

Supplemental table 1. Population characteristics according to different types of maternal diabetes: The National Vital Statistics System 2018 (N=3,746,390)

Variable	No diabetes	Pre-pregnancy diabetes	Gestational diabetes	P-value
Total	3459162	35530	251698	
Age, years (mean, SD)	29.0 (5.6)	31.3 (5.8)	31.4 (5.5)	
Age, years, n (%)				
<25	826703 (23.9)	4991 (14.0)	29733 (11.8)	
25-29.9	1029789 (29.8)	8464 (23.8)	61656 (24.5)	
30-34.9	996999 (28.8)	10827 (30.5)	83834 (33.3)	<0.001
35-39.9	499666 (14.4)	8468 (23.8)	59100 (23.5)	
≥40	106005 (3.1)	2780 (7.8)	17375 (6.9)	
Race/ethnicity, n (%)				
Hispanic	799821 (23.1)	9705 (27.3)	63764 (25.3)	
Non-Hispanic white	1807858 (52.3)	14787 (41.6)	117280 (46.6)	
Non-Hispanic black	504577 (14.6)	6809 (19.2)	28732 (11.4)	<0.001
Other	346906 (10.0)	4229 (11.9)	41922 (16.7)	
Education levels, n (%)				
Lower than high school	399163 (11.5)	5623 (15.8)	31233 (12.4)	
High school	891044 (25.8)	9983 (28.1)	59559 (23.7)	
Higher than high school	2125075 (61.4)	19576 (55.1)	157501 (62.6)	<0.001
Unknown	43880 (1.3)	348 (1.0)	3405 (1.4)	
Marital status, n (%)				
Married	1836407 (53.1)	18649 (52.5)	147178 (58.5)	
Unmarried	1205583 (34.9)	13512 (38.0)	73630 (29.3)	<0.001
Unknown	417172 (12.1)	3369 (9.5)	30890 (12.3)	
Parity, n (%)				
1	1296476 (37.5)	11848 (33.3)	83613 (33.2)	
2	1116403 (32.3)	10769 (30.3)	79632 (31.6)	
3	596915 (17.3)	6699 (18.9)	47541 (18.9)	<0.001
≥4	440080 (12.7)	6140 (17.3)	40493 (16.1)	
Unknown	9288 (0.3)	74 (0.2)	419 (0.2)	
Smoking before pregnancy, n (%)				
Yes	290579 (8.4)	3474 (9.8)	20132 (8.0)	
No	3153164 (91.2)	31870 (89.7)	230529 (91.6)	<0.001
Unknown	15419 (0.4)	186 (0.5)	1037 (0.4)	

Smoking during pregnancy, n (%)				
Yes	109594 (3.2)	1253 (3.5)	6875 (2.7)	
No	3202486 (92.6)	32255 (90.8)	235478 (93.6)	<0.001
Unknown	147082 (4.3)	2022 (5.7)	9345 (3.7)	
Timing of initiation of prenatal care, n (%)				
No prenatal care	59760 (1.7)	445 (1.3)	1534 (0.6)	
1 st to 3 rd month	2614565 (75.6)	27579 (77.6)	198007 (78.7)	
4 th to 6 th month	546190 (15.8)	5341 (15.0)	37563 (14.9)	<0.001
7 th to final month	151629 (4.4)	1243 (3.5)	9617 (3.8)	
Unknown	87018 (2.5)	922 (2.6)	4977 (2.0)	
Pre-pregnancy BMI, n (%)				
Underweight<18.5	110479 (3.2)	315 (0.9)	3678 (1.5)	
Normal 18.5-24.9	1469570 (42.5)	6315 (17.8)	62459 (24.8)	
Overweight 25.0-29.9	903776 (26.1)	7945 (22.4)	64793 (25.7)	
Obesity I 30.0-34.9	496155 (14.3)	7708 (21.7)	53128 (21.1)	<0.001
Obesity II 35.0-39.9	237393 (6.9)	5860 (16.5)	33297 (13.2)	
Extreme obesity III ≥40.0	164249 (4.7)	6514 (18.3)	29362 (11.7)	
Unknown	77540 (2.2)	873 (2.5)	4981 (2.0)	
Infant sex, n (%)				
Male	1766864 (51.1)	18074 (50.9)	130134 (51.7)	<0.001
Female	1692298 (48.9)	17456 (49.1)	121564 (48.3)	
Pre-pregnancy Hypertension, n (%)				
Yes	60128 (1.7)	5924 (16.7)	11854 (4.7)	<0.001
No	3399034 (98.3)	29606 (83.3)	239844 (95.3)	

Supplemental table 2. Association of pre-pregnancy and gestational diabetes with any type or major subtypes of congenital anomalies identified at birth: NVSS 2018

