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Influence of Maternal Age and Birth Weight on Type 1 Diabetes Risk: Insights from a Retrospective Study

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Abstract

Background: Diabetes mellitus is a significant health concern, particularly in children, thus, maintaining normal glucose levels during pregnancy is crucial for the health of both mother and fetus. Understanding the factors that contribute to the risk of diabetes diagnosis is crucial for early intervention and prevention.
Objective: This study investigates the association between maternal factors, such as birth weight, birth order, maternal age, and the risk of type 1 diabetes in children in Bauchi State, Nigeria.
Methods: A cross-sectional retrospective cohort design was employed, using data from two major hospitals in Bauchi State. The study included 147 birth records from two major hospitals over one year (June 2022 to June 2023). Inclusion criteria encompassed gestational age less than 37 weeks and birth weights ranging between 1,500 and 4,499 grams. The exclusion criteria included instances of multiple pregnancies and major congenital anomalies. Data were analyzed using SPSS version 23, with linear regression to assess associations between maternal factors and childhood type 1 diabetes diagnosis.
Results: The regression analysis revealed that the model explained approximately 48.7% of the variance in diabetes diagnosis (R-square = 0.487). Maternal age (B = 0.012, p = 0.003) and child birth weight (B = 0.145, p < 0.001) were identified as significant positive factors, indicating that as maternal age and birth weight increase, the likelihood of diabetes diagnosis also increases. Conversely, paternal age showed a significant negative association (B = -0.021, p < 0.001). No significant associations were found between birth order and gender.
Conclusion: This study highlights the importance of maternal age and child birth weight as critical factors in predicting the risk of diabetes in children. The findings underscore the need for targeted interventions to mitigate these risk factors and improve maternal and child health outcomes in Bauchi State. Further research is warranted to explore the underlying mechanisms and develop comprehensive strategies for diabetes prevention in children.

Keywords: *Type 1 diabetes, Maternal age, Birth weight, Birth order, Retrospective Cohort, Nigeria.*

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Introduction

Diabetes mellitus, whether type 1 or 2 is known to contribute to morbidity and mortality in various conditions, including maternal health (Choudhury & Rajeswari, 2021). Maintaining normal glucose levels during pregnancy is essential for the health of the mother and fetus (McCance & Cassidy, 2024). The incidence of diabetes first diagnosed during pregnancy is rising globally, affecting about 1 in 6 pregnancies (Wang *et al*., 2022). The mortality rate in pregnant women with type 1 diabetes is around 0.5%, which is 5 to 20 times higher than those without diabetes (Gualdani *et al*., 2021). The causes of mortality in these women are primarily associated with complications of the pregnancy itself (such as preeclampsia, eclampsia, and pulmonary edema) and of diabetes (such as hypoglycemia, ketoacidosis, and diabetic nephropathy) (Knorr *et al*., 2018; Lin *et al*., 2017). Other causes include brain stem

infarction and complications from anesthesia (Leinonen *et al*., 2001). Factors increasing maternal mortality risk include longer diabetes duration (>20 years), poor glycemic control, diabetic nephropathy, and unplanned pregnancy with inadequate preconception care (Knorr *et al*., 2018; Stone *et al*., 2020). In line with the Sustainable Development Goals (SDGs), the precise cause of the mortality and other associated risks need to be investigated and addressed.

Diabetes mellitus is characterized by hyperglycemia and glucose intolerance due either to insulin deficiency, impaired insulin action, or a combination of the two (Venyo, 2023). Previous studies have shown strong associations between maternal age, birth order, gestational age, and type I diabetes. Maternal age at delivery has recently increased in both developed and developing countries, including Nigeria (Zhang *et al*., 2022). Research has shown that older maternal age is linked to pregnancy complications, including preterm delivery and low birth weight (Rydahl *et al*., 2019), and childhood diseases such as asthma (Bekkar *et al*., 2020), leukemia (Magnusson *et al*., 2021), and type 1 diabetes (White *et al*., 2023). Childhood-onset type 1 diabetes results from the autoimmune destruction of pancreatic beta cells, leading to insulin deficiency in genetically susceptible individuals triggered by environmental factors (Esposito *et al*., 2019).

