



Pregnancy outcomes in women with type 1 diabetes in China during 2004 to 2014: A retrospective study (the CARNATION Study)

Sihui Luo^{1†} | Xingwu Ran^{2†} | Mei Zhang^{3†} | Ji Hu^{4†} | Daizhi Yang⁵ | Dalong Zhu⁶ | Jiajun Zhao⁷ | Xinhua Xiao⁸ | Xiaohui Guo⁹ | Tao Yang³ | Qin Huang¹⁰ | Fang Liu¹¹ | Lu Jing⁶ | Jing Ma² | Xinli Zhou⁷ | Fan Ping⁸ | Nan Gu⁹ | Wenwen Li¹⁰ | Yaling Yang¹² | Chen Fang⁴ | Wei Bao¹³ | Xueying Zheng¹ | Jinhua Yan⁵ | Zhiguang Zhou¹² | Jianping Weng^{1,5}

¹Department of Endocrinology, the First Affiliated Hospital of USTC, Division of Life Sciences and Medicine, University of Science and Technology of China, Hefei, China

²Department of Endocrinology and Metabolism, West China University Hospital, Sichuan University, Chengdu, China

³Department of Endocrinology and Metabolism, Jiangsu Province Hospital, Nanjing, China

⁴Department of Endocrinology and Metabolism, The Second Affiliated Hospital of Soochow University, Suzhou, China

⁵Department of Endocrinology and Metabolism, The Third Affiliated Hospital of Sun Yat-sen University, Guangzhou, China

⁶Department of Endocrinology and Metabolism, Nanjing Drum Tower Hospital, The Affiliated Hospital of Nanjing University Medical School, Nanjing, China

⁷Department of Endocrinology and Metabolism, Shandong Provincial Hospital Affiliated to Shandong University, Jinan, China

⁸Department of Endocrinology and Metabolism, Peking Union Medical College Hospital, Beijing, China

⁹Department of Endocrinology and Metabolism, Peking University First Hospital, Beijing, China

¹⁰Department of Endocrinology and Metabolism, Changhai Hospital, Second Military Medical University, Shanghai, China

¹¹Department of Endocrinology and Metabolism, Shanghai Jiao Tong University Affiliated Sixth People's Hospital, Shanghai, China

¹²Department of Endocrinology and Metabolism, The Second Xiangya Hospital of Central South University, Changsha, China

¹³Department of Epidemiology, College of Public Health, University of Iowa, Iowa City, Iowa, USA

Correspondence

Zhiguang Zhou, Department of Endocrinology and Metabolism, The Second Xiangya Hospital of Central South University, 139 Renmin Zhong Road, Changsha 410011, China.
Email: zhouzhiguang@csu.edu.cn

Jianping Weng, Department of Endocrinology, the First Affiliated Hospital of USTC Division of Life Sciences and Medicine, University of Science and

Abstract

Background: We aimed to report pregnancy outcomes of women with type 1 diabetes (T1D) in China, on which data were sparse.

Methods: This is a nationwide retrospective study conducted in 11 general medical centers in 8 cities across China. We investigated the clinical data of all women who attended these centers with a singleton pregnancy and whose pregnancy ended between 1 January 2004 and 31 December 2014. Pregnancies of

† Sihui Luo, Xingwu Ran, Mei Zhang, and Ji Hu contributed equally to this work.

Technology of China 17 Lujiang Road,
Hefei 230001, China.
Email: wengjp@ustc.edu.cn

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women with pregestational T1D were ascertained and compared with those of women without T1D.

Results: From over 300 000 pregnancies over the 11-year study period, we identified 265 singleton pregnancies of women with T1D. One maternal death was documented among 265 (0.37%) women with T1D and 83 among 318 486 (0.03%) women without T1D. Women with T1D suffered from higher rates of pregnancy loss (13.21% vs 2.92%, crude risk ratio [cRR] 5.08 [95% CI, 3.56-7.26]) and preeclampsia (17.74% vs 4.20%, cRR 4.94 [95% CI, 3.60-6.77]) compared with those without T1D. Infants of these women with T1D had elevated rates of neonatal death (5.65% vs 0.16%, cRR 37.36 [95% CI, 21.21-65.82]) and congenital malformation(s) (8.26% vs 3.53%, cRR 2.46 [95% CI, 1.54-3.93]) compared with those of women without T1D. No significant improvement in pregnancy outcomes in women with T1D was observed over the period 2004 to 2014.