Birth defect	Non-diabetes	Pre-pregnancy diabetes	P-value	Gestational diabetes	P-value
^aAny type					
Case/No. of participants	9948/3459162	304/35530		909/251698	
Model 1	1.00 (ref)	^b 3.03 (2.70-3.39)	<0.001	1.26 (1.18-1.35)	<0.001
Model 2	1.00 (ref)	2.80 (2.49-3.15)	<0.001	1.23 (1.14-1.32)	<0.001
Model 3	1.00 (ref)	2.67 (2.37-3.01)	<0.001	1.22 (1.13-1.31)	<0.001
Cyanotic congenital heart disease					
Case/No. of participants	1875/3459162	111/35530		211/251698	
Model 1	1.00 (ref)	5.95 (4.91-7.21)	<0.001	1.58 (1.37-1.82)	<0.001
Model 2	1.00 (ref)	5.44 (4.46-6.64)	<0.001	1.54 (1.33-1.79)	<0.001
Model 3	1.00 (ref)	5.20 (4.25-6.37)	<0.001	1.53 (1.33-1.78)	<0.001
Hypospadias^c					
Case/No. of participants	1977/1766864	46/18074		193/130134	
Model 1	1.00 (ref)	2.41 (1.80-3.23)	<0.001	1.37 (1.18-1.59)	<0.001
Model 2	1.00 (ref)	2.22 (1.65-2.99)	<0.001	1.30 (1.11-1.51)	<0.001
Model 3	1.00 (ref)	2.05 (1.52-2.77)	<0.001	1.28 (1.10-1.49)	0.002
Cleft lip with or without cleft palate					
Case/No. of participants	1793/3459162	55/35530		178/251698	
Model 1	1.00 (ref)	3.14 (2.40-4.11)	<0.001	1.39 (1.19-1.62)	<0.001
Model 2	1.00 (ref)	2.78 (2.10-3.69)	<0.001	1.27 (1.08-1.50)	0.01
Model 3	1.00 (ref)	2.73 (2.05-3.63)	<0.001	1.27 (1.07-1.50)	0.01
Down syndrome					
Case/No. of participants	800/3459162	21/35530		94/251698	
Model 1	1.00 (ref)	1.66 (1.08-2.57)	0.02	1.13 (0.91-1.40)	0.28
Model 2	1.00 (ref)	1.60 (1.02-2.50)	0.04	1.10 (0.87-1.38)	0.43
Model 3	1.00 (ref)	1.49 (0.94-2.35)	0.09	1.08 (0.86-1.37)	0.49
Cleft palate alone					
Case/No. of participants	797/3459162	23/35530		88/251698	
Model 1	1.00 (ref)	3.16 (2.09-4.79)	<0.001	1.65 (1.32-2.06)	<0.001
Model 2	1.00 (ref)	2.79 (1.82-4.28)	<0.001	1.60 (1.27-2.01)	<0.001
Model 3	1.00 (ref)	2.61 (1.69-4.03)	<0.001	1.58 (1.26-1.99)	<0.001
Gastroschisis					
Case/No. of participants	771/3459162	2/35530		20/251698	

Model 1	1.00 (ref)	0.35 (0.09-1.40)	0.14	0.50 (0.32-0.78)	0.002
Model 2	1.00 (ref)	0.46 (0.11-1.85)	0.27	0.64 (0.41-1.02)	0.06
Model 3	1.00 (ref)	0.47 (0.12-1.87)	0.28	0.65 (0.41-1.02)	0.06
Suspected chromosomal disorder					
Case/No. of participants	526/3459162	12/35530		38/251698	
Model 1	1.00 (ref)	1.81 (1.02-3.21)	0.04	0.81 (0.58-1.14)	0.23
Model 2	1.00 (ref)	1.76 (0.98-3.14)	0.06	0.75 (0.52-1.07)	0.11
Model 3	1.00 (ref)	1.69 (0.94-3.04)	0.08	0.74 (0.52-1.06)	0.10
Meningomyelocele/spina bifida					
Case/No. of participants	495/3459162	11/35530		38/251698	
Model 1	1.00 (ref)	2.29 (1.26-4.17)	0.01	1.09 (0.78-1.52)	0.62
Model 2	1.00 (ref)	1.84 (0.98-3.47)	0.06	1.04 (0.74-1.46)	0.81
Model 3	1.00 (ref)	1.71 (0.90-3.24)	0.10	1.03 (0.73-1.44)	0.87
Limb reduction defect					
Case/No. of participants	426/3459162	16/35530		37/251698	
Model 1	1.00 (ref)	3.75 (2.27-6.19)	<0.001	1.22 (0.87-1.71)	0.25
Model 2	1.00 (ref)	3.48 (2.09-5.78)	<0.001	1.18 (0.84-1.68)	0.34
Model 3	1.00 (ref)	3.48 (2.08-5.81)	<0.001	1.18 (0.84-1.68)	0.34
Congenital diaphragmatic hernia					
Case/No. of participants	421/3459162	7/35530		31/251698	
Model 1	1.00 (ref)	1.66 (0.79-3.51)	0.18	1.01 (0.70-1.46)	0.96
Model 2	1.00 (ref)	1.53 (0.72-3.25)	0.27	0.92 (0.63-1.35)	0.67
Model 3	1.00 (ref)	1.29 (0.60-2.76)	0.51	0.90 (0.61-1.31)	0.57
Omphalocele					
Case/No. of participants	369/3459162	5/35530		27/251698	
Model 1	1.00 (ref)	1.29 (0.53-3.12)	0.57	1.02 (0.69-1.52)	0.91
Model 2	1.00 (ref)	1.01 (0.37-2.71)	0.99	1.07 (0.71-1.61)	0.74
Model 3	1.00 (ref)	0.98 (0.36-2.67)	0.98	1.07 (0.71-1.60)	0.75
Anencephaly					
Case/No. of participants	314/3459162	13/35530		20/251698	
Model 1	1.00 (ref)	4.37 (2.50-7.62)	<0.001	0.94 (0.60-1.48)	0.79
Model 2	1.00 (ref)	4.37 (2.48-7.68)	<0.001	0.99 (0.62-1.59)	0.98
Model 3	1.00 (ref)	4.73 (2.68-8.34)	<0.001	1.00 (0.63-1.61)	0.98

