

Supplementary Materials

Effects of steatotic liver disease and cardiometabolic risk factors in MASLD on adverse pregnancy outcomes

Shuhan Yang¹, Huimin Guan², Youxin Wang¹, Mingyue Wang¹, Antje Hebestreit³, Yuying Wu¹, Yifan Yang¹, Lei Yang², Hui Wang¹

¹Department of Maternal and Child Health, School of Public Health, Peking University, Beijing 100191, China.

²Department of Obstetrics and Gynecology, Beijing Friendship Hospital, Capital University of Medical Sciences, Beijing 100050, China.

³Leibniz Institute for Prevention Research and Epidemiology-BIPS, Bremen 28359, Germany.

Correspondence to: Dr. Hui Wang, Department of Maternal and Child Health, School of Public Health, Peking University, No. 38 Xueyuan Road, Haidian District, Beijing 100191, China. E-mail: huiwang@bjmu.edu.cn; Dr. Lei Yang, Department of Obstetrics and Gynecology, Beijing Friendship Hospital, Capital University of Medical Sciences, No. 95, Yong'an Road, Xicheng District, Beijing 100050, China. E-mail: betty_ll@mail.ccmu.edu.cn

Supplementary Table 1. Pre-pregnancy BMI and corresponding recommended gestational weight gain ranges^[1]

Pre-pregnancy BMI (kg/m ²)	Recommended gestational weight gain (kg)
BMI<18.5	11.0-16.0
18.5≤BMI<24.0	8.0-14.0
24.0≤BMI<28.0	7.0-11.0
BMI≥28.0	5.0-9.0

BMI, body mass index.

Supplementary Table 2. Comparations of characteristics of the pregnant participants