Conclusions: Pregnancy outcomes were persistently poor in women with T1D during 2004 to 2014 in China. Pregnancy care needs to be improved to reduce adverse pregnancy outcomes among Chinese women with T1D.

KEYWORDS

diabetes mellitus type 1, pregnancy in diabetics, pregnancy outcomes, retrospective study

Highlights

- This retrospective study is the first to report pregnancy outcomes among Chinese women with type 1 diabetes during 2004 to 2014.
- We found that the pregnancy outcomes were poor among this population, despite dramatic improvement in the outcomes of the maternal care system for the general population, scientific progress, and release of guidelines.
- Our findings implicate a great burden of women with type 1 diabetes and that there is an urgent need to take measures to reduce adverse pregnancy outcomes.

1 | INTRODUCTION

Pregnancy affects the life and the health of women with type 1 diabetes (T1D) and their offspring. It is accepted that T1D is associated with an increased risk of adverse outcomes in both pregnant women with T1D and their infants.¹ In 1989, European countries agreed in St. Vincent that pregnancy-related adverse outcomes in women with T1D should be brought down to the level of normoglycemic women, which also inspired other parts of the world to follow.² In subsequent years, efforts have been made to improve the care and outcomes of pregnancies complicated with T1D in these countries, including medical and technical strategies such as preconception care,³ intensive glycaemic control,⁴ continuous glycaemic monitoring,⁵ and blood pressure control.¹ Implementation of these comprehensive

strategies has propelled the reduction of stillbirth and congenital malformations in some European countries.^{1,3,4,6} But the goals of the St Vincent Declaration remain yet to be fulfilled.² A renewed focus on pregnancy care in women with T1D is imperative. The National Institute for Health and Care Excellence guidelines suggest that we may still lack key information on potential barriers, which reflect diverse unmet needs, leading to persistent adverse results.⁷

Studies aiming to address the unmet needs of pregnant women with T1D are of great importance in China, where the population with T1D ranks fourth globally,⁸ alongside a 4-fold increased incidence over the past decade.⁹ However, data on pregnancy outcome in women with T1D are scarce. It is partly due to the population remaining largely covert as a result of the enduring systemic marginalization of individuals with T1D.¹⁰ This



has led to great obscurity in the needs and adversities of this vulnerable community, posing a considerable challenge to the United Nations' Millennium Development Goals in maternal health "to leave no one behind."¹¹

Therefore, the National Health and Family Planning Commission of China initiated a program (the CARNA-TION Study) aiming to enhance pregnancy care for women with T1D. As the first step of this program, we aimed to understand the status of pregnancy of women with T1D, and we conducted this nationwide retrospective study on pregnancy outcomes. These results would serve as the foundation to pave the way for strategies to improve the pregnancy outcomes in women with T1D in China.

2 | METHODS

We conducted a retrospective study in 11 general medical centers from 8 cities across China (Appendix, Table S1). These centers were selected because they are evenly distributed from north to south across China and represent different levels of economic development.

2.1 | Study population

We extracted data of pregnancies that had an outcome of either live birth(s), stillbirth, or miscarriage between 1 January 2004 and 31 December 2014 from the participating centers' hospital information system.

We studied the pregnancy outcomes of all pregnant women with T1D treated in these centers during the study period of 2004 to 2014. We included the data of women with pregestational T1D and singleton pregnancy into the analysis. We excluded those (a) with gestational diabetes, type 2 diabetes, or monogenetic diabetes; (b) pregnancy termination due to nonmedical reasons; (c) multiple pregnancy; or (d) crucial data missing. Medical records of eligible patients were retrieved from the participating centers' hospital information systems based on *International Classification of Diseases* (ICD) codes and reviewed by trained staff. (Please refer to the Supplemental Materials for details.) We collected demographic data, age at diabetes diagnosis, pregestational chronic diabetic complications, insulin regimen, and glycosylated hemoglobin (HbA1c) levels during the peri-pregnancy period, and pregnancy outcomes.