^a Any type of congenital anomalies in all 12 types of congenital anomalies of NVSS dataset

^b RR; 95% CI in parentheses (all such values)

^c Only in boys.

Model 1: Adjusted for maternal age, race/ethnicity.

Model 2: Model 1 + education levels, marital status, parity, smoking before pregnancy, smoking during pregnancy, timing of initiation of prenatal care, pre-pregnancy BMI and infant sex.

Model 3: Model 2 + pre-pregnancy hypertension.

Supplemental table 3. Association of pre-pregnancy diabetes and gestational diabetes with any type of congenital anomalies identified at birth, stratified by maternal age, race/ethnicity, pre-pregnancy BMI and infant sex separately: NVSS 2018

Variables	Non-diabetes	Pre-pregnancy diabetes		Gestational diabetes		P for interaction
		RR (95%CI)	P	RR (95%CI)	P	
Age, years						
<25	1.00 (ref)	3.58 (2.74-4.67)	<0.001	1.21 (1.00-1.46)	0.06	0.01
25-29.9	1.00 (ref)	3.03 (2.38-3.86)	<0.001	1.17 (1.01-1.36)	0.03	
30-34.9	1.00 (ref)	2.47 (1.95-3.14)	<0.001	1.22 (1.07-1.40)	0.003	
35-39.9	1.00 (ref)	2.37 (1.84-3.05)	<0.001	1.18 (1.02-1.37)	0.03	
≥40	1.00 (ref)	1.72 (1.16-2.57)	0.01	1.26 (1.01-1.56)	0.04	
Race/ethnicity						
Hispanic	1.00 (ref)	3.09 (2.42-3.95)	<0.001	1.16 (0.98-1.36)	0.09	0.75
Non-Hispanic white	1.00 (ref)	2.38 (2.00-2.82)	<0.001	1.24 (1.13-1.36)	<0.001	
Non-Hispanic black	1.00 (ref)	3.08 (2.32-4.09)	<0.001	1.22 (0.97-1.53)	0.09	
Other	1.00 (ref)	2.62 (1.81-3.79)	<0.001	1.24 (1.01-1.52)	0.04	
Pre-pregnancy BMI						
Underweight<18.5	1.00 (ref)	3.53 (1.13-11.0)	0.03	1.15 (0.61-2.17)	0.66	0.78
Normal 18.5-24.9	1.00 (ref)	2.75 (2.08-3.65)	<0.001	1.35 (1.17-1.55)	<0.001	
Overweight 25.0-29.9	1.00 (ref)	2.88 (2.25-3.68)	<0.001	1.11 (0.96-1.28)	0.17	
Obesity I 30.0-34.9	1.00 (ref)	2.40 (1.83-3.15)	<0.001	1.18 (1.01-1.38)	0.04	
Obesity II 35.0-39.9	1.00 (ref)	2.80 (2.11-3.71)	<0.001	1.15 (0.95-1.40)	0.15	
Extreme obesity III ≥40.0	1.00 (ref)	2.38 (1.78-3.18)	<0.001	1.16 (0.95-1.43)	0.14	
Unknown	1.00 (ref)	2.82 (1.48-5.37)	0.002	1.55 (1.03-2.31)	0.03	
Infant sex						
Male	1.00 (ref)	2.52 (2.16-2.94)	<0.001	1.29 (1.18-1.40)	<0.001	0.17
Female	1.00 (ref)	2.93 (2.43-3.53)	<0.001	1.10 (0.97-1.24)	0.14	

Maternal age, race/ethnicity, education levels, marital status, parity, smoking before pregnancy, smoking during pregnancy, timing of initiation of prenatal care, pre-pregnancy BMI, infant sex and pre-pregnancy hypertension were adjusted in models.

Maternal age, race/ethnicity, pre-pregnancy BMI and infant sex category were not adjusted for when used as a stratified variable, respectively.