Characteristics	Non-SLD&CMRF	CMRF-only	SLD-only	MASLD	<i>P</i> value ^a	<i>P</i> value ^b	<i>P</i> value ^c	<i>P</i> value ^d	<i>P</i> value ^e	<i>P</i> value ^f	<i>P</i> value ^g
Number of participants	2321 (56.36%)	1474 (35.79%)	21 (0.51%)	302 (7.33%)							
Age (year)	31.15 (29.07, 33.13)	31.39 (29.04, 33.54)	30.11 (28.15, 32.82)	32.10 (30.22, 35.00)	<0.001	0.057	0.312	<0.001	0.234	<0.001	0.022
<35 years	2075 (89.4%)	1260 (85.5%)	18 (85.7%)	226 (74.8%)	<0.001	<0.001	0.849	<0.001	1.000	<0.001	0.390
≥35 years	246 (10.6%)	214 (14.5%)	3 (14.3%)	76 (25.2%)							
Pre-pregnant weight (kg)	54.00 (50.00, 58.00)	60.00 (54.12, 67.00)	57.00 (54.00, 63.00)	73.00 (66.00, 80.00)	<0.001	<0.001	0.003	<0.001	0.229	<0.001	<0.001
Height (cm)	163 (160, 166)	163 (160, 166)	163 (159, 165)	163 (160, 166)	0.844	0.599	0.671	0.651	0.605	0.465	0.781
BMI (kg/m ²)	20.31 (19.07, 21.63)	23.05 (20.51, 25.13)	22.43 (21.37, 23.43)	27.68 (25.59, 30.10)	<0.001	<0.001	<0.001	<0.001	0.157	<0.001	<0.001
Underweight	329 (14.2%)	86 (5.8%)	0 (0.0%)	0 (0.0%)							
Normal	1992 (85.8%)	755 (51.2%)	21 (100.0%)	34 (11.3%)	<0.001	<0.001	0.122	<0.001	<0.001	<0.001	<0.001
Overweight	0 (0.0%)	531 (36.0%)	0 (0.0%)	131 (43.4%)							
Obesity	0 (0.0%)	102 (6.9%)	0 (0.0%)	137 (45.4%)							
History of chronic hypertension	0 (0.0%)	47 (3.2%)	0 (0.0%)	27 (8.9%)	<0.001	<0.001	-	<0.001	0.840	<0.001	0.306
History of T2DM	0 (0.0%)	40 (2.7%)	0 (0.0%)	25 (8.3%)	<0.001	<0.001	-	<0.001	0.933	<0.001	0.342
Gestational weight gain (kg)	13.70 (11.00, 16.60)	13.00 (9.50, 16.00)	14.00 (12.00, 15.70)	10.00 (5.85, 14.00)	<0.001	<0.001	0.602	<0.001	0.211	<0.001	<0.001
Insufficient	263 (11.3%)	187 (12.7%)	2 (9.5%)	79 (26.2%)							
Normal	1096 (47.3%)	587 (39.9%)	9 (42.9%)	93 (30.8%)	<0.001	<0.001	0.842	<0.001	0.900	<0.001	0.205
Excessive	959 (41.4%)	698 (47.4%)	10 (47.6%)	130 (43.0%)							
Multigravidity	58 (2.5%)	43 (2.9%)	0 (0.0%)	7 (2.3%)	0.724	0.496	0.977	1.000	0.891	0.701	1.000
Educational level											
Below Bachelor's degree	439 (18.9%)	351 (23.8%)	4 (19.0%)	86 (28.5%)	<0.001	<0.001	1.000	<0.001	0.802	0.101	0.496
Bachelor's degree or above	1882 (81.1%)	1123 (76.2%)	17 (81.0%)	216 (71.5%)							
Gestational age at diagnosis (wk)	9 ⁺⁶ (9 ⁺⁰ , 11 ⁺⁰)	9.86 (9 ⁺⁰ , 11 ⁺¹)	10 ⁺¹ (8 ⁺⁵ , 10 ⁺⁴)	9 ⁺⁶ (9 ⁺⁰ , 11 ⁺⁰)	0.604	0.452	0.368	0.644	0.319	0.384	0.438
SBP (mmHg)	112 (105, 118)	116 (108, 122)	115 (109, 123)	122 (115, 129)	<0.001	<0.001	0.150	<0.001	0.805	<0.001	0.004
DBP (mmHg)	66 (61, 71)	69 (63, 75)	72 (61, 78)	74 (68, 80)	<0.001	<0.001	0.060	<0.001	0.650	<0.001	0.210
AST (U/L)	16.80 (15.00, 19.70)	17.30 (14.90, 20.30)	17.20 (15.40, 20.80)	18.30 (15.30, 22.10)	<0.001	0.009	0.310	<0.001	0.557	0.002	0.707
ALT (U/L)	13.00 (10.00, 18.00)	15.00 (11.00, 22.00)	18.00 (13.00, 25.00)	21.00 (14.25, 30.00)	<0.001	<0.001	0.008	<0.001	0.150	<0.001	0.233
TC (mmol/L)	4.38 (3.96, 4.82)	4.27 (3.72, 4.87)	4.65 (4.34, 5.01)	4.70 (4.16, 5.26)	<0.001	<0.001	0.113	<0.001	0.071	<0.001	0.698

TG (mmol/L)	0.94 (0.76, 1.15)	1.13 (0.86, 1.53)	1.22 (0.96, 1.42)	1.36 (1.10, 1.77)	<0.001	<0.001	0.003	<0.001	0.867	<0.001	0.027
FBG (mmol/L)	4.59 (4.36, 4.83)	4.69 (4.43, 4.94)	4.64 (4.43, 4.79)	4.89 (4.63, 5.25)	<0.001	<0.001	0.888	<0.001	0.339	<0.001	0.001
GGT (U/L)	13.00 (11.00, 17.00)	15.00 (12.00, 21.00)	20.00 (17.00, 24.00)	24.00 (18.00, 33.75)	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	0.061
HDL-C (mmol/L)	1.60 (1.46, 1.78)	1.29 (1.20, 1.55)	1.44 (1.38, 1.65)	1.29 (1.10, 1.45)	<0.001	<0.001	0.007	<0.001	0.002	<0.001	<0.001
LDL-C (mmol/L)	2.28 (2.01, 2.59)	2.38 (2.02, 2.75)	2.58 (2.29, 2.79)	2.76 (2.36, 3.14)	<0.001	<0.001	0.019	<0.001	0.197	<0.001	0.106

^a *P* value comparison among 4 groups, calculated using the Kruskal-Wallis test.