We also collected annual institutional data of all the women with a singleton pregnancy without T1D, who had their pregnancy outcomes during the same study period. These pregnant women without T1D served as the background population. Data were retrieved from the medical record management departments of the participating

centers. For these women without T1D, we collected data on numbers of adverse maternal outcomes, including maternal death, preeclampsia and caesarean deliveries, and other available variables. We also collected the total number of live births and neonatal/fetal outcomes in the participating centers during the study period. Data of neonatal/fetal outcomes included annual numbers of neonatal death, preterm birth, congenital malformation(s), admission to neonatal intensive care unit (NICU), and other available variables.

2.2 | Outcome measurements

Primary outcomes included maternal death, neonatal death, and congenital malformation(s). Maternal death was defined as the death of a woman while pregnant or within 42 days from the end of pregnancy, irrespective of the cause of death. Neonatal death included infant death that occurs at <28 days after birth. Infant congenital malformation(s) included ICD 10 codes Q00 to Q99.¹²

Other outcomes of interest included the incidence of pregnancy loss, preeclampsia, caesarean delivery, the progression of diabetic retinopathy and/or nephropathy, preterm birth, large-for-gestational age (LGA), small-for-gestational age (SGA), macrosomia, and admission to NICU.¹¹ Pregnancy loss included miscarriage and stillbirth. LGA was defined as the live-born infant's birth weight above the 90th percentile for gestational age and SGA as those below the 10th percentile, based on Chinese neonatal sex-specific birth weight charts for different gestational ages.¹³ Macrosomia was defined as birth weight ≥ 4000 g. Neonatal admission to NICU was defined as any outcomes that required NICU admission >24 hours.

We used the same definition of these outcomes in the study population of women with T1D as in the background population of women without T1D.

2.3 | Statistical analysis

We compared pregnancy outcomes between women with and without T1D using Pearson χ^2 test or Fisher's exact method, with crude risk ratios (cRRs) and 95% CIs. We divided the study population according to the time of their pregnancy outcomes: 2004 to 2007, 2008 to 2011, and 2012 to 2014. The division was aimed to investigate the temporal changes of pregnancy outcomes of women with T1D during the study period. The rationale behind this division is that in May 2007 the first Chinese national guideline of pregnancy complicated with diabetes was released.¹⁴ So we set the first division point at the end of

2007, aiming to investigate the temporal change before and after the release of this guideline. The second division point was set considering dividing the study period evenly. The changes in maternal characteristics and the pregnancy outcomes among these three periods were analyzed using linear regression models, Pearson χ^2 test, or logistic regression analysis, when appropriate. *P* values $<.05$ were considered statistically significant. Statistical analysis was performed with IBM SPSS version 23.0 and Stata version 14.0.

2.4 | Ethics

This study has been approved by the ethics committee of each participating center. These committees agreed that individual patient consent was waived for using anonymized data in this retrospective study.

3 | RESULTS

3.1 | Status of pregnancy outcomes in women with T1D in China

From over 300 000 pregnant women, 289 women with pregestational T1D with a singleton pregnancy were initially ascertained from the 11 participating centers.

Twenty-four were excluded due to elective abortion for nonmedical reasons or missing data. Finally, 265 women were included in the analysis (Figure 1). Twenty-five (25/265, 9.43%) of them had a previous history of adverse pregnancy outcomes. For the background population, we managed to collect data from 10 centers (Supplemental Materials, Table S1). The weighted average age at the end of the pregnancy of these women without T1D was 28.88 years.

Table 1 shows the maternal characteristics of the studied women with T1D. The number of pregnant women with T1D increased nearly 7-fold over the 11-year study period. However, no significant differences in maternal characteristics were observed among the three periods of 2004 to 2008, 2008 to 2011, and 2012 to 2014. Less than 60% of the studied women used appropriate insulin treatment (basal-bolus injections and continuous subcutaneous insulin injection), and 39.2% used insulin regimens like multiple injections of premixed insulin. Notably, only 22.64% (60/265) of the studied women had their HbA1c tested during the peri-pregnancy period. Among the patients with HbA1c records available, 61.67% (37/60) achieved the peri-conception HbA1c target ($\leq 7.0\%$), and 43.33% (26/60) achieved the third trimester HbA1c target ($\leq 6.5\%$).

