selection and follow-up in the longitudinal cohort study.



Supplementary Figure S2. Associations Between Phthalate Exposure and Cardiometabolic Risk Progression Patterns in Model 1 and Model 2. Results from multinomial logistic regression models. Model 1 was unadjusted. Model 2 was adjusted for age, sex, and residence. Phthalate exposures were categorized into quartiles, with the lowest quartile as the reference. OR, odds ratio; CI, confidence interval.

Supplementary Table S1. Detection frequencies and proportions below the limit of detection for urinary phthalate metabolites

Metabolite	LOD	2018 %<LOD	2019 %<LOD	2020 %<LOD	Overall detection
MMP	0.333	5.3%	4.4%	2.7%	95.9%
MEP	0.058	5.4%	3.5%	1%	96.7%

MBP	0.368	5.2%	29.1%	19.3%	82.1%
MEHP	0.012	47.9%	3.6%	1%	82.5%
	5				
MEOHP	0.208	20.9%	3.5%	1%	91.5%
MEHHP	0.127	4.9%	3.5%	1%	96.8%
MiBP	0.442	7.8%	4%	1.2%	95.7%

Limits of detection (LOD) and detection frequencies of urinary phthalate metabolites. Concentrations below the LOD were imputed as LOD divided by the square root of two.

Supplementary Table S2. Baseline prevalence of individual cardiometabolic risk components overall and stratified by sex

Cardiometabolic_Component	Overall <i>n</i> (%)	Boys <i>n</i> (%)	Girls <i>n</i> (%)
			9
Elevated triglycerides	45 (5.8)	36 (9.7)	(2.3)
			10
Low HDL-C	20 (2.6)	10 (2.7)	(2.5)
			2
Elevated fasting glucose	9 (1.2)	7 (1.9)	(0.5)
Elevated blood pressure	21 (2.7)	13 (3.5)	8 (2)

Central obesity 86 (11.2) 74 (19.8) (3)

Baseline prevalence of cardiometabolic risk components. Values are presented as n (%).

Supplementary Table S3. Associations between continuous phthalate exposure (per IQR increase) and cardiometabolic risk progression patterns

Exposure	Outcome Pattern	Model 1	Model 1	Model 2	Model 2	Model 3	Model 3
		OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>
MMP	Persistently abnormal	1.08 (0.86–1.37)	0.501	1.07 (0.82–1.40)	0.599	1.09 (0.83–1.42)	0.546
	Improving	1.10 (0.74–1.65)	0.625	1.09 (0.72–1.64)	0.680	1.08 (0.72–1.63)	0.696
	Fluctuating	1.03 (0.81–1.31)	0.791	1.02 (0.80–1.30)	0.864	1.04 (0.81–1.32)	0.769
	Worsening	0.85 (0.68–1.06)	0.156	0.84 (0.66–1.05)	0.125	0.85 (0.67–1.07)	0.170
MEP	Persistently abnormal	1.19 (0.93–1.53)	0.176	1.22 (0.94–1.60)	0.140	1.22 (0.93–1.61)	0.142
	Improving	1.51 (1.04–2.18)	0.029	1.50 (1.04–2.18)	0.030	1.51 (1.04–2.19)	0.030
	Fluctuating	1.13 (0.88–1.45)	0.348	1.14 (0.88–1.46)	0.325	1.13 (0.88–1.46)	0.333
	Worsening	0.98 (0.77–1.24)	0.851	0.98 (0.78–1.25)	0.899	0.97 (0.77–1.24)	0.831
MBP	Persistently abnormal	1.18 (0.88–1.57)	0.261	1.07 (0.79–1.45)	0.662	1.13 (0.83–1.53)	0.452
	Improving	0.88 (0.53–1.46)	0.620	0.86 (0.52–1.44)	0.569	0.87 (0.52–1.46)	0.605
	Fluctuating	1.07 (0.81–1.42)	0.642	1.04 (0.79–1.39)	0.764	1.04 (0.78–1.39)	0.782
	Worsening	0.86 (0.67–1.10)	0.236	0.84 (0.65–1.07)	0.159	0.85 (0.66–1.10)	0.223

MEHP	Persistently abnormal	1.15 (0.86–1.53)	0.341	1.06 (0.77–1.44)	0.729	1.17 (0.85–1.60)	0.337
	Improving	1.22 (0.74–2.00)	0.430	1.17 (0.72–1.92)	0.523	1.20 (0.74–1.96)	0.460
	Fluctuating	0.96 (0.72–1.28)	0.766	0.93 (0.70–1.25)	0.641	0.95 (0.71–1.28)	0.732
	Worsening	0.95 (0.74–1.22)	0.682	0.92 (0.72–1.19)	0.540	0.95 (0.74–1.24)	0.723
MEOHP	Persistently abnormal	1.18 (0.92–1.52)	0.201	1.23 (0.94–1.61)	0.135	1.27 (0.97–1.67)	0.082
	Improving	1.28 (0.84–1.96)	0.250	1.29 (0.84–1.97)	0.240	1.28 (0.84–1.96)	0.248
	Fluctuating	0.96 (0.74–1.24)	0.737	0.97 (0.74–1.26)	0.813	0.96 (0.73–1.25)	0.760
	Worsening	0.97 (0.77–1.22)	0.789	0.98 (0.78–1.24)	0.887	0.99 (0.78–1.24)	0.915
MEHHP	Persistently abnormal	1.24 (0.97–1.58)	0.080	1.26 (0.97–1.65)	0.084	1.30 (1.00–1.70)	0.053
	Improving	1.48 (1.02–2.14)	0.037	1.47 (1.01–2.12)	0.043	1.44 (1.00–2.08)	0.052
	Fluctuating	1.06 (0.82–1.36)	0.647	1.06 (0.82–1.37)	0.645	1.05 (0.81–1.36)	0.703
	Worsening	0.99 (0.80–1.24)	0.965	0.99 (0.79–1.25)	0.965	0.99 (0.79–1.24)	0.936
MiBP	Persistently abnormal	1.51 (1.16–1.95)	0.002	1.31 (1.00–1.72)	0.051	1.33 (1.01–1.76)	0.042
	Improving	0.99 (0.60–1.64)	0.982	0.94 (0.56–1.56)	0.812	0.94 (0.57–1.57)	0.822
	Fluctuating	0.93 (0.69–1.23)	0.596	0.88 (0.66–1.18)	0.399	0.86 (0.64–1.15)	0.317
	Worsening	1.02 (0.80–1.30)	0.894	0.97 (0.76–1.24)	0.791	0.96 (0.75–1.23)	0.736
ΣLMWP	Persistently abnormal	1.27 (0.98–1.65)	0.075	1.18 (0.90–1.56)	0.231	1.22 (0.92–1.61)	0.164
	Improving	0.82 (0.49–1.36)	0.440	0.80 (0.48–1.34)	0.394	0.79 (0.47–1.33)	0.379
	Fluctuating	1.10 (0.85–1.44)	0.466	1.08 (0.83–1.42)	0.568	1.08 (0.82–1.42)	0.597
	Worsening	0.86 (0.67–1.10)	0.221	0.84 (0.65–1.07)	0.161	0.86 (0.67–1.10)	0.218

ΣHMWP	Persistently abnormal	1.22 (0.95–1.57)	0.121	1.24 (0.94–1.64)	0.127	1.31 (0.99–1.73)	0.057
	Improving	1.34 (0.88–2.03)	0.175	1.32 (0.87–2.01)	0.191	1.32 (0.87–2.00)	0.188
	Fluctuating	0.95 (0.73–1.24)	0.696	0.95 (0.73–1.24)	0.697	0.95 (0.72–1.24)	0.692
	Worsening	1.01 (0.81–1.27)	0.928	1.01 (0.80–1.27)	0.923	1.02 (0.81–1.29)	0.862
ΣPAE	Persistently abnormal	1.23 (0.94–1.61)	0.130	1.18 (0.89–1.58)	0.256	1.25 (0.93–1.67)	0.143
	Improving	1.04 (0.64–1.68)	0.884	1.03 (0.63–1.68)	0.904	1.05 (0.64–1.71)	0.857
	Fluctuating	1.15 (0.88–1.50)	0.320	1.13 (0.87–1.49)	0.361	1.13 (0.86–1.49)	0.375
	Worsening	0.90 (0.70–1.14)	0.370	0.89 (0.69–1.13)	0.329	0.91 (0.71–1.16)	0.429

Results from multinomial logistic regression models. Phthalate exposure variables were log10-transformed and modeled as continuous variables (per interquartile range increase). Model 1 was unadjusted. Model 2 was adjusted for age, sex, and residence. Model 3 was further adjusted for parental educational attainment, only-child status, mode of delivery, and family history of cardiometabolic diseases. OR, odds ratio; CI, confidence interval.

Supplementary Table S4. Comparison of effect estimates across progressively adjusted models

Exposure	Outcome	Contrast	Model 1	Model 1	Model 2	Model 2	Model 3	Model 3
			OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>
MMP	Persistently abnormal	Q2 vs Q1	0.75 (0.39–1.45)	0.396	0.76 (0.38–1.51)	0.428	0.75 (0.37–1.52)	0.423

Persistently abnormal	Q3 vs Q1	0.84 (0.44–1.60)	0.595	0.74 (0.37–1.45)	0.376	0.76 (0.38–1.52)	0.442
Persistently abnormal	Q4 vs Q1	1.24 (0.68–2.25)	0.487	1.17 (0.62–2.22)	0.624	1.19 (0.62–2.29)	0.596
Improving	Q2 vs Q1	1.49 (0.41–5.42)	0.549	1.50 (0.41–5.48)	0.542	1.50 (0.41–5.51)	0.543
Improving	Q3 vs Q1	2.50 (0.76–8.23)	0.132	2.37 (0.72–7.85)	0.156	2.46 (0.74–8.18)	0.143
Improving	Q4 vs Q1	1.80 (0.51–6.35)	0.359	1.74 (0.49–6.14)	0.392	1.73 (0.48–6.17)	0.398
Fluctuating	Q2 vs Q1	1.65 (0.87–3.15)	0.128	1.65 (0.86–3.15)	0.131	1.65 (0.86–3.17)	0.134
Fluctuating	Q3 vs Q1	1.44 (0.75–2.80)	0.275	1.38 (0.71–2.68)	0.342	1.38 (0.71–2.69)	0.349
Fluctuating	Q4 vs Q1	1.49 (0.77–2.88)	0.239	1.45 (0.74–2.81)	0.276	1.48 (0.75–2.89)	0.255
Worsening	Q2 vs Q1	0.79 (0.47–1.33)	0.370	0.79 (0.46–1.33)	0.367	0.78 (0.46–1.33)	0.360
Worsening	Q3 vs Q1	0.77 (0.46–1.31)	0.336	0.74 (0.43–1.25)	0.257	0.75 (0.44–1.28)	0.292