The risk of childhood type 1 diabetes has been linked to high maternal age, with several studies suggesting a significant association. For instance, a systematic review and meta-analysis found that children born to older mothers have a 5% increased risk of childhood type 1 diabetes for each 5-year increase in maternal age (Cardwell *et al*., 2010). Another study reported similar findings (Ayati *et al*., 2020). In contrast, the association between paternal age and childhood type 1 diabetes is less clear, with some studies reporting a weak association and others finding no significant correlation. For example, maternal age of higher than 25 was a significant risk factor, but paternal age was not (Ayati *et al*., 2020).

Though the underlying environmental factors are still not clear, several factors have been proposed including viral infections (Qiu *et al*., 2024), dietary factors such as cow's milk protein and gluten (Cardwell *et al*., 2010), environmental toxins (Cardwell *et al*., 2010), increased infant weight gain (Katsarou *et al*., 2017), and antenatal factors such as maternal age and birth order (Hidayat *et al*., 2019). Increasing birth order has been reported to decrease the risk of type 1 diabetes in childhood (Tanoey *et al*., 2022), whereas the risk is lowest in the first-born children of parents with type 1 diabetes (Bingley *et al*., 2000). Many studies have found consistent relationships between type 1 diabetes and maternal age (Hidayat *et al*., 2019) and gestational age (Metsälä *et al*., 2024), but less for birth orders (Tanoey, 2022), paternal age (Crump *et al*., 2020) and birth weight (Ludvigsson *et al*., 2019). Most of these studies were conducted in developed nations, thus there is a need to conduct related studies within specific populations such as Bauchi State to explore these factors and address local health issues effectively. Therefore, this retrospective cross-sectional cohort study aims to investigate the association between maternal factors such as birth weight, birth orders, maternal age, and risks of type 1 diabetes within the Bauchi state population.

Methodology

Study Design

The study employed a cross-sectional retrospective cohort design to examine the potential association between the incidence of type 1 diabetes and some perinatal factors including maternal age, birth order, and paternal age, as well as birth weight. The research utilized retrospective data collected from two prominent hospitals in the Bauchi South senatorial zone of Bauchi State: Abubakar Tafawa Balewa University Teaching Hospital (ATBUTH) Bauchi and Specialist Hospital Bauchi. These hospitals were selected due to their status as major government healthcare facilities in the state, with the highest volume of deliveries recorded among government hospitals in the region.

Data Collection Duration

Data collection was done between June 2022 to June 2023 from the health management departments of the two hospitals. The study population was determined through retrospective data analysis, focusing on individuals meeting specific eligibility criteria.

Study Population and Selection Criteria

Inclusion criteria encompassed gestational age less than 37 weeks and birth weights ranging between 1,500 and 4,499 g. The exclusion criteria included instances of multiple pregnancies, major congenital anomalies, and loss of follow-up within the second year of life. A sampling frame was constructed from comprehensive birth records obtained with written permission from hospital management registries, with the individual data record serving as the sampling unit. Sample size calculation was conducted using Gpower software, yielding a total sample size of 150 birth records across all hospitals. Stratified sampling proportional to the number of birth records in each hospital was subsequently employed.

Instrument for Data Collection

A pro forma was utilized as the data collection instrument to capture maternal demographic data and details of childhood type 1 diabetes cases. Data were collected manually, and supplemented by additional validation procedures to ensure data accuracy. Quality control measures, including content validity assessment by a supervisory committee comprising child health experts, were implemented to enhance the reliability of the collected data.

Statistical Analysis

Data entry and statistical analysis were conducted using the SPSS version 23 package. Before analysis, the dataset undergoes exploration to identify and remove outliers and assess normal distribution. Linear regression was employed to estimate standardized and unstandardized coefficients along with 95% confidence intervals (CI). This analysis allowed for the examination of the association or relationship between variables and trends across categories.

Ethical Approval

The study was approved by the Bauchi State Ministry of Health (ethical approval number: NREC/040/11/19B/2021/097) and the Abubakar Tafawa Balewa University Teaching Hospital (ATBUTH) Bauchi (ethical approval number: 0064/2023). All procedures performed in this study were following the ethical standards of these institutions.

Results

A total of about 147 folders were accessed for the study period, the results show slightly more females (53.7%) were born than males (46.3%) during the study period, and diabetes diagnosis data indicate 11 of the children were diagnosed with type 1 diabetes.