Adverse pregnancy outcomes in women with and without T1D are summarized in Table 2. One maternal death (0.38%, 1/265) was observed in women with T1D

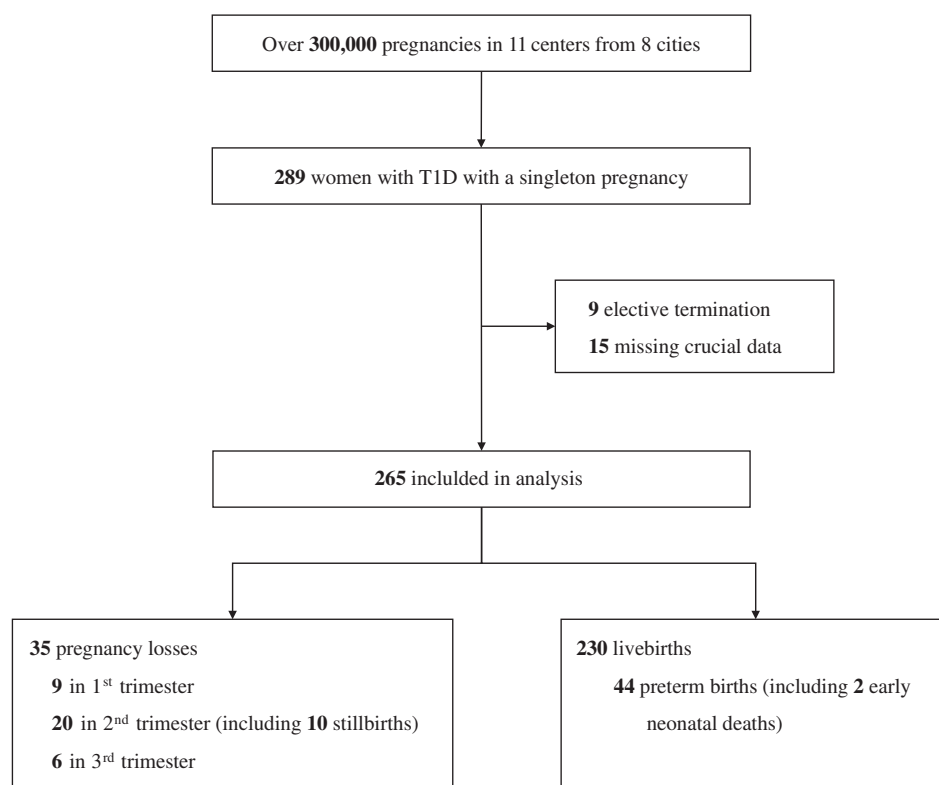


FIGURE 1 Ascertainment of pregnant women with type 1 diabetes whose pregnancies ended during 1 January 2004 and 31 December 2014 in the participating centers. T1D, type 1 diabetes


TABLE 1 Maternal characteristics of singleton pregnant women with pregestational type 1 diabetes in the participating centers