MEP	Worsening	Q4 vs Q1	0.73 (0.42– 1.24)	0.242	0.70 (0.41– 1.21)	0.203	0.73 (0.42– 1.26)	0.262
	Persistently abnormal	Q2 vs Q1	1.43 (0.73– 2.81)	0.297	1.68 (0.83– 3.42)	0.151	1.57 (0.76– 3.24)	0.225
	Persistently abnormal	Q3 vs Q1	1.90 (0.99– 3.63)	0.053	1.87 (0.95– 3.70)	0.072	2.03 (1.01– 4.08)	0.046
	Persistently abnormal	Q4 vs Q1	1.57 (0.81– 3.05)	0.182	1.75 (0.87– 3.52)	0.115	1.73 (0.85– 3.54)	0.130
	Improving	Q2 vs Q1	1.40 (0.37– 5.36)	0.623	1.41 (0.37– 5.40)	0.618	1.27 (0.33– 4.92)	0.733
	Improving	Q3 vs Q1	2.06 (0.59– 7.26)	0.259	2.12 (0.60– 7.47)	0.245	2.03 (0.57– 7.23)	0.273
	Improving	Q4 vs Q1	3.11 (0.96– 10.08)	0.059	3.16 (0.97– 10.26)	0.056	3.09 (0.95– 10.13)	0.062
	Fluctuating	Q2 vs Q1	1.12 (0.62– 2.04)	0.710	1.15 (0.63– 2.11)	0.640	1.07 (0.58– 1.97)	0.840
	Fluctuating	Q3 vs Q1	0.83 (0.43– 1.59)	0.572	0.83 (0.43– 1.59)	0.575	0.85 (0.44– 1.63)	0.617
	Fluctuating	Q4 vs Q1	1.13 (0.62– 2.06)	0.686	1.16 (0.64– 2.12)	0.623	1.14 (0.62– 2.10)	0.664

MBP	Worsening	Q2 vs Q1	1.33 (0.77–2.29)	0.302	1.38 (0.80–2.38)	0.252	1.35 (0.77–2.36)	0.293
	Worsening	Q3 vs Q1	1.58 (0.93–2.70)	0.091	1.58 (0.93–2.71)	0.093	1.65 (0.96–2.85)	0.070
	Worsening	Q4 vs Q1	1.10 (0.62–1.92)	0.750	1.13 (0.64–1.99)	0.674	1.12 (0.63–1.99)	0.696
	Persistently abnormal	Q2 vs Q1	0.57 (0.28–1.13)	0.108	0.43 (0.21–0.90)	0.025	0.48 (0.23–1.01)	0.052
	Persistently abnormal	Q3 vs Q1	1.10 (0.59–2.04)	0.770	0.93 (0.48–1.81)	0.839	1.08 (0.55–2.13)	0.822
	Persistently abnormal	Q4 vs Q1	1.11 (0.60–2.06)	0.746	0.84 (0.44–1.64)	0.618	0.96 (0.49–1.90)	0.917
	Improving	Q2 vs Q1	1.04 (0.37–2.91)	0.933	1.00 (0.36–2.81)	0.998	1.00 (0.35–2.84)	0.994
	Improving	Q3 vs Q1	0.77 (0.25–2.38)	0.653	0.74 (0.24–2.30)	0.606	0.77 (0.25–2.41)	0.652
	Improving	Q4 vs Q1	0.65 (0.20–2.12)	0.475	0.62 (0.19–2.03)	0.425	0.64 (0.19–2.12)	0.467
	Fluctuating	Q2 vs Q1	0.62 (0.32–1.19)	0.151	0.58 (0.30–1.13)	0.107	0.58 (0.30–1.14)	0.115

MEHP	Fluctuating	Q3 vs Q1	0.90 (0.48– 1.68)	0.743	0.87 (0.46– 1.62)	0.656	0.86 (0.46– 1.62)	0.635
	Fluctuating	Q4 vs Q1	1.13 (0.62– 2.05)	0.692	1.06 (0.58– 1.95)	0.847	1.06 (0.58– 1.96)	0.848
	Worsening	Q2 vs Q1	0.62 (0.37– 1.04)	0.071	0.58 (0.34– 0.97)	0.039	0.58 (0.34– 0.99)	0.046
	Worsening	Q3 vs Q1	0.61 (0.36– 1.04)	0.071	0.58 (0.34– 1.00)	0.050	0.60 (0.35– 1.03)	0.062
	Worsening	Q4 vs Q1	0.56 (0.33– 0.97)	0.037	0.52 (0.30– 0.90)	0.019	0.53 (0.31– 0.93)	0.027
	Persistently abnormal	Q2 vs Q1	1.67 (0.86– 3.25)	0.132	1.27 (0.63– 2.56)	0.503	1.50 (0.73– 3.09)	0.273
	Persistently abnormal	Q3 vs Q1	1.61 (0.82– 3.19)	0.170	1.20 (0.59– 2.46)	0.617	1.36 (0.65– 2.85)	0.415
	Persistently abnormal	Q4 vs Q1	1.54 (0.80– 3.00)	0.200	1.31 (0.65– 2.63)	0.455	1.69 (0.82– 3.50)	0.155
	Improving	Q2 vs Q1	2.89 (0.89– 9.37)	0.077	2.65 (0.81– 8.64)	0.107	2.71 (0.81– 9.07)	0.105
	Improving	Q3 vs Q1	1.14 (0.28– 4.69)	0.855	1.07 (0.26– 4.42)	0.926	1.12 (0.27– 4.71)	0.878

MEOHP	Improving	Q4 vs Q1	1.95 (0.57– 6.65)	0.289	1.85 (0.54– 6.35)	0.328	2.04 (0.58– 7.19)	0.265
	Fluctuating	Q2 vs Q1	1.05 (0.55– 2.01)	0.884	0.97 (0.51– 1.88)	0.938	1.02 (0.52– 1.99)	0.959
	Fluctuating	Q3 vs Q1	1.76 (0.96– 3.23)	0.066	1.65 (0.89– 3.03)	0.109	1.66 (0.89– 3.08)	0.110
	Fluctuating	Q4 vs Q1	0.97 (0.51– 1.86)	0.931	0.93 (0.49– 1.79)	0.837	0.98 (0.50– 1.90)	0.951
	Worsening	Q2 vs Q1	0.77 (0.45– 1.30)	0.330	0.71 (0.41– 1.20)	0.201	0.74 (0.43– 1.29)	0.290
	Worsening	Q3 vs Q1	0.96 (0.58– 1.61)	0.888	0.89 (0.53– 1.50)	0.654	0.90 (0.53– 1.52)	0.687
	Worsening	Q4 vs Q1	0.60 (0.35– 1.04)	0.070	0.58 (0.33– 1.00)	0.049	0.62 (0.35– 1.08)	0.091
	Persistently abnormal	Q2 vs Q1	2.54 (1.27– 5.09)	0.009	2.74 (1.32– 5.67)	0.007	3.13 (1.48– 6.61)	0.003
	Persistently abnormal	Q3 vs Q1	1.57 (0.74– 3.30)	0.236	1.54 (0.71– 3.34)	0.273	1.78 (0.80– 3.96)	0.157
	Persistently abnormal	Q4 vs Q1	2.08 (1.01– 4.26)	0.046	2.49 (1.17– 5.28)	0.018	2.84 (1.31– 6.14)	0.008

MEHHP	Improving	Q2 vs Q1	0.58 (0.14– 2.50)	0.468	0.59 (0.14– 2.55)	0.483	0.61 (0.14– 2.63)	0.504
	Improving	Q3 vs Q1	2.14 (0.72– 6.37)	0.173	2.04 (0.68– 6.11)	0.205	2.19 (0.72– 6.68)	0.170
	Improving	Q4 vs Q1	1.60 (0.51– 5.06)	0.424	1.67 (0.52– 5.31)	0.386	1.74 (0.54– 5.61)	0.352
	Fluctuating	Q2 vs Q1	0.60 (0.31– 1.15)	0.126	0.61 (0.32– 1.18)	0.144	0.61 (0.32– 1.18)	0.144
	Fluctuating	Q3 vs Q1	1.04 (0.58– 1.85)	0.899	1.03 (0.57– 1.83)	0.932	0.97 (0.54– 1.76)	0.922
	Fluctuating	Q4 vs Q1	0.76 (0.41– 1.41)	0.382	0.80 (0.43– 1.49)	0.477	0.79 (0.42– 1.49)	0.468
	Worsening	Q2 vs Q1	0.74 (0.44– 1.24)	0.252	0.75 (0.45– 1.27)	0.290	0.76 (0.45– 1.28)	0.299
	Worsening	Q3 vs Q1	0.57 (0.33– 0.99)	0.045	0.56 (0.32– 0.98)	0.041	0.56 (0.32– 0.99)	0.045
	Worsening	Q4 vs Q1	0.78 (0.47– 1.31)	0.353	0.83 (0.49– 1.39)	0.474	0.82 (0.48– 1.40)	0.470
	Persistently abnormal	Q2 vs Q1	2.14 (1.07– 4.31)	0.032	1.98 (0.95– 4.13)	0.068	2.17 (1.03– 4.59)	0.042