^b *P* value comparison between Non-SLD&CMRF group and CMRF-only group, calculated using the Fisher's exact test.

^c *P* value comparison between Non-SLD&CMRF group and SLD-only group, calculated using the Fisher's exact test.

^d *P* value comparison between Non-SLD&CMRF group and MASLD group, calculated using the Fisher's exact test.

^e *P* value comparison between CMRF-only group and SLD-only group, calculated using the Fisher's exact test.

^f *P* value comparison between CMRF-only group and MASLD group, calculated using the Fisher's exact test.

^g *P* value comparison between SLD-only group and MASLD group, calculated using the Fisher's exact test.

CMRF, cardiometabolic risk factors; SLD, steatotic liver disease; MASLD, metabolic dysfunction–associated steatotic liver disease; BMI, body mass index; T2DM, type 2 diabetes mellitus; SBP, systolic blood pressure; DBP, diastolic blood pressure; AST, aspartate aminotransferase; ALT, alanine aminotransferase; TC, total cholesterol; TG, triglycerides; FBG, fasting blood glucose; GGT, gamma-glutamyl transferase; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

Supplementary Table 3. Adverse pregnancy outcomes in pregnant women with or without MASLD

Outcomes	Non-MASLD (N=3816)	MASLD (N=302)	<i>P</i> value*
Gestational age at delivery (wk)	39 ⁺⁶ (39 ⁺⁰ , 40 ⁺⁴)	39 ⁺³ (38 ⁺⁴ , 40 ⁺³)	0.001
Cesarean section	1509 (39.5%)	190 (62.9%)	<0.001
Gestational diabetes mellitus	710 (18.6%)	121 (40.1%)	<0.001
Pregnancy-associated hypertension	200 (5.2%)	38 (12.6%)	<0.001
Preterm birth	159 (4.2%)	24 (7.9%)	0.003
Large-for-gestational-age neonates	284 (7.4%)	49 (16.2%)	<0.001
Small-for-gestational-age neonates	533 (14.0%)	39 (12.9%)	0.668
Postpartum hemorrhage	229 (6.0%)	15 (5.0%)	0.544

**P* value calculated using the Fisher's exact test.

MASLD, metabolic dysfunction–associated steatotic liver disease.

Supplementary Table 4. Comparations of adverse pregnancy outcomes in pregnant women with different states

Outcomes	Non- SLD&CMRF (N=2321)	CMRF-only (N=1474)	SLD-only (N=21)	MASLD (N=302)	<i>P</i> value ^a	<i>P</i> value ^b	<i>P</i> value ^c	<i>P</i> value ^d	<i>P</i> value ^e	<i>P</i> value ^f	<i>P</i> value ^g
Gestational age at delivery	39 ⁺⁶ (39 ⁺⁰ , 40 ⁺⁴)	39 ⁺⁶ (38 ⁺⁶ , 40 ⁺⁴)	39 ⁺⁴ (37 ⁺⁶ , 41 ⁺⁰)	39 ⁺³ (38 ⁺⁴ , 40 ⁺³)	0.015	0.728	0.629	0.001	0.661	0.004	0.805
Cesarean section	861 (37.1%)	635 (43.1%)	13 (61.9%)	190 (62.9%)	<0.001	<0.001	0.035	<0.001	0.132	<0.001	1.000
Gestational diabetes mellitus	362 (15.6%)	340 (23.1%)	8 (38.1%)	121 (40.1%)	<0.001	<0.001	0.012	<0.001	0.174	<0.001	1.000
Pregnancy-associated hypertension	88 (3.8%)	111 (7.5%)	1 (4.8%)	38 (12.6%)	<0.001	<0.001	1.000	<0.001	0.951	0.006	0.473
Preterm birth	82 (3.5%)	74 (5.0%)	3 (14.3%)	24 (7.9%)	<0.001	0.030	0.042	<0.001	0.158	0.059	0.544
Large-for-gestational-age neonates	158 (6.8%)	123 (8.4%)	3 (14.3%)	49 (16.2%)	<0.001	0.090	0.361	<0.001	0.506	<0.001	1.000
Small-for-gestational age neonates	336 (14.5%)	194 (13.2%)	3 (14.3%)	39 (12.9%)	0.665	0.204	1.000	0.517	1.000	0.979	1.000
Postpartum hemorrhage	149 (6.4%)	79 (5.4%)	1 (4.8%)	15 (5.0%)	0.491	0.204	1.000	0.393	1.000	0.891	1.000