Variable	Period 1 2004-2007	Period 2 2008-2011	Period 3 2012-2014	Overall	P for trend 2004-2014
Number of pregnant women with T1D	30	82	153	265	NA
Primiparas, n (%)	19 (63.33)	46 (56.10)	99 (64.71)	164 (61.88)	.426
History of adverse pregnancy outcomes prior to the study period, n (%)	5 (16.67)	6 (7.31)	14 (9.15)	25 (9.43)	.362
Age at conception, y (SD) ^a	27.83 (3.38)	27.85 (4.13)	28.30 (4.03)	28.11 (3.98)	.398
Age at diabetes diagnosis, y (SD) ^a	21.45 (8.31)	22.56 (6.56)	22.58 (6.77)	22.02 (6.89)	.514
Duration of diabetes at delivery, y (SD) ^a	7.16 (7.39)	5.67 (5.41)	6.25 (5.26)	5.61 (5.68)	.801
Middle school or higher, n (%)	4 (100)	33 (89.19)	93 (95.88)	130 (94.2)	.384
Chronic hypertension, n (%)	0	5 (6.2)	3 (2.0)	8 (3.0)	NA
Preconception diabetic microvascular complications	-	-	-	-	-
Diabetes nephropathy, n (%)	4 (13.33)	3 (3.66)	10 (6.54)	17 (6.42)	.181
Diabetes retinopathy, n (%)	7 (23.33)	10 (12.20)	19 (12.42)	36 (13.58)	.254
Mode of insulin treatment	-	-	-	-	-
Basal-bolus injections, n (%)	12 (40.0)	36 (43.9)	73 (47.7)	121 (45.7)	NA
CSII, n (%)	4 (13.3)	11 (13.4)	21 (13.7)	36 (13.6)	NA
Others ^b , n (%)	11 (36.7)	36 (41.5)	59 (38.6)	104 (39.2)	NA
Unknown, n (%)	3 (10)	1 (1.2)	0	4 (1.50)	NA
Smoking in pregnancy, n	0	0	0	0	NA
Drinking in pregnancy, n	0	0	0	0	NA
Preconception/first trimester HbA1c ≤ 7.0%, % ([n/N])	44.44 (4/9)	75 (15/20)	58.06 (18/31)	61.67 (37/60)	.246
HbA1c at delivery ≤ 6.5%, % ([n/N])	44.44 (4/9)	50 (10/20)	38.71 (12/31)	43.33 (26/60)	.184

Note: All the denominators of the percentages were the respective numbers of pregnant women with T1D presented in the first row unless otherwise noted. Abbreviations: CSII, continuous subcutaneous insulin injection; HbA1c, glycosylated hemoglobin; NA, not applicable; T1D, type 1 diabetes.

^aThe trend of these variables was tested with linear regression models, and the trend of other variables was tested with Pearson χ^2 test.

^bOthers meant insulin regimens other than basal-bolus injections or CSII, such as multiple premixed insulin injections or a combination of premixed and short-/rapid-acting insulin injections.

and 83 (0.03%, 83/318486) in women without T1D. Also, women with T1D had significantly higher rates of pregnancy loss (13.21% vs 2.92%, cRR 5.08 [95% CI, 3.56-7.26]), preeclampsia (17.74% vs 4.20%, cRR 4.94 [95% CI, 3.60-6.77]), and caesarean delivery (70.19% vs 51.15%, cRR 2.25 [95% CI, 1.73-2.93]). Besides, 11.32% (30/265) of women with T1D suffered from the progression of diabetic complication(s) during pregnancy.

Adverse outcomes in infants of the studied population are also shown in Table 2. Compared to those born to women without T1D, infants born to women with T1D had increased rates of neonatal death (5.65% vs 0.16%, cRR 37.36 [95% CI, 21.21-65.82]) and congenital malformation(s) (8.26% vs 3.53%, cRR 2.46 [95% CI, 1.54-3.93]) as well as elevated risk of preterm birth (19.13% vs 3.53%, cRR 2.46 [95% CI, 1.77-3.43]), macrosomia (15.93% vs 2.66%, cRR 6.93 [95% CI,

4.85-9.90]), and admission to NICU (42.17% vs 30.56%, cRR 1.66 [95% CI, 1.28-2.15]).

We divided the studied population of women with T1D into three groups according to the time of their pregnancy outcomes: 2004 to 2007, 2008 to 2011, and 2012 to 2014. The pregnancy outcomes of the three periods are summarized in Table 3. We found that the pregnancy outcomes of women with T1D during these periods were largely similar. We established logistic regression models to determine the association of different time periods with the adverse outcomes, adjusted for potential confounding factors. The results indicate that despite approaches to improve pregnancy health exerted over these periods, time period had no statistically significant association with the incidences of adverse pregnancy outcomes in our studied women with T1D (Table 3, all $P > .05$).