Persistently abnormal	Q3 vs Q1	1.74 (0.86–3.52)	0.126	1.36 (0.65–2.86)	0.415	1.47 (0.69–3.14)	0.323
Persistently abnormal	Q4 vs Q1	2.21 (1.10–4.45)	0.026	2.30 (1.10–4.82)	0.027	2.51 (1.18–5.33)	0.017
Improving	Q2 vs Q1	0.36 (0.07–1.81)	0.214	0.32 (0.06–1.65)	0.174	0.33 (0.07–1.72)	0.189
Improving	Q3 vs Q1	1.30 (0.43–3.86)	0.641	1.13 (0.37–3.42)	0.828	1.20 (0.39–3.68)	0.747
Improving	Q4 vs Q1	2.03 (0.72–5.69)	0.180	1.95 (0.69–5.53)	0.210	1.97 (0.69–5.63)	0.207
Fluctuating	Q2 vs Q1	1.03 (0.55–1.92)	0.929	0.99 (0.52–1.85)	0.964	1.01 (0.53–1.90)	0.980
Fluctuating	Q3 vs Q1	1.01 (0.55–1.86)	0.972	0.93 (0.50–1.73)	0.823	0.97 (0.52–1.82)	0.922
Fluctuating	Q4 vs Q1	1.11 (0.59–2.05)	0.752	1.11 (0.59–2.07)	0.748	1.10 (0.58–2.07)	0.771
Worsening	Q2 vs Q1	1.02 (0.61–1.70)	0.934	0.97 (0.58–1.63)	0.915	0.98 (0.58–1.65)	0.940
Worsening	Q3 vs Q1	0.59 (0.34–1.03)	0.061	0.53 (0.30–0.94)	0.030	0.54 (0.31–0.96)	0.037

MiBP	Worsening	Q4 vs Q1	0.87 (0.52– 1.48)	0.617	0.87 (0.51– 1.49)	0.620	0.87 (0.50– 1.49)	0.604
	Persistently abnormal	Q2 vs Q1	1.53 (0.74– 3.17)	0.254	1.43 (0.67– 3.07)	0.356	1.53 (0.70– 3.33)	0.285
	Persistently abnormal	Q3 vs Q1	1.95 (0.96– 3.95)	0.063	1.63 (0.78– 3.43)	0.194	1.70 (0.80– 3.62)	0.166
	Persistently abnormal	Q4 vs Q1	2.50 (1.27– 4.94)	0.008	1.87 (0.92– 3.83)	0.086	1.99 (0.96– 4.14)	0.066
	Improving	Q2 vs Q1	1.63 (0.52– 5.15)	0.404	1.56 (0.49– 4.96)	0.447	1.68 (0.53– 5.37)	0.381
	Improving	Q3 vs Q1	2.10 (0.69– 6.36)	0.189	1.89 (0.62– 5.76)	0.264	1.99 (0.65– 6.13)	0.229
	Improving	Q4 vs Q1	0.82 (0.22– 3.16)	0.777	0.74 (0.19– 2.86)	0.660	0.74 (0.19– 2.88)	0.662
	Fluctuating	Q2 vs Q1	1.14 (0.62– 2.09)	0.667	1.11 (0.61– 2.05)	0.726	1.11 (0.60– 2.07)	0.731
	Fluctuating	Q3 vs Q1	1.05 (0.57– 1.95)	0.876	0.98 (0.53– 1.84)	0.960	0.97 (0.52– 1.83)	0.937
	Fluctuating	Q4 vs Q1	0.91 (0.48– 1.71)	0.761	0.83 (0.44– 1.57)	0.565	0.76 (0.40– 1.46)	0.413

ΣLMWP	Worsening	Q2 vs Q1	0.77 (0.46– 1.30)	0.328	0.75 (0.44– 1.27)	0.287	0.72 (0.42– 1.24)	0.239
	Worsening	Q3 vs Q1	0.77 (0.45– 1.30)	0.332	0.72 (0.42– 1.23)	0.225	0.71 (0.41– 1.21)	0.206
	Worsening	Q4 vs Q1	0.73 (0.43– 1.24)	0.249	0.66 (0.39– 1.13)	0.134	0.63 (0.36– 1.09)	0.096
	Persistently abnormal	Q2 vs Q1	1.00 (0.50– 1.99)	0.990	0.76 (0.37– 1.57)	0.460	0.85 (0.40– 1.79)	0.667
	Persistently abnormal	Q3 vs Q1	1.58 (0.82– 3.03)	0.171	1.31 (0.66– 2.60)	0.446	1.48 (0.73– 3.00)	0.280
	Persistently abnormal	Q4 vs Q1	1.38 (0.72– 2.67)	0.334	1.13 (0.57– 2.27)	0.727	1.25 (0.61– 2.54)	0.542
	Improving	Q2 vs Q1	1.02 (0.36– 2.93)	0.964	0.96 (0.33– 2.76)	0.936	0.94 (0.32– 2.72)	0.903
	Improving	Q3 vs Q1	0.98 (0.33– 2.90)	0.970	0.91 (0.31– 2.72)	0.872	0.87 (0.29– 2.62)	0.807
	Improving	Q4 vs Q1	0.66 (0.20– 2.15)	0.488	0.61 (0.19– 2.01)	0.417	0.60 (0.18– 2.00)	0.407
	Fluctuating	Q2 vs Q1	0.68 (0.35– 1.31)	0.252	0.63 (0.33– 1.23)	0.176	0.64 (0.33– 1.25)	0.191

ΣHMWP	Fluctuating	Q3 vs Q1	1.02 (0.55–1.89)	0.954	0.97 (0.52–1.80)	0.913	0.93 (0.49–1.74)	0.815
	Fluctuating	Q4 vs Q1	1.03 (0.56–1.90)	0.917	0.97 (0.53–1.80)	0.933	0.99 (0.53–1.84)	0.969
	Worsening	Q2 vs Q1	0.74 (0.44–1.23)	0.249	0.69 (0.41–1.15)	0.153	0.71 (0.42–1.20)	0.196
	Worsening	Q3 vs Q1	0.68 (0.40–1.16)	0.158	0.64 (0.37–1.10)	0.107	0.65 (0.38–1.13)	0.125
	Worsening	Q4 vs Q1	0.56 (0.33–0.97)	0.038	0.53 (0.30–0.91)	0.023	0.55 (0.32–0.96)	0.037
	Persistently abnormal	Q2 vs Q1	2.56 (1.28–5.15)	0.008	2.30 (1.11–4.78)	0.025	2.76 (1.30–5.86)	0.008
	Persistently abnormal	Q3 vs Q1	2.13 (1.03–4.40)	0.041	1.72 (0.81–3.67)	0.159	2.10 (0.96–4.58)	0.063
	Persistently abnormal	Q4 vs Q1	1.78 (0.86–3.68)	0.121	1.85 (0.86–3.97)	0.113	2.26 (1.03–4.95)	0.042
	Improving	Q2 vs Q1	0.34 (0.07–1.71)	0.189	0.31 (0.06–1.59)	0.160	0.33 (0.06–1.68)	0.181
	Improving	Q3 vs Q1	1.66 (0.57–4.85)	0.353	1.52 (0.52–4.46)	0.446	1.63 (0.55–4.85)	0.380

ΣΡΑΕ	Improving	Q4 vs Q1	1.60 (0.56– 4.57)	0.376	1.59 (0.55– 4.56)	0.388	1.69 (0.58– 4.94)	0.334
	Fluctuating	Q2 vs Q1	0.85 (0.45– 1.61)	0.615	0.81 (0.43– 1.55)	0.530	0.81 (0.42– 1.56)	0.534
	Fluctuating	Q3 vs Q1	1.46 (0.81– 2.64)	0.207	1.38 (0.76– 2.50)	0.292	1.39 (0.76– 2.55)	0.283
	Fluctuating	Q4 vs Q1	0.81 (0.43– 1.53)	0.515	0.82 (0.43– 1.56)	0.539	0.81 (0.42– 1.56)	0.534
	Worsening	Q2 vs Q1	0.77 (0.46– 1.29)	0.319	0.73 (0.43– 1.24)	0.246	0.75 (0.44– 1.28)	0.288
	Worsening	Q3 vs Q1	0.77 (0.45– 1.31)	0.336	0.72 (0.42– 1.23)	0.229	0.74 (0.43– 1.28)	0.277
	Worsening	Q4 vs Q1	0.65 (0.38– 1.10)	0.109	0.66 (0.38– 1.12)	0.123	0.67 (0.39– 1.15)	0.149
	Persistently abnormal	Q2 vs Q1	1.35 (0.68– 2.69)	0.388	1.20 (0.58– 2.46)	0.628	1.48 (0.70– 3.11)	0.306
	Persistently abnormal	Q3 vs Q1	1.46 (0.74– 2.88)	0.280	1.19 (0.58– 2.44)	0.640	1.37 (0.65– 2.87)	0.410
	Persistently abnormal	Q4 vs Q1	1.64 (0.84– 3.20)	0.148	1.55 (0.76– 3.13)	0.225	1.85 (0.89– 3.85)	0.097

Improving	Q2 vs Q1	1.80 (0.58–5.56)	0.307	1.78 (0.57–5.52)	0.317	1.90 (0.60–6.02)	0.275
Improving	Q3 vs Q1	1.24 (0.37–4.19)	0.732	1.15 (0.34–3.94)	0.818	1.20 (0.35–4.14)	0.775
Improving	Q4 vs Q1	1.24 (0.37–4.19)	0.732	1.23 (0.36–4.19)	0.739	1.31 (0.38–4.55)	0.668
Fluctuating	Q2 vs Q1	1.05 (0.54–2.03)	0.890	1.02 (0.53–1.98)	0.949	1.03 (0.52–2.02)	0.933
Fluctuating	Q3 vs Q1	1.18 (0.62–2.26)	0.620	1.12 (0.58–2.16)	0.735	1.09 (0.56–2.12)	0.804
Fluctuating	Q4 vs Q1	1.38 (0.73–2.59)	0.323	1.37 (0.72–2.58)	0.336	1.37 (0.72–2.61)	0.339
Worsening	Q2 vs Q1	0.73 (0.43–1.24)	0.243	0.71 (0.41–1.22)	0.212	0.76 (0.44–1.32)	0.330
Worsening	Q3 vs Q1	0.82 (0.48–1.39)	0.461	0.78 (0.46–1.33)	0.361	0.81 (0.47–1.40)	0.451
Worsening	Q4 vs Q1	0.68 (0.39–1.18)	0.167	0.68 (0.39–1.17)	0.165	0.72 (0.41–1.26)	0.251

Results from multinomial logistic regression models. Model 1 was unadjusted. Model 2 was adjusted for age, sex, and residence. Model 3 was further adjusted for parental educational attainment, only-child status, mode of delivery, and family history of cardiometabolic diseases. OR, odds ratio; CI, confidence interval.