^a *P* value comparison among 4 groups, calculated using the Kruskal-Wallis test.

^b *P* value comparison between Non-SLD/CMRF group and CMRF-only group, calculated using the Fisher's exact test.

^c *P* value comparison between Non-SLD/CMRF group and SLD-only group, calculated using the Fisher's exact test.

^d *P* value comparison between Non-SLD/CMRF group and MASLD group, calculated using the Fisher's exact test.

^e *P* value comparison between CMRF-only group and SLD-only group, calculated using the Fisher's exact test.

^f *P* value comparison between CMRF-only group and MASLD group, calculated using the Fisher's exact test.

^g *P* value comparison between SLD-only group and MASLD group, calculated using the Fisher's exact test.

CMRF, cardiometabolic risk factors; SLD, steatotic liver disease; MASLD, metabolic dysfunction–associated steatotic liver disease.

Supplementary Table 5. Association of different states of steatosis liver or cardiometabolic risk factors and the risk of adverse pregnancy outcomes

Adverse pregnancy outcomes	Non-SLD&CMRF	CMRF-only		SLD-only		MASLD	
		RR (95%CI)	<i>P</i> value	RR (95%CI)	<i>P</i> value	RR (95%CI)	<i>P</i> value
Cesarean section							
Undadjusted	Ref.	1.161 (1.048 , 1.287)	<0.001	1.669 (0.965 , 2.886)	0.067	1.696 (1.449 , 1.984)	<0.001
		Ref.		1.437 (0.830 , 2.488)	0.196	1.460 (1.242 , 1.717)	<0.001
		Ref.			1.016 (0.579 , 1.783)	0.955	
Adjusted	Ref.	1.117 (1.007 , 1.238)	0.036	1.677 (0.970 , 2.901)	0.064	1.532 (1.304 , 1.800)	<0.001
		Ref.		1.484 (0.857 , 2.572)	0.159	1.387 (1.177 , 1.634)	<0.001
		Ref.			0.980 (0.555 , 1.729)	0.944	
Gestational diabetes mellitus							
Undadjusted	Ref.	1.479 (1.275 , 1.715)	<0.001	2.443 (1.212 , 4.921)	0.012	2.569 (2.091 , 3.156)	<0.001
		Ref.		1.652 (0.819 , 3.329)	0.161	1.737 (1.412 , 2.137)	<0.001
		Ref.			1.052 (0.514 , 2.151)	0.890	
Adjusted	Ref.	1.487 (1.281 , 1.726)	<0.001	2.551 (1.266 , 5.143)	0.009	2.410 (1.948 , 2.980)	<0.001
		Ref.		1.642 (0.814 , 3.313)	0.166	1.734 (1.405 , 2.139)	<0.001
		Ref.			1.046 (0.507 , 2.158)	0.903	
Pregnancy-associated hypertension							
Undadjusted	Ref.	1.986 (1.501 , 2.627)	<0.001	1.256 (0.175 , 9.016)	0.821	3.319 (2.268 , 4.855)	<0.001
		Ref.		0.632 (0.088 , 4.529)	0.648	1.671 (1.156 , 2.415)	0.006
		Ref.			2.642 (0.363 , 19.246)	0.337	
Adjusted	Ref.	1.842 (1.390 , 2.443)	<0.001	1.190 (0.166 , 8.544)	0.863	3.050 (2.060 , 4.515)	<0.001
		Ref.		0.662 (0.092 , 4.748)	0.682	1.606 (1.105 , 2.333)	0.013
		Ref.			2.892 (0.394 , 21.217)	0.296	
Preterm birth							
Undadjusted	Ref.	1.421 (1.038 , 1.946)	0.028	4.044 (1.278 , 12.797)	0.017	2.249 (1.427 , 3.545)	<0.001
		Ref.		2.846 (0.897 , 9.026)	0.076	1.583 (0.999 , 2.509)	0.051