TABLE 2 Maternal, neonatal, and fetal adverse pregnancy outcomes of women with type 1 diabetes compared to those of women without type 1 diabetes in the participating centers during 2004 and 2014

Pregnancy outcomes	Women with T1D	Women without T1D	χ^2 value	P value	Crude risk ratio	95% CI
Overall number (%)	265 (100)	318 486 (100)	NA	NA	NA	NA
Maternal death, n (%)	1 (0.38)	83 (0.03)	2.61 ^a	.067	14.53	2.11-104.76
All pregnancy loss, n (%)	35 (13.21)	9259 (2.92)	98.80	<.001	5.08	3.56-7.26
In the second trimester, n (%)	20 (7.55)	NA	NA	NA	NA	NA
In the third trimester, n (%)	6 (2.26)	NA	NA	NA	NA	NA
Preeclampsia, n (%)	47 (17.74)	13 330 (4.20)	120.41	<.001	4.94	3.60-6.77
Caesarean delivery, n (%)	186 (70.19)	162 891 (51.15)	38.43	<.001	2.25	1.73-2.93
Progression of diabetic complication(s), n (%)	30 (11.32)	NA	NA	NA	NA	NA
Infants of women with T1D		Infants of women without T1D	χ^2 value	P value	Crude risk ratio	95% CI
Gestational age at birth (wk)	28-36	All	NA	NA	NA	NA
Overall number (%)	43 (100)	230 (100)	NA	NA	NA	NA
Neonatal death, n (%)	2 (4.65)	5 (2.67)	390.59 ^a	<.001	37.36	21.21-65.82
Preterm birth, n (%)	NA	NA	30.38	<.001	2.46	1.77-3.43
Congenital malformation(s), n (%) ^b	5 (11.63)	14 (7.49)	15.04	.001	2.46	1.54-3.93
SGA, n (%) ^c	0 (0.00)	12 (6.42)	6.54	.012	0.48	0.27-0.85
LGA, n (%) ^c	9 (23.08)	59 (31.55)	NA	NA	NA	NA
Macrosomia, n (%) ^c	3 (7.69)	33 (17.65)	152.90	<.001	6.93	4.85-9.90
Admission to NICU, n (%)	33 (76.74)	64 (34.22)	14.61	<.001	1.66	1.28-2.15

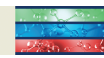
Note: All the denominators of the percentages were the respective overall numbers presented in the first row unless otherwise noted.

Abbreviations: LGA, large-for-gestational age; NA, not applicable; NICU, neonatal intensive care unit; SGA, small-for-gestational age; T1D, type 1 diabetes.

^aThe χ^2 value was subjected to continuity correction.

^bData were not available in Nanjing Drum Tower Hospital. The number of live births of women without T1D was 282 509 excluding Nanjing Drum Tower Hospital.

^cThe birth weight data of four neonates of women with T1D were missing.

**TABLE 3** Trends in maternal and neonatal outcomes of pregnant women with type 1 diabetes in the retrospective study, 2004 to 2014

	All	Period 1 2004-2007	Period 2 2008-2011	Period 3 2012-2014	P value ^a
No. of pregnant women with T1D	265	30	82	153	NA
Maternal outcomes					
Maternal death, n (%)	1 (0.38)	0 (0)	0 (0)	1 (0.65)	NA
Caesarean delivery, n (%)	186 (70.19)	22 (88.00)	60 (81.08)	104 (78.79)	.338
Preeclampsia, n (%)	48 (18.11)	6 (20)	19 (23.17)	23 (15.03)	.295
Pregnancy loss, n (%)	34 (12.83)	5 (16.67)	8 (9.76)	21 (13.73)	.502
Number of live births	230	25	74	132	N/A
Neonatal outcomes					
Neonatal death, n (%)	7 (3.03)	0 (0)	1 (1.35)	6 (4.55)	NA
Congenital malformation, n (%)	20 (8.65)	4 (16)	5 (6.76)	11 (8.33)	.739
Preterm birth, n (%)	43 (18.61)	5 (20)	15 (20.27)	23 (17.42)	.719
Gestational age at delivery, wk (SD)	37.45 (1.76)	37.12 (1.64)	37.36 (1.96)	37.48 (1.75)	.352 ^b
SGA, n (%)	13 (5.62)	0 (0)	5 (6.94)	8 (6.15)	.300
LGA, n (%)	70 (30.3)	8 (32.0)	20 (27.78)	42 (32.31)	.953
Macrosomia, n (%)	36 (15.59)	3 (12)	13 (18.06)	20 (15.38)	.747
Neonatal hypoglycemia, n (%)	38 (16.45)	4 (16.0)	13 (17.57)	21 (15.91)	.995
Neonatal jaundice, n (%)	54 (23.37)	3 (12.0)	22 (29.73)	29 (21.97)	.639
Respiratory distress, n (%)	17 (7.35)	2 (8.0)	8 (10.81)	7 (5.3)	.415
Neonatal admission to NICU, n (%)	96 (41.56)	10 (40.0)	31 (41.89)	55 (41.67)	.411

Note: The denominators of the percentages of maternal outcomes were the respective number of pregnant women with T1D in the first row, and the denominators of the percentages of neonatal outcomes were the respective number of live births.