Supplementary Table S5. Diet-adjusted sensitivity analysis of associations between phthalate exposure and cardiometabolic risk progression patterns

Exposure	Outcome Pattern	Q2 vs Q1	Q2 vs Q1	Q3 vs Q1	Q3 vs Q1	Q4 vs Q1	Q4 vs
		OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>	OR (95% CI)	Q1 <i>P</i>
MMP	Persistently abnormal	2.16 (1.24–3.74)	0.006	0.74 (0.30–1.84)	0.519	1.57 (1.07–2.30)	0.020
	Improving	0.14 (0.00–6.86)	0.322	0.65 (0.02–17.34)	0.796	2.16 (0.04–132.97)	0.713
	Fluctuating	0.96 (0.66–1.41)	0.846	0.42 (0.15–1.20)	0.106	0.57 (0.31–1.03)	0.064
	Worsening	1.10 (0.47–2.57)	0.819	1.27 (0.60–2.69)	0.530	2.07 (0.82–5.23)	0.122
MEP	Persistently abnormal	2.20 (1.26–3.84)	0.005	0.71 (0.29–1.77)	0.464	1.59 (1.08–2.33)	0.018
	Improving	0.21 (0.00–9.97)	0.429	0.47 (0.02–12.51)	0.652	1.47 (0.02–93.58)	0.855
	Fluctuating	0.95 (0.65–1.39)	0.798	0.40 (0.14–1.12)	0.081	0.55 (0.30–1.00)	0.049
	Worsening	1.05 (0.45–2.43)	0.910	1.32 (0.62–2.80)	0.468	2.09 (0.83–5.27)	0.120
MBP	Persistently abnormal	2.20 (1.26–3.83)	0.005	0.73 (0.29–1.81)	0.497	1.56 (1.07–2.28)	0.022
	Improving	0.26 (0.01–12.82)	0.499	1.12 (0.04–31.13)	0.948	3.03 (0.05–200.92)	0.604
	Fluctuating	0.96 (0.66–1.41)	0.847	0.40 (0.14–1.13)	0.084	0.55 (0.30–1.00)	0.052
	Worsening	1.06 (0.46–2.48)	0.888	1.34 (0.63–2.86)	0.450	1.93 (0.77–4.84)	0.162
MEHP	Persistently abnormal	2.31 (1.32–4.03)	0.003	0.68 (0.27–1.67)	0.399	1.59 (1.09–2.34)	0.017
	Improving	0.20 (0.00–9.89)	0.418	0.69 (0.02–18.93)	0.825	1.77 (0.03–109.56)	0.786

MEOHP	Fluctuating	0.95 (0.65–1.38)	0.782	0.44 (0.15–1.24)	0.120	0.57 (0.31–1.04)	0.068
	Worsening	1.06 (0.45–2.50)	0.891	1.23 (0.58–2.62)	0.594	2.18 (0.86–5.52)	0.099
	Persistently abnormal	2.24 (1.28–3.91)	0.005	0.75 (0.30–1.86)	0.535	1.61 (1.09–2.36)	0.015
	Improving	0.25 (0.01–12.33)	0.486	0.85 (0.03–23.48)	0.925	0.85 (0.01–55.92)	0.941
MEHHP	Fluctuating	0.97 (0.66–1.41)	0.861	0.43 (0.15–1.22)	0.113	0.58 (0.32–1.05)	0.074
	Worsening	1.06 (0.46–2.47)	0.886	1.26 (0.59–2.66)	0.552	2.16 (0.85–5.51)	0.108
	Persistently abnormal	2.17 (1.25–3.77)	0.006	0.75 (0.30–1.85)	0.528	1.57 (1.07–2.31)	0.020
	Improving	0.22 (0.00–11.03)	0.447	0.92 (0.03–26.39)	0.962	0.78 (0.01–54.40)	0.910
MiBP	Fluctuating	1.00 (0.68–1.47)	0.990	0.39 (0.14–1.14)	0.085	0.55 (0.30–1.01)	0.053
	Worsening	1.06 (0.46–2.48)	0.885	1.21 (0.57–2.57)	0.616	2.02 (0.79–5.13)	0.140
	Persistently abnormal	2.10 (1.21–3.65)	0.008	0.73 (0.30–1.82)	0.504	1.58 (1.08–2.31)	0.018
	Improving	0.25 (0.01–11.48)	0.474	0.73 (0.03–19.91)	0.853	1.35 (0.02–87.26)	0.889
ΣLMWP	Fluctuating	0.97 (0.66–1.42)	0.874	0.40 (0.14–1.14)	0.087	0.53 (0.29–0.97)	0.038
	Worsening	1.09 (0.47–2.52)	0.849	1.28 (0.60–2.72)	0.520	1.96 (0.78–4.91)	0.151
	Persistently abnormal	2.14 (1.23–3.72)	0.007	0.74 (0.30–1.82)	0.507	1.54 (1.05–2.26)	0.025
	Improving	0.37 (0.01–18.35)	0.616	1.14 (0.04–31.55)	0.940	2.39 (0.04–160.04)	0.685
ΣHMWP	Fluctuating	0.95 (0.65–1.39)	0.780	0.39 (0.14–1.11)	0.078	0.51 (0.28–0.93)	0.028
	Worsening	1.09 (0.47–2.53)	0.848	1.28 (0.60–2.72)	0.518	2.04 (0.81–5.09)	0.128
	Persistently abnormal	2.32 (1.33–4.05)	0.003	0.71 (0.28–1.78)	0.465	1.56 (1.06–2.29)	0.023
	Improving	0.19 (0.00–9.25)	0.401	0.80 (0.03–21.77)	0.894	1.31 (0.02–83.30)	0.900

ΣPAE	Fluctuating	0.95 (0.65–1.38)	0.776	0.40 (0.14–1.15)	0.089	0.58 (0.32–1.05)	0.073
	Worsening	1.05 (0.45–2.45)	0.901	1.26 (0.59–2.66)	0.551	2.15 (0.85–5.43)	0.106
	Persistently abnormal	2.47 (1.39–4.39)	0.002	0.81 (0.33–2.03)	0.660	1.59 (1.09–2.34)	0.017
	Improving	0.22 (0.00–12.00)	0.462	0.59 (0.02–18.33)	0.765	4.81 (0.07–350.42)	0.473
	Fluctuating	0.84 (0.57–1.25)	0.396	0.44 (0.15–1.29)	0.136	0.51 (0.27–0.93)	0.030
	Worsening	1.14 (0.48–2.73)	0.765	1.39 (0.65–2.99)	0.396	2.01 (0.79–5.12)	0.144

Results from multinomial logistic regression models. Diet-adjusted models were based on complete-case analyses after inclusion of four additional dietary covariates; therefore, the analytical sample size was smaller than that of the primary Model 3 analyses. Model 3 was adjusted for age, sex, residence, parental educational attainment, only-child status, mode of delivery, and family history of cardiometabolic diseases. OR, odds ratio; CI, confidence interval.

Supplementary Table S6. Sensitivity analysis excluding only-child status and mode of delivery

Exposure	Outcome Pattern	Q2 vs Q1	Q2 vs Q1	Q3 vs Q1	Q3 vs Q1	Q4 vs Q1	Q4 vs
		OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>	OR (95% CI)	Q1 <i>P</i>
MMP	Persistently abnormal	0.75 (0.37–1.52)	0.431	0.78 (0.39–1.55)	0.470	1.20 (0.62–2.29)	0.590
	Improving	1.49 (0.41–5.48)	0.547	2.47 (0.74–8.19)	0.140	1.77 (0.50–6.29)	0.378
	Fluctuating	1.64 (0.85–3.14)	0.138	1.38 (0.71–2.69)	0.345	1.49 (0.76–2.91)	0.245
	Worsening	0.78 (0.46–1.33)	0.371	0.76 (0.44–1.30)	0.313	0.73 (0.42–1.27)	0.264
MEP	Persistently abnormal	1.55 (0.76–3.19)	0.231	1.99 (1.00–3.99)	0.051	1.70 (0.84–3.47)	0.142

	Improving	1.36 (0.35–5.26)	0.652	2.06 (0.58–7.31)	0.262	3.09 (0.95–10.08)	0.062
	Fluctuating	1.10 (0.60–2.02)	0.753	0.85 (0.44–1.64)	0.637	1.15 (0.63–2.10)	0.659
	Worsening	1.30 (0.75–2.27)	0.346	1.61 (0.94–2.77)	0.084	1.10 (0.62–1.95)	0.738
MBP	Persistently abnormal	0.47 (0.22–0.99)	0.048	1.06 (0.54–2.09)	0.861	0.95 (0.48–1.87)	0.886
	Improving	1.01 (0.36–2.85)	0.985	0.77 (0.25–2.42)	0.659	0.64 (0.19–2.10)	0.460
	Fluctuating	0.58 (0.30–1.14)	0.114	0.86 (0.46–1.61)	0.635	1.06 (0.58–1.96)	0.849
	Worsening	0.58 (0.34–0.98)	0.041	0.59 (0.34–1.01)	0.053	0.53 (0.30–0.92)	0.024
MEHP	Persistently abnormal	1.52 (0.74–3.12)	0.259	1.36 (0.65–2.86)	0.411	1.68 (0.81–3.46)	0.163
	Improving	2.80 (0.84–9.33)	0.094	1.12 (0.27–4.71)	0.874	2.01 (0.57–7.05)	0.274
	Fluctuating	1.03 (0.53–2.02)	0.921	1.65 (0.89–3.07)	0.112	0.97 (0.50–1.88)	0.928
	Worsening	0.75 (0.43–1.29)	0.297	0.90 (0.53–1.52)	0.682	0.61 (0.35–1.07)	0.084
MEOHP	Persistently abnormal	3.09 (1.47–6.52)	0.003	1.81 (0.82–4.03)	0.143	2.82 (1.30–6.09)	0.008
	Improving	0.60 (0.14–2.60)	0.497	2.24 (0.74–6.82)	0.155	1.72 (0.53–5.52)	0.364
	Fluctuating	0.61 (0.31–1.17)	0.136	0.98 (0.54–1.77)	0.949	0.78 (0.42–1.47)	0.449
	Worsening	0.76 (0.45–1.28)	0.302	0.56 (0.32–0.99)	0.047	0.82 (0.48–1.39)	0.465
MEHHP	Persistently abnormal	2.15 (1.02–4.54)	0.044	1.47 (0.69–3.14)	0.318	2.51 (1.18–5.34)	0.017
	Improving	0.33 (0.06–1.67)	0.179	1.16 (0.38–3.53)	0.797	1.97 (0.69–5.61)	0.206
	Fluctuating	0.99 (0.53–1.87)	0.984	0.95 (0.51–1.78)	0.878	1.10 (0.59–2.07)	0.767
	Worsening	0.98 (0.58–1.65)	0.943	0.55 (0.31–0.98)	0.042	0.87 (0.50–1.49)	0.601
MiBP	Persistently abnormal	1.51 (0.70–3.28)	0.296	1.69 (0.79–3.58)	0.173	1.99 (0.96–4.13)	0.065