Adverse pregnancy outcomes	Non-SLD&CMRF	CMRF-only RR (95%CI)	P value	SLD-only RR (95%CI)	P value	MASLD RR (95%CI)	P value
				Ref.		0.556 (0.168 , 1.847)	0.338
Adjusted	Ref.	1.427 (1.038 , 1.961)	0.029	4.530 (1.428 , 14.375)	0.010	2.146 (1.342 , 3.430)	0.001
		Ref.		2.908 (0.915 , 9.242)	0.070	1.525 (0.956 , 2.433)	0.076
				Ref.		0.531 (0.156 , 1.805)	0.311
Large-for-gestational-age neonates							
Undadjusted	Ref.	1.226 (0.968 , 1.551)	0.091	2.097 (0.669 , 6.571)	0.204	2.381 (1.728 , 3.281)	<0.001
		Ref.		1.711 (0.544 , 5.378)	0.358	1.943 (1.395 , 2.706)	<0.001
				Ref.		1.136 (0.354 , 3.644)	0.831
Adjusted	Ref.	1.180 (0.931 , 1.496)	0.172	2.097 (0.669 , 6.577)	0.204	2.224 (1.599 , 3.095)	<0.001
		Ref.		1.712 (0.544 , 5.383)	0.358	1.845 (1.318 , 2.581)	<0.001
				Ref.		1.037 (0.321 , 3.351)	0.952
Small-for-gestational-age neonates							
Undadjusted	Ref.	0.909 (0.762 , 1.085)	0.290	0.986 (0.316 , 3.073)	0.981	0.891 (0.640 , 1.242)	0.496
		Ref.		1.085 (0.347 , 3.393)	0.889	0.981 (0.695 , 1.383)	0.911
				Ref.		0.904 (0.279 , 2.925)	0.866
Adjusted	Ref.	0.930 (0.778 , 1.111)	0.421	0.996 (0.320 , 3.106)	0.995	0.929 (0.663 , 1.300)	0.666
		Ref.		1.041 (0.332 , 3.262)	0.944	1.032 (0.729 , 1.460)	0.861
				Ref.		0.915 (0.277 , 3.017)	0.883
Postpartum hemorrhage							
Undadjusted	Ref.	0.835 (0.636 , 1.097)	0.195	0.742 (0.104 , 5.301)	0.766	0.774 (0.455 , 1.316)	0.344
		Ref.		0.888 (0.124 , 6.386)	0.906	0.927 (0.534 , 1.610)	0.787
				Ref.		1.043 (0.138 , 7.897)	0.967
Adjusted	Ref.	0.828 (0.629 , 1.089)	0.177	0.774 (0.108 , 5.536)	0.799	0.733 (0.428 , 1.257)	0.259
		Ref.		0.897 (0.125 , 6.458)	0.914	0.911 (0.522 , 1.590)	0.743
				Ref.		1.031 (0.133 , 8.007)	0.977

*Adjusted for age, education level, gravidity, and gestational weight gain.

CMRF, cardiometabolic risk factors; SLD, steatotic liver disease; MASLD, metabolic dysfunction–associated steatotic liver disease; T2DM, type 2 diabetes mellitus.

REFERENCE

1. National Health Commission of the People's Republic of China. Standard of recommendation for weight gain during pregnancy period (WS/T 801-2022). Beijing: Standards Press of China; 2022. (In Chinese) URL: <https://www.nhc.gov.cn/wjw/c100311/202208/deb61e5c2299451ea1b957b0672272b3.shtml>