Abbreviations: LGA, large-for-gestational age; NA, not applicable; NICU, neonatal intensive care unit; SGA, small-for-gestational age; T1D, type 1 diabetes.

^aLogistic regression models were established to determine the association of different periods with the adverse outcomes, using time period as a covariate, adjusted for age at conception, duration of diabetes at conception, preconceptional diabetic complication(s), and education level (middle school or higher).

^bThe test was done by linear regression models, and *P* for trend was calculated.

4 | DISCUSSION

This study is the first to report the status of pregnancy in women with T1D in China during 2004 to 2014. We summarized the pregnancy outcomes of 265 women with T1D from 11 centers in 8 cities in China during 2004 to 2014. Previously, these data were absent. While we had suspected worse pregnancy outcomes in women with T1D than the background population, we were astonished by the prevailing high rates of adverse outcomes, particularly considering the vigorous improvements in the general population in the same time frame. These results also indicate significant challenges in access to adequate care during the peri-pregnancy period for the studied women.

4.1 | Pregnancy outcomes in Chinese women with T1D were poor

Previous studies have established that T1D increases the risk and burden of pregnancy; various means have been suggested to reduce the adversities.¹ To improve pregnancy

outcomes among women with T1D in China, we must first estimate the current status before identifying the unmet needs. However, epidemiological data of pregnancies with T1D in China were absent. In this study, it is sad to find that the pregnancy outcomes of women with T1D were shockingly poor. Women with T1D in our study were facing a higher rate of preeclampsia (17.74%) and a doubled rate of neonatal deaths (5.65%) compared with those reported in the United Kingdom (preeclampsia 11%, perinatal mortality 23 per 1000 live births; 2005 to 2009)³ and Denmark (preeclampsia 12.5%, perinatal mortality 17 per 1000 live births; 1996 to 2000)¹⁵ in an approximately similar time frame. Also, significantly higher rates of caesarean delivery and congenital malformation(s) in their infants were observed.

This may be mainly attributed to the poor pre-pregnancy and peri-pregnancy diabetic care for the studied women with T1D. It is accepted that controlling peri-pregnancy glycemia and blood pressure effectively reduces the risk of neonatal death, malformation, and preeclampsia in pregnancies complicated with T1D.¹ In our study, only a small proportion (22.64%) of the studied

women tested HbA1c preconceptionally or at the early stage of pregnancy, compared with over 60% reported in the United Kingdom in 2002 to 2003.¹⁶ Also, among these women who had tested HbA1c during pregnancy, nearly 40% failed to reach the preconceptional glycemic control target and more than half failed to achieve the late pregnancy target. The suboptimal glycemic control could be partly attributed to their inadequate insulin usage: Nearly 40% of the study population did not use the insulin regimens recommended in the guidelines.^{7,14,17} Taken together, the low HbA1c testing rate and HbA1c on-target rate at delivery in our studied women indicated inadequate diabetes management during pregnancy in China. This may also explain the elevated rates of neonatal death, malformation, and preeclampsia as well as the progression of diabetic complications in our studied patients.