	Improving	1.56 (0.49–4.95)	0.453	1.90 (0.62–5.82)	0.262	0.75 (0.19–2.94)	0.685
	Fluctuating	1.08 (0.58–2.00)	0.805	0.95 (0.51–1.79)	0.876	0.76 (0.40–1.46)	0.409
	Worsening	0.74 (0.43–1.25)	0.259	0.71 (0.41–1.22)	0.213	0.63 (0.36–1.09)	0.096
ΣLMWP	Persistently abnormal	0.84 (0.40–1.77)	0.652	1.46 (0.72–2.95)	0.292	1.23 (0.60–2.49)	0.570
	Improving	0.97 (0.34–2.80)	0.954	0.92 (0.31–2.75)	0.880	0.63 (0.19–2.06)	0.440
	Fluctuating	0.64 (0.33–1.25)	0.195	0.95 (0.51–1.78)	0.869	0.99 (0.54–1.84)	0.985
	Worsening	0.70 (0.42–1.18)	0.184	0.64 (0.37–1.11)	0.111	0.54 (0.31–0.95)	0.032
ΣHMWP	Persistently abnormal	2.75 (1.30–5.82)	0.008	2.09 (0.96–4.56)	0.064	2.25 (1.03–4.93)	0.043
	Improving	0.32 (0.06–1.66)	0.175	1.62 (0.54–4.82)	0.386	1.68 (0.58–4.89)	0.342
	Fluctuating	0.80 (0.42–1.54)	0.510	1.38 (0.75–2.52)	0.296	0.81 (0.42–1.55)	0.520
	Worsening	0.76 (0.45–1.29)	0.307	0.74 (0.43–1.28)	0.284	0.67 (0.39–1.15)	0.146
ΣPAE	Persistently abnormal	1.43 (0.68–3.01)	0.341	1.35 (0.64–2.81)	0.430	1.79 (0.87–3.69)	0.115
	Improving	1.93 (0.61–6.03)	0.261	1.22 (0.35–4.18)	0.755	1.32 (0.38–4.52)	0.660
	Fluctuating	1.03 (0.53–2.02)	0.927	1.10 (0.57–2.13)	0.779	1.37 (0.72–2.60)	0.335
	Worsening	0.74 (0.43–1.28)	0.288	0.79 (0.46–1.36)	0.404	0.70 (0.40–1.22)	0.211

Results from multinomial logistic regression models. Model 3 was adjusted for age, sex, residence, parental educational attainment, and family history of cardiometabolic diseases (excluding only-child status and mode of delivery). OR, odds ratio; CI, confidence interval.

Supplementary Table S7. Sensitivity analysis using alternative exposure categorization to reduce sparse cells

Exposure	Outcome Pattern	Model 1	Model 1	Model 2	Model 2	Model 3	Model
		OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>	OR (95% CI)	3 <i>P</i>
MMP	Persistently abnormal	1.18 (0.76–1.85)	0.464	1.08 (0.67–1.73)	0.761	1.11 (0.68–1.80)	0.677
	Improving	1.73 (0.78–3.88)	0.180	1.65 (0.74–3.71)	0.224	1.68 (0.74–3.80)	0.215
	Fluctuating	1.10 (0.71–1.71)	0.655	1.07 (0.69–1.66)	0.776	1.07 (0.69–1.68)	0.754
	Worsening	0.84 (0.57–1.23)	0.368	0.81 (0.55–1.19)	0.277	0.83 (0.56–1.23)	0.358
MEP	Persistently abnormal	1.44 (0.92–2.26)	0.113	1.39 (0.87–2.24)	0.171	1.50 (0.92–2.43)	0.103
	Improving	2.18 (0.96–4.98)	0.063	2.23 (0.97–5.08)	0.057	2.28 (1.00–5.24)	0.051
	Fluctuating	0.93 (0.60–1.44)	0.749	0.93 (0.60–1.45)	0.750	0.97 (0.62–1.52)	0.900
	Worsening	1.16 (0.79–1.69)	0.457	1.15 (0.79–1.69)	0.467	1.19 (0.80–1.75)	0.389
MBP	Persistently abnormal	1.45 (0.92–2.28)	0.108	1.34 (0.83–2.16)	0.228	1.48 (0.90–2.41)	0.121
	Improving	0.69 (0.31–1.53)	0.367	0.68 (0.31–1.50)	0.340	0.70 (0.31–1.57)	0.389
	Fluctuating	1.29 (0.83–2.00)	0.264	1.26 (0.81–1.97)	0.302	1.25 (0.80–1.96)	0.322
	Worsening	0.74 (0.51–1.09)	0.128	0.72 (0.49–1.07)	0.103	0.74 (0.50–1.09)	0.130
MEHP	Persistently abnormal	1.19 (0.76–1.86)	0.451	1.08 (0.68–1.74)	0.739	1.19 (0.73–1.94)	0.473
	Improving	0.82 (0.37–1.80)	0.620	0.81 (0.37–1.78)	0.596	0.85 (0.38–1.89)	0.687
	Fluctuating	1.30 (0.84–2.03)	0.237	1.28 (0.82–1.99)	0.275	1.29 (0.82–2.02)	0.267
	Worsening	0.87 (0.59–1.27)	0.464	0.85 (0.58–1.25)	0.402	0.86 (0.58–1.27)	0.455
MEOHP	Persistently abnormal	1.02 (0.65–1.60)	0.927	1.06 (0.66–1.70)	0.805	1.14 (0.70–1.85)	0.607

	Improving	2.37 (1.02–5.55)	0.046	2.35 (1.00–5.52)	0.049	2.45 (1.04–5.81)	0.041
	Fluctuating	1.13 (0.73–1.75)	0.591	1.14 (0.73–1.77)	0.563	1.11 (0.71–1.73)	0.662
	Worsening	0.78 (0.53–1.14)	0.198	0.79 (0.53–1.16)	0.221	0.79 (0.53–1.16)	0.228
MEHHP	Persistently abnormal	1.26 (0.81–1.98)	0.309	1.17 (0.73–1.89)	0.513	1.21 (0.74–1.96)	0.444
	Improving	2.38 (1.02–5.56)	0.045	2.30 (0.98–5.40)	0.055	2.35 (0.99–5.54)	0.051
	Fluctuating	1.04 (0.67–1.61)	0.857	1.02 (0.66–1.59)	0.922	1.03 (0.66–1.60)	0.912
	Worsening	0.71 (0.49–1.05)	0.086	0.70 (0.47–1.03)	0.070	0.70 (0.47–1.04)	0.074
MiBP	Persistently abnormal	1.76 (1.11–2.79)	0.016	1.44 (0.89–2.34)	0.140	1.46 (0.89–2.40)	0.131
	Improving	1.11 (0.51–2.42)	0.793	1.02 (0.46–2.24)	0.963	1.02 (0.46–2.25)	0.968
	Fluctuating	0.91 (0.59–1.42)	0.684	0.86 (0.55–1.33)	0.491	0.82 (0.52–1.28)	0.377
	Worsening	0.85 (0.58–1.24)	0.395	0.79 (0.54–1.16)	0.233	0.78 (0.52–1.15)	0.206
ΣLMWP	Persistently abnormal	1.48 (0.94–2.34)	0.091	1.40 (0.87–2.27)	0.167	1.48 (0.90–2.42)	0.121
	Improving	0.80 (0.37–1.76)	0.585	0.77 (0.35–1.70)	0.525	0.76 (0.34–1.68)	0.497
	Fluctuating	1.23 (0.79–1.92)	0.354	1.21 (0.77–1.89)	0.402	1.19 (0.76–1.87)	0.452
	Worsening	0.72 (0.49–1.05)	0.091	0.70 (0.48–1.03)	0.074	0.71 (0.48–1.06)	0.092
ΣHMWP	Persistently abnormal	1.09 (0.70–1.71)	0.700	1.05 (0.65–1.69)	0.839	1.15 (0.71–1.87)	0.574
	Improving	2.43 (1.04–5.69)	0.040	2.41 (1.03–5.65)	0.043	2.52 (1.07–5.95)	0.035
	Fluctuating	1.20 (0.78–1.87)	0.409	1.20 (0.77–1.86)	0.420	1.20 (0.77–1.88)	0.421
	Worsening	0.80 (0.54–1.17)	0.246	0.79 (0.54–1.17)	0.238	0.80 (0.54–1.19)	0.274
ΣPAE	Persistently abnormal	1.32 (0.83–2.08)	0.243	1.23 (0.75–2.00)	0.407	1.29 (0.78–2.14)	0.313

Improving	0.88 (0.40–1.96)	0.761	0.86 (0.38–1.91)	0.703	0.87 (0.39–1.95)	0.729
Fluctuating	1.25 (0.79–1.96)	0.337	1.23 (0.78–1.94)	0.376	1.21 (0.76–1.91)	0.421
Worsening	0.87 (0.59–1.28)	0.477	0.85 (0.58–1.27)	0.434	0.87 (0.58–1.29)	0.490

Results from multinomial logistic regression models. Model 1 was unadjusted. Model 2 was adjusted for age, sex, and residence. Model 3 was further adjusted for parental educational attainment, only-child status, mode of delivery, and family history of cardiometabolic diseases. OR, odds ratio; CI, confidence interval.

Supplementary Table S8. Sensitivity analysis using conventional creatinine correction in multinomial models of phthalate exposure and cardiometabolic risk progression patterns

Exposure	Outcome Pattern	Q2 vs Q1	Q2 vs Q1	Q3 vs Q1	Q3 vs Q1	Q4 vs Q1	Q4 vs
		OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>	OR (95% CI)	Q1 <i>P</i>
MMP	Persistently abnormal	0.75 (0.38–1.46)	0.398	0.86 (0.44–1.67)	0.652	0.79 (0.40–1.56)	0.498
	Improving	3.80 (0.78–18.46)	0.098	4.89 (1.03–23.17)	0.046	3.18 (0.64–15.79)	0.158
	Fluctuating	1.30 (0.69–2.45)	0.413	1.13 (0.59–2.18)	0.712	1.02 (0.53–1.97)	0.943
	Worsening	0.61 (0.36–1.05)	0.072	0.67 (0.39–1.15)	0.148	0.60 (0.35–1.03)	0.062
MEP	Persistently abnormal	1.77 (0.91–3.45)	0.095	1.31 (0.65–2.63)	0.446	1.31 (0.65–2.63)	0.443
	Improving	0.18 (0.02–1.55)	0.119	1.69 (0.57–5.03)	0.346	1.96 (0.69–5.60)	0.209
	Fluctuating	1.20 (0.65–2.21)	0.558	0.92 (0.49–1.75)	0.810	0.91 (0.48–1.70)	0.766
	Worsening	1.58 (0.91–2.74)	0.105	1.40 (0.81–2.45)	0.232	1.05 (0.59–1.86)	0.870

MBP	Persistently abnormal	0.47 (0.23–0.96)	0.039	0.97 (0.51–1.85)	0.927	0.75 (0.38–1.49)	0.419
	Improving	0.69 (0.24–2.02)	0.504	0.78 (0.27–2.29)	0.654	0.52 (0.16–1.67)	0.273
	Fluctuating	0.62 (0.32–1.21)	0.160	0.93 (0.50–1.74)	0.820	0.89 (0.48–1.66)	0.722
	Worsening	0.67 (0.40–1.13)	0.135	0.67 (0.39–1.16)	0.150	0.50 (0.28–0.87)	0.015
MEHP	Persistently abnormal	0.85 (0.44–1.65)	0.632	0.88 (0.44–1.75)	0.718	0.81 (0.40–1.64)	0.559
	Improving	1.72 (0.49–6.06)	0.396	1.48 (0.40–5.51)	0.560	1.98 (0.57–6.83)	0.279
	Fluctuating	1.14 (0.59–2.19)	0.703	1.35 (0.71–2.55)	0.365	0.99 (0.51–1.91)	0.968
	Worsening	0.57 (0.33–1.00)	0.048	0.77 (0.46–1.30)	0.333	0.49 (0.28–0.86)	0.012
MEOHP	Persistently abnormal	1.92 (1.00–3.69)	0.050	0.70 (0.32–1.55)	0.384	1.50 (0.74–3.04)	0.265
	Improving	0.57 (0.13–2.48)	0.452	2.06 (0.67–6.37)	0.208	1.60 (0.49–5.22)	0.438
	Fluctuating	0.62 (0.32–1.19)	0.149	1.02 (0.56–1.87)	0.936	0.70 (0.36–1.34)	0.278
	Worsening	0.63 (0.37–1.08)	0.095	0.60 (0.34–1.04)	0.068	0.68 (0.40–1.17)	0.162
MEHHP	Persistently abnormal	1.26 (0.65–2.45)	0.498	1.12 (0.56–2.24)	0.750	1.08 (0.52–2.24)	0.836
	Improving	0.97 (0.23–4.03)	0.963	1.82 (0.52–6.41)	0.351	2.88 (0.86–9.64)	0.086
	Fluctuating	1.01 (0.54–1.90)	0.973	0.71 (0.36–1.38)	0.311	1.16 (0.62–2.16)	0.645
	Worsening	0.72 (0.42–1.22)	0.223	0.61 (0.35–1.07)	0.083	0.72 (0.41–1.24)	0.231
MiBP	Persistently abnormal	1.32 (0.64–2.75)	0.453	1.66 (0.82–3.36)	0.163	1.45 (0.72–2.94)	0.301
	Improving	1.59 (0.50–5.10)	0.432	2.13 (0.69–6.54)	0.186	0.67 (0.17–2.62)	0.568
	Fluctuating	1.33 (0.71–2.48)	0.370	1.30 (0.69–2.43)	0.414	0.64 (0.32–1.28)	0.211
	Worsening	0.73 (0.43–1.24)	0.244	0.71 (0.41–1.22)	0.211	0.60 (0.35–1.03)	0.066

ΣLMWP	Persistently abnormal	1.05 (0.52–2.10)	0.892	1.20 (0.62–2.34)	0.590	0.92 (0.45–1.86)	0.818
	Improving	0.81 (0.26–2.53)	0.712	0.83 (0.27–2.53)	0.749	0.86 (0.29–2.60)	0.790
	Fluctuating	0.84 (0.45–1.59)	0.599	0.65 (0.34–1.24)	0.190	0.97 (0.53–1.77)	0.910
	Worsening	1.07 (0.64–1.81)	0.796	0.59 (0.34–1.05)	0.072	0.66 (0.38–1.16)	0.147
ΣHMWP	Persistently abnormal	1.73 (0.89–3.38)	0.107	1.22 (0.59–2.52)	0.590	1.34 (0.65–2.77)	0.427
	Improving	0.62 (0.14–2.68)	0.517	2.10 (0.68–6.44)	0.196	1.60 (0.49–5.23)	0.434
	Fluctuating	1.03 (0.54–1.96)	0.924	1.19 (0.63–2.25)	0.594	0.99 (0.51–1.89)	0.967
	Worsening	0.68 (0.40–1.16)	0.158	0.61 (0.35–1.05)	0.076	0.63 (0.37–1.09)	0.098
ΣPAE	Persistently abnormal	1.06 (0.53–2.11)	0.866	1.20 (0.61–2.36)	0.596	1.03 (0.51–2.10)	0.927
	Improving	0.91 (0.28–2.97)	0.877	1.16 (0.38–3.55)	0.797	1.04 (0.33–3.28)	0.945
	Fluctuating	0.78 (0.40–1.50)	0.452	0.92 (0.49–1.74)	0.794	1.09 (0.58–2.03)	0.788
	Worsening	0.76 (0.45–1.27)	0.296	0.47 (0.27–0.83)	0.009	0.60 (0.35–1.03)	0.066

Results from multinomial logistic regression models using conventional creatinine correction. Model 3 was adjusted for age, sex, residence, parental educational attainment, only-child status, mode of delivery, and family history of cardiometabolic diseases. OR, odds ratio; CI, confidence interval.

Supplementary Table S9. Sex-by-exposure interaction estimates across phthalate exposure quartiles in multinomial logistic regression models (Model 3)

Exposure	Outcome Pattern	Q2 vs Q1	Q2 vs Q1	Q3 vs Q1	Q3 vs Q1	Q4 vs Q1	Q4 vs
		OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>	OR (95% CI)	Q1

							<i>P</i>
MMP	Persistently abnormal	0.72 (0.10–4.98)	0.740	0.96 (0.14–6.56)	0.970	1.81 (0.39–8.50)	0.451
	Improving	0.67 (0.05–9.71)	0.767	1.69 (0.15–18.97)	0.671	2.10 (0.16–27.02)	0.570
	Fluctuating	1.82 (0.48–6.85)	0.374	1.08 (0.28–4.22)	0.914	1.63 (0.42–6.35)	0.479
	Worsening	2.36 (0.80–7.00)	0.120	2.34 (0.79–6.91)	0.124	0.82 (0.26–2.58)	0.737
MEP	Persistently abnormal	0.38 (0.07–2.25)	0.289	0.34 (0.06–1.98)	0.232	0.48 (0.09–2.53)	0.384
	Improving	NE	-	NE	-	NE	-
	Fluctuating	0.94 (0.28–3.18)	0.927	1.56 (0.42–5.85)	0.510	0.55 (0.16–1.88)	0.341
	Worsening	0.79 (0.26–2.39)	0.677	0.69 (0.23–2.04)	0.498	0.78 (0.25–2.46)	0.670
MBP	Persistently abnormal	0.36 (0.03–3.92)	0.402	0.57 (0.11–2.98)	0.506	1.14 (0.23–5.66)	0.869
	Improving	0.23 (0.02–2.21)	0.205	0.06 (0.00–1.05)	0.054	1.99 (0.12–33.46)	0.633
	Fluctuating	1.18 (0.31–4.53)	0.807	1.05 (0.29–3.79)	0.935	0.96 (0.28–3.28)	0.945
	Worsening	0.56 (0.19–1.64)	0.291	0.26 (0.09–0.81)	0.020	0.41 (0.13–1.30)	0.131
MEHP	Persistently abnormal	0.92 (0.17–4.92)	0.922	0.51 (0.07–3.59)	0.501	0.60 (0.11–3.20)	0.550
	Improving	1.31 (0.12–14.11)	0.826	1.47 (0.09–25.55)	0.790	0.93 (0.08–11.13)	0.952
	Fluctuating	1.78 (0.47–6.71)	0.392	1.41 (0.41–4.86)	0.585	0.84 (0.22–3.16)	0.795
	Worsening	0.50 (0.17–1.52)	0.223	0.55 (0.19–1.61)	0.273	0.27 (0.08–0.85)	0.025
MEOHP	Persistently abnormal	0.14 (0.03–0.78)	0.025	NE	-	0.33 (0.06–1.67)	0.179
	Improving	0.37 (0.02–8.08)	0.528	1.66 (0.18–15.59)	0.659	0.71 (0.07–7.58)	0.777
	Fluctuating	0.43 (0.11–1.66)	0.221	1.20 (0.37–3.90)	0.759	1.13 (0.31–4.12)	0.849