Moreover, the ascertained number of pregnant women with T1D is relatively low in our study. This is partly due to the low T1D incidence in China of 1.01 per 100 000 person-years.⁹ Also, many concerns of women with China have hindered them from getting pregnant and receiving diabetes-specific pregnancy care. A questionnaire-based survey in Chinese women with T1D showed that only 12.6% were aware of appropriate preconception care in pregnancy complicated with diabetes, and up to 86% of the surveyed women expressed a dilemma caused by T1D in the decision of marriage and pregnancy.¹⁸ This also explains the inadequate diabetes management in the studied population as a survey also shows that pregnancy-related health care providers expressed that they lacked the chance to see patients with T1D and the management skills for pregnancy in diabetes.¹⁹

4.2 | Poor pregnancy outcomes in women with T1D were persistent

An obligatory universal maternal care system for the general population has been established since 1995 in China and has reached nationwide coverage by 2004.²⁰ As a result, maternal mortality had reduced by 53.4%, and neonatal mortality reduced by 72.3% during 2000 to 2015,^{21,22} approximately the same time frame as that of our study. Moreover, evidence from other populations has shown that the addition of multifaceted peripregnancy care specified for women with T1D could reduce the risk of adverse maternal and neonatal outcomes.¹⁷ Therefore, in 2007, the first version of the Chinese guidelines for the care of pregnancies with diabetes was published, with multifaceted clinical guidance from prepregnancy to peripregnancy.¹⁴ With these efforts, improvement in pregnancy outcomes among women with T1D should have been expected. However, our study

results demonstrated that the high rates of adverse pregnancy outcomes in women with T1D remained relatively unchanged (Table 3), despite the achievements gained in the general population and the publication of guidelines. In fact, in our later study, in the medical centers with matched geographical, economical, and expertise characteristics with our participating centers, we found that the pregnancy outcomes among women with T1D during 2015 to 2017 were also suboptimal,²³ similar to the studied women in this study during 2004 to 2014.

In other words, neither the implementation of the universal care system nor the release of evidence-based guidelines was enough to have a significant impact on the adverse pregnancy outcomes of women with T1D in China. As the Ending Preventable Stillbirth initiatives suggested, implementation of integrated interventions is key to improve such preventable adverse pregnancy outcomes.²⁴ Our findings revealed that a great gap existed between the needs and health care provision for pregnancy complicated with T1D in China. Similarly, the implementation and uptake of multifaceted care is still a challenge even in high-income countries.^{25,26} All of the above suggested that further investigation is needed to elucidate the underlying cause of ill implementation of evidence-based pregnancy care. Based on our findings, qualitative aiming to identify the barriers of implementation of appropriate pregnancy care for women with T1D in China was performed.¹⁹ Combining the findings, we developed, updated, and pilot-tested a comprehensive management plan for Chinese women with T1D in the same 11 participating centers since the beginning of 2015. This management plan turned out to be associated with a significant reduction of various pregnancy outcomes in the participating centers.²³ These findings, in summary, emphasize the importance of finding the hidden adverse outcomes of pregnancies with T1D, identification of unmet needs, and reforming implementation of integrated care based on unmet needs.

4.3 | Strengths and limitations

The major strength of our study is the nationwide collaboration of data on pregnancies of women with T1D. With one of the lowest incidence rates of T1D globally, we managed to collect enough data to describe the status of pregnancy complicated with T1D in China. However, limitations have to be acknowledged. We could not acquire data on pregnancy outcomes from the general population in the studied area due to a lack of data publication from the local ministry. Nevertheless, we used the data of women without T1D in the same centers during the same period as the background.



Collectively, we found that the pregnancy outcomes were poor in women with T1D during 2004 to 2014 in China. The pregnancy outcomes remained suboptimal for this population, despite dramatic improvement in the outcomes of the maternal care system for the general population, scientific progress, and the release of local guidelines. These findings implicate a significant burden on women with T1D and their families. There is an urgent need to identify and implement evidence-based interventions to improve health for women with T1D during pregnancy in China.

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DISCLOSURE

All authors have completed the International Committee of Medical Journal Editors (ICMJE) uniform disclosure form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author). No financial relationships with any organizations that might have an interest in the submitted work in the past 3 years and no other relationships or activities have influenced the submitted work.

ORCID

Sihui Luo <https://orcid.org/0000-0001-8503-0310>
 Xingwu Ran <https://orcid.org/0000-0002-6634-1241>
 Dalong Zhu <https://orcid.org/0000-0001-5775-5103>
 Jiajun Zhao <https://orcid.org/0000-0003-3267-9292>
 Chen Fang <https://orcid.org/0000-0003-4329-9471>
 Wei Bao <https://orcid.org/0000-0002-7301-5786>
 Zhiguang Zhou <https://orcid.org/0000-0002-0374-1838>

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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