MEHHP	Worsening	0.54 (0.18–1.57)	0.255	1.48 (0.48–4.54)	0.494	0.46 (0.16–1.33)	0.151
	Persistently abnormal	0.56 (0.09–3.32)	0.520	0.57 (0.08–4.39)	0.593	0.68 (0.12–3.85)	0.661
	Improving	NE	-	6.01 (0.59–60.68)	0.129	0.98 (0.11–8.91)	0.987
MiBP	Fluctuating	0.48 (0.13–1.78)	0.271	1.16 (0.33–4.05)	0.819	1.87 (0.50–6.91)	0.351
	Worsening	0.94 (0.33–2.70)	0.914	1.33 (0.43–4.18)	0.622	0.88 (0.29–2.61)	0.812
	Persistently abnormal	0.17 (0.02–1.17)	0.072	0.16 (0.02–1.12)	0.065	0.41 (0.08–2.01)	0.271
	Improving	0.62 (0.06–6.55)	0.689	0.76 (0.08–7.36)	0.811	0.31 (0.02–5.92)	0.433
	Fluctuating	0.51 (0.14–1.80)	0.295	0.37 (0.10–1.36)	0.135	0.61 (0.16–2.29)	0.465
ΣLMWP	Worsening	0.97 (0.33–2.89)	0.962	0.63 (0.21–1.86)	0.402	0.61 (0.20–1.87)	0.392
	Persistently abnormal	0.56 (0.08–3.95)	0.563	0.50 (0.09–2.69)	0.422	0.71 (0.13–3.78)	0.688
	Improving	0.35 (0.04–3.42)	0.369	0.06 (0.00–0.94)	0.045	2.07 (0.12–34.57)	0.614
	Fluctuating	2.97 (0.76–11.58)	0.117	0.74 (0.21–2.65)	0.644	1.27 (0.37–4.39)	0.710
ΣHMWP	Worsening	0.62 (0.21–1.80)	0.382	0.62 (0.21–1.88)	0.399	0.43 (0.14–1.36)	0.151
	Persistently abnormal	0.41 (0.07–2.43)	0.325	0.72 (0.11–4.79)	0.736	0.51 (0.08–3.10)	0.463
	Improving	1.89 (0.07–52.39)	0.708	3.71 (0.39–35.35)	0.254	1.48 (0.16–13.67)	0.730
	Fluctuating	0.54 (0.14–2.04)	0.364	1.11 (0.33–3.76)	0.862	1.47 (0.38–5.67)	0.575
ΣPAE	Worsening	0.58 (0.20–1.69)	0.317	1.24 (0.42–3.70)	0.697	0.62 (0.21–1.87)	0.399
	Persistently abnormal	0.91 (0.14–5.88)	0.920	0.88 (0.14–5.71)	0.896	0.80 (0.14–4.73)	0.806
	Improving	0.23 (0.02–3.18)	0.272	0.05 (0.00–1.25)	0.069	0.48 (0.03–8.31)	0.614
	Fluctuating	1.09 (0.28–4.19)	0.900	1.39 (0.37–5.23)	0.624	0.98 (0.27–3.58)	0.980

Worsening	1.31 (0.44–3.92)	0.626	0.69 (0.23–2.06)	0.506	0.91 (0.30–2.80)	0.869
-----------	------------------	-------	------------------	-------	------------------	-------

Estimates represent exponentiated coefficients of the sex-by-exposure interaction terms derived from multinomial logistic regression models. Model 3 was adjusted for age, sex, residence, parental educational attainment, only-child status, mode of delivery, and family history of cardiometabolic diseases. NE indicates estimates not calculable due to sparse data or model instability. OR, odds ratio; CI, confidence interval.

Supplementary Table S10. Associations between phthalate exposure quartiles and cardiometabolic risk progression patterns stratified by individual components of the 24-hour movement guidelines.

Movement component	Exposure	Outcome Pattern	Q2 vs Q1 OR (95% CI)	Q2 vs Q1 <i>P</i>	Q3 vs Q1 OR (95% CI)	Q3 vs Q1 <i>P</i>	Q4 vs Q1 OR (95% CI)	Q4 vs Q1 <i>P</i>
Physical activity guideline met	MMP	Persistently abnormal	9.63 (0.90–102.87)	0.061	2.15 (0.46–10.14)	0.333	3.27 (0.65–16.60)	0.152
		Improving	NE	-	3.01† (0.13–71.01)	0.495	0.38 (0.02–6.34)	0.499
		Fluctuating	1.39 (0.24–8.15)	0.716	0.60 (0.11–3.14)	0.542	0.76 (0.13–4.27)	0.752
		Worsening	4.63 (1.01–21.15)	0.048	3.93 (0.96–16.10)	0.058	2.58 (0.62–10.71)	0.193
	MEP	Persistently abnormal	3.84 (0.56–26.51)	0.172	2.25 (0.37–13.61)	0.379	0.55 (0.11–2.65)	0.453
		Improving	NE	-	3.40† (0.17–67.36)	0.421	2.01† (0.15–27.15)	0.598
		Fluctuating	0.16 (0.03–0.96)	0.045	0.12 (0.02–0.79)	0.028	0.22 (0.03–1.50)	0.121
		Worsening	0.72 (0.19–2.76)	0.628	1.57 (0.31–8.01)	0.588	0.34 (0.08–1.41)	0.137

MBP	Persistently abnormal	0.30 (0.04–2.08)	0.224	0.73 (0.11–4.82)	0.745	0.30 (0.05–1.75)	0.181
	Improving	NE	-	NE	-	NE	-
	Fluctuating	0.24 (0.04–1.29)	0.095	0.82 (0.14–4.81)	0.825	0.73 (0.13–4.07)	0.724
	Worsening	0.59 (0.15–2.39)	0.459	0.59 (0.14–2.40)	0.459	0.94 (0.20–4.42)	0.934
MEHP	Persistently abnormal	0.47 (0.08–2.82)	0.412	0.45 (0.08–2.69)	0.384	0.45 (0.07–3.02)	0.412
	Improving	NE	-	NE	<0.001	NE	-
	Fluctuating	0.33 (0.07–1.62)	0.173	1.35 (0.26–6.99)	0.72	0.27 (0.05–1.39)	0.117
	Worsening	0.48 (0.12–1.90)	0.294	0.55 (0.15–2.02)	0.369	0.59 (0.12–2.94)	0.519
MEOHP	Persistently abnormal	0.64 (0.11–3.63)	0.613	0.58 (0.09–3.74)	0.563	0.79 (0.10–6.01)	0.819
	Improving	NE	-	NE	-	NE	-
	Fluctuating	0.65 (0.15–2.89)	0.573	1.20 (0.26–5.44)	0.818	0.76 (0.14–4.02)	0.75

MEHHP	Worsening	0.36 (0.09–1.45)	0.15	0.15 (0.04–0.61)	0.008	0.34 (0.07–1.67)	0.185
	Persistently abnormal	1.72 (0.33–8.79)	0.517	0.90 (0.16–5.16)	0.902	2.88 (0.36–22.95)	0.317
	Improving	NE	-	NE	-	NE	-
	Fluctuating	0.59 (0.14–2.42)	0.464	1.21 (0.23–6.39)	0.824	1.24 (0.19–8.10)	0.825
MiBP	Worsening	0.33 (0.09–1.25)	0.102	0.33 (0.07–1.61)	0.171	0.31 (0.06–1.54)	0.153
	Persistently abnormal	2.01 (0.27–14.75)	0.494	0.43 (0.07–2.54)	0.349	1.62 (0.26–10.07)	0.602
	Improving	NE	-	NE	-	NE	-
	Fluctuating	1.70 (0.38–7.62)	0.485	1.84 (0.35–9.78)	0.473	1.08 (0.24–4.94)	0.921
ΣLMWP	Worsening	2.65 (0.55–12.72)	0.223	0.55 (0.15–2.02)	0.364	1.14 (0.28–4.65)	0.851
	Persistently abnormal	0.47 (0.06–4.07)	0.496	0.25 (0.04–1.79)	0.169	0.37 (0.05–2.73)	0.33
	Improving	NE	<0.001	NE	-	NE	-

		Fluctuating	0.29 (0.05–1.58)	0.152	0.46 (0.09–2.50)	0.371	1.10 (0.17–6.99)	0.923
		Worsening	0.67 (0.17–2.66)	0.564	0.67 (0.16–2.81)	0.58	0.62 (0.14–2.75)	0.53
	ΣHMWP	Persistently abnormal	0.66 (0.12–3.56)	0.631	0.56 (0.10–3.23)	0.518	1.35 (0.16–11.28)	0.779
		Improving	NE		NE	<0.001	NE	
		Fluctuating	0.20 (0.04–0.88)	0.033	0.68 (0.15–3.13)	0.622	0.65 (0.10–4.34)	0.654
		Worsening	0.19 (0.05–0.75)	0.017	0.23 (0.06–0.91)	0.036	0.36 (0.07–1.84)	0.218
	ΣPAE	Persistently abnormal	0.59 (0.08–4.61)	0.615	0.16 (0.02–1.19)	0.074	0.43 (0.06–3.20)	0.406
		Improving	NE	<0.001	NE	-	NE	-
		Fluctuating	0.52 (0.10–2.87)	0.456	0.44 (0.08–2.52)	0.353	0.87 (0.15–5.20)	0.88
		Worsening	1.47 (0.36–6.04)	0.594	0.95 (0.22–3.99)	0.939	0.89 (0.21–3.76)	0.875
Screen time	MMP	Persistently abnormal	5.35 (0.40–72.11)	0.206	1.57 (0.18–14.05)	0.684	0.94 (0.15–6.01)	0.948

guideline
met

MEP	Improving	NE	-	NE	-	NE	<0.001
	Fluctuating	1.48 (0.19–11.29)	0.708	1.01 (0.12–8.64)	0.992	1.35 (0.16–11.38)	0.786
	Worsening	1.51 (0.35–6.50)	0.579	1.69 (0.33–8.63)	0.53	4.19 (0.63–27.79)	0.138
	Persistently abnormal	NE	-	NE	-	NE	-
MBP	Improving	1.81 (0.06–51.77)	0.728	4.78 (0.18–130.10)	0.353	1.67 (0.10–28.93)	0.725
	Fluctuating	0.18 (0.02–2.21)	0.182	0.28 (0.02–3.59)	0.33	0.28 (0.02–3.28)	0.31
	Worsening	0.96 (0.20–4.66)	0.964	3.65 (0.70–19.17)	0.126	1.88 (0.35–9.93)	0.459
	Persistently abnormal	2.80 (0.21–36.74)	0.433	1.94 (0.22–17.09)	0.551	0.67 (0.11–4.19)	0.669
	Improving	0.47 (0.03–7.87)	0.6	0.15 (0.01–2.81)	0.203	0.60 (0.02–14.72)	0.755

MEHP	Fluctuating	2.94 (0.24–36.69)	0.402	2.87 (0.22–36.66)	0.417	0.54 (0.09–3.03)	0.48
	Worsening	2.26 (0.42–12.10)	0.342	1.06 (0.20–5.47)	0.947	0.81 (0.18–3.60)	0.785
	Persistently abnormal	0.12 (0.01–1.45)	0.095	NE	-	0.09 (0.01–1.08)	0.058
	Improving	8.16 (0.44–149.53)	0.157	NE	-	11.28† (0.44–288.02)	0.143
MEOHP	Fluctuating	1.68 (0.23–12.25)	0.61	3.27 (0.45–23.65)	0.24	1.00 (0.16–6.09)	0.999
	Worsening	0.41 (0.07–2.29)	0.308	0.22 (0.05–1.09)	0.064	0.22 (0.04–1.14)	0.071
	Persistently abnormal	NE	-	NE	-	NE	-
	Improving	NE	-	43.19† (1.77–1055.04)	0.021	23.39† (0.96–570.99)	0.053
	Fluctuating	0.82 (0.12–6.33)	0.848	1.16 (0.20–6.82)	0.872	1.57 (0.22–11.08)	0.652
	Worsening	0.44 (0.09–2.26)	0.327	1.18 (0.18–7.87)	0.863	0.35 (0.08–1.48)	0.152

MEHHP	Persistently abnormal	6.19 (0.39–97.71)	0.195	0.88 (0.10–7.60)	0.906	0.82 (0.10–7.02)	0.857
	Improving	NE	-	22.13† (1.20–407.03)	0.037	23.01† (1.30–406.78)	0.032
	Fluctuating	0.80 (0.12–5.11)	0.81	1.20 (0.17–8.36)	0.852	1.65 (0.20–13.61)	0.644
	Worsening	1.94 (0.34–11.25)	0.459	0.55 (0.11–2.80)	0.467	0.39 (0.08–1.85)	0.236
MiBP	Persistently abnormal	0.36 (0.03–4.98)	0.443	2.05 (0.09–46.08)	0.652	0.49 (0.04–5.76)	0.568
	Improving	5.35 (0.29–100.35)	0.262	2.30 (0.17–30.86)	0.53	3.19 (0.15–67.84)	0.457
	Fluctuating	0.24 (0.02–2.76)	0.251	0.25 (0.02–3.20)	0.287	0.33 (0.03–3.87)	0.381
	Worsening	2.60 (0.48–13.99)	0.266	1.59 (0.31–8.08)	0.575	1.99 (0.44–8.92)	0.37
ΣLMWP	Persistently abnormal	0.74 (0.07–7.56)	0.798	2.96 (0.33–26.83)	0.334	0.52 (0.08–3.62)	0.513
	Improving	0.17 (0.01–2.97)	0.224	0.30 (0.02–5.24)	0.411	0.44 (0.02–10.74)	0.615

ΣHMWP	Fluctuating	0.33 (0.03–3.26)	0.342	0.67 (0.08–5.37)	0.702	0.37 (0.05–2.63)	0.322
	Worsening	0.33 (0.07–1.62)	0.172	1.05 (0.21–5.33)	0.952	0.55 (0.11–2.64)	0.456
	Persistently abnormal	0.28 (0.02–3.46)	0.323	0.77 (0.03–17.26)	0.871	0.17 (0.01–2.21)	0.177
	Improving	NE	-	9.37† (0.51–171.17)	0.131	10.13† (0.58–175.59)	0.112
	Fluctuating	4.63 (0.43–49.96)	0.206	1.36 (0.23–8.14)	0.733	1.88 (0.27–13.04)	0.523
ΣPAE	Worsening	0.48 (0.10–2.34)	0.362	0.49 (0.08–2.91)	0.429	0.19 (0.04–0.84)	0.029
	Persistently abnormal	0.74 (0.06–8.59)	0.812	2.08 (0.19–23.24)	0.553	0.58 (0.07–4.67)	0.612
	Improving	0.28 (0.02–5.25)	0.396	0.35 (0.02–6.77)	0.49	1.07 (0.04–26.22)	0.969
	Fluctuating	0.18 (0.02–1.47)	0.109	NE	-	0.53 (0.07–3.79)	0.529
	Worsening	0.59 (0.11–3.15)	0.534	1.42 (0.28–7.07)	0.67	1.02 (0.23–4.58)	0.982

Sleep duration guideline met	MMP	Persistently abnormal	0.31 (0.05–1.78)	0.19	0.46 (0.09–2.32)	0.344	1.78 (0.43–7.37)	0.424
		Improving	NE	-	NE	-	NE	-
		Fluctuating	1.87 (0.48–7.31)	0.37	0.91 (0.22–3.76)	0.9	0.76 (0.17–3.28)	0.709
		Worsening	0.48 (0.16–1.46)	0.198	0.70 (0.23–2.09)	0.522	0.33 (0.10–1.09)	0.068
	MEP	Persistently abnormal	0.46 (0.10–2.14)	0.319	0.38 (0.09–1.71)	0.209	0.20 (0.04–1.08)	0.062
		Improving	1.24 (0.08–18.96)	0.879	0.33 (0.02–4.66)	0.413	0.92 (0.08–10.07)	0.948
		Fluctuating	1.76 (0.49–6.27)	0.382	1.04 (0.26–4.15)	0.96	0.78 (0.21–2.89)	0.709
		Worsening	1.09 (0.34–3.43)	0.887	1.05 (0.34–3.25)	0.937	0.97 (0.29–3.27)	0.964
	MBP	Persistently abnormal	0.13 (0.01–1.40)	0.093	1.24 (0.30–5.11)	0.763	0.76 (0.17–3.44)	0.726

MEHP	Improving	1.81 (0.22–14.87)	0.58	0.56 (0.05–5.93)	0.627	3.03 (0.27–34.60)	0.371
	Fluctuating	0.56 (0.13–2.40)	0.436	0.80 (0.22–2.92)	0.73	1.22 (0.34–4.38)	0.758
	Worsening	1.13 (0.38–3.36)	0.821	0.88 (0.29–2.71)	0.826	1.56 (0.49–4.95)	0.449
	Persistently abnormal	0.34 (0.07–1.70)	0.188	0.49 (0.10–2.31)	0.367	0.78 (0.17–3.49)	0.744
MEOHP	Improving	0.93 (0.08–10.30)	0.955	0.82 (0.05–14.32)	0.895	1.01 (0.08–12.18)	0.996
	Fluctuating	1.37 (0.34–5.48)	0.66	0.62 (0.17–2.31)	0.481	1.80 (0.46–7.08)	0.402
	Worsening	0.83 (0.26–2.66)	0.75	1.21 (0.41–3.59)	0.732	2.43 (0.78–7.59)	0.126
	Persistently abnormal	0.06 (0.01–0.41)	0.004	0.43 (0.08–2.24)	0.315	0.50 (0.10–2.51)	0.4
	Improving	0.72 (0.03–15.72)	0.834	1.13 (0.12–10.84)	0.918	1.11 (0.10–11.75)	0.934
	Fluctuating	2.39 (0.58–9.84)	0.226	1.05 (0.29–3.79)	0.941	2.26 (0.60–8.53)	0.228

MEHHP	Worsening	1.63 (0.54–4.92)	0.387	0.67 (0.20–2.25)	0.517	1.31 (0.44–3.91)	0.626
	Persistently abnormal	0.55 (0.10–2.92)	0.48	1.02 (0.20–5.11)	0.979	0.99 (0.20–4.75)	0.985
	Improving	NE	-	1.07 (0.11–10.04)	0.95	1.19 (0.15–9.69)	0.87
	Fluctuating	1.02 (0.26–3.98)	0.974	0.64 (0.17–2.49)	0.524	1.73 (0.48–6.26)	0.403
MiBP	Worsening	2.72 (0.90–8.19)	0.075	1.49 (0.44–5.01)	0.517	2.61 (0.85–8.00)	0.093
	Persistently abnormal	0.27 (0.05–1.48)	0.131	0.49 (0.09–2.51)	0.391	0.56 (0.12–2.67)	0.463
	Improving	1.02 (0.10–10.75)	0.988	1.18 (0.12–11.53)	0.888	1.27 (0.08–19.67)	0.867
	Fluctuating	0.92 (0.25–3.37)	0.904	2.12 (0.56–7.98)	0.265	0.89 (0.21–3.68)	0.868
ΣLMWP	Worsening	0.43 (0.14–1.30)	0.134	0.38 (0.12–1.21)	0.101	0.78 (0.25–2.39)	0.662
	Persistently abnormal	0.34 (0.06–1.83)	0.208	0.84 (0.19–3.77)	0.82	0.55 (0.11–2.69)	0.457

ΣHMWP	Improving	0.58 (0.07–4.98)	0.62	0.22 (0.02–2.22)	0.198	1.24 (0.11–14.20)	0.865
	Fluctuating	0.41 (0.10–1.66)	0.209	0.58 (0.16–2.14)	0.415	0.67 (0.18–2.51)	0.557
	Worsening	1.42 (0.49–4.13)	0.516	0.39 (0.12–1.28)	0.122	0.92 (0.28–3.01)	0.89
	Persistently abnormal	0.33 (0.06–1.79)	0.196	0.91 (0.17–4.84)	0.916	1.03 (0.19–5.51)	0.973
	Improving	NE	-	0.47 (0.05–4.22)	0.497	1.24 (0.14–10.65)	0.846
ΣPAE	Fluctuating	0.65 (0.16–2.64)	0.545	0.70 (0.19–2.52)	0.583	1.95 (0.51–7.49)	0.331
	Worsening	0.92 (0.30–2.77)	0.876	0.79 (0.25–2.47)	0.686	1.42 (0.46–4.35)	0.537
	Persistently abnormal	0.10 (0.02–0.64)	0.014	0.64 (0.13–3.14)	0.581	0.69 (0.14–3.43)	0.652
	Improving	0.39 (0.04–4.08)	0.433	0.08 (0.00–1.37)	0.081	1.46 (0.11–19.46)	0.773
	Fluctuating	0.37 (0.09–1.52)	0.165	0.48 (0.12–1.93)	0.298	1.31 (0.33–5.13)	0.697

Worsening	1.22 (0.39–3.78)	0.731	0.48 (0.15–1.57)	0.228	2.12 (0.65–6.94)	0.215
-----------	------------------	-------	------------------	-------	------------------	-------

Note: Results from multinomial logistic regression models (Model 3). Model 3 was adjusted for age, sex, residence, parental educational attainment, only-child status, mode of delivery, and family history of cardiometabolic diseases. NE indicates estimates not calculable due to sparse data or model instability. † indicates estimates that were unstable due to sparse data and should be interpreted cautiously. OR, odds ratio; CI, confidence interval.