The sociodemographic characteristics of mothers as shown in Table 1 revealed a predominantly homogeneous sample. Among the participants, a vast majority identified with Islam, accounting for 95.92% (141 mothers), while a small fraction (4.08%, 6 mothers) identified with Christianity. The marital status distribution shows that nearly all the mothers were married, representing 97.96% (144 mothers), with minimal representation from divorced (0.68%, 1 mother) and widowed (1.36%, 2 mothers) individuals. In terms of ethnicity, the Hausa ethnic group was the most prevalent, comprising 81.63% (120 mothers) of the sample. This was followed by the Fulani ethnic group, which accounted for 9.52% (14 mothers). Other ethnicities, including Yoruba and Igbo, each represented 0.68% (1 mother each), while 7.48% (11 mothers) identified with other ethnic groups. The educational status of the mothers indicates a significant portion had informal education, representing 74.83% (110 mothers). Mothers with primary education were a minority at 2.04% (3 mothers), while those with secondary education constituted 16.33% (24 mothers). Finally, 6.80% (10 mothers) had attained tertiary education.

Table 1: Sociodemographic characteristics of mothers of children born between June 2022 to 2023

Variables	Frequency (%)
Religion	
Islam	141 (95.92)
Christianity	6 (4.08)
Marital Status	
Married	144 (97.96)
Divorced	1 (0.68)
Widow	2 (1.36)
Ethnicity	
Hausa	10 (81.63)
Fulani	14 (9.52)
Yoruba	1 (0.68)
Igbo	1 (0.68)
Others	11 (7.48)
Educational Status	
Informal	110 (74.83)
Primary	3 (2.04)
Secondary	24 (16.33)
Tertiary	10 (6.80)

Table 2 shows the distribution of maternal ages, paternal history of diabetes and child birth weight. The distribution of maternal age at delivery shows a wide range of ages among the mothers. The largest proportion of mothers fell within the 20 to 25-year age group, representing 25.17% (37 cases). This was followed by the 26 to 30-year age group at 22.45% (33 cases) and the 31 to 35-year age group at 12.93% (19 cases). Mothers aged 36 and above comprised 6.12% (9 cases), while those under 20 years old accounted for 3.40% (5 cases). In terms of paternal history of diabetes, only 6.80% (10 cases) indicated a positive history, while 27.21% (40 cases) reported no paternal history of diabetes. Childbirth weight is a critical factor, with children in the 3.1 to 4 kg range representing the highest percentage at 36.73% (54 cases). Those weighing between 2 to 3 kg accounted for 15.65% (23 cases). Low birth weight (<2 kg) and high birth weight (≥4.1 kg) each represented 1.36% (2 cases). A significant portion, 44.90% (66 cases), did not state the birth weight. The distribution of birth order among the children indicates that firstborns constitute 25.17% (37 cases), second-born children account for 18.37% (27 cases), and third-borns represent 8.84% (13 cases). Children of fourth birth order or higher make up 33.33% (49 cases), and 14.29% (21 cases) were not stated.

Table 2: Maternal and Child Health Characteristics

Variables	Frequency (%)
Maternal age at delivery	
< 20	5 (3.40)
20 to 25	37 (25.17)
26 to 30	33 (22.45)
31 to 35	19 (12.93)
≥ 36	9 9 (6.12)
Others	44 (29.93)
Paternal history	
Yes	10 (6.80)
No	40 (27.21)
Not stated	97 (65.99)
Child birth weight (kg)	
< 2	2 (1.36)
2 to 3	23 (15.65)
3.1 to 4	54 (36.73)
≥ 4.1	2 (1.36)
Not stated	66 (44.90)
Birth order	
First	37 (25.17)
Second	29 (18.37)
Third	13 (8.84)
≥Fourth	49 (33.33)
Not stated	21 (14.29)

Regression analysis was conducted to examine the relationship between various independent variables —parity/birth order, paternal age, child birth weight, maternal age, maternal and paternal history of diabetes, maternal educational status, and child gender —with the dependent variable; diabetes diagnosis. The analysis aimed to assess how these factors collectively contribute to the prediction of diabetes diagnosis among the children in the study population. The results of the regression analysis are shown in Tables 3 and 4.

Table 3: Regression Summary

Metric	Value
R	0.698
R Square	0.487
Adjusted R Square	0.469

As shown in table 3 the model's R-value is 0.698, indicating a strong correlation between the independent variables and the dependent variable (diabetes diagnosis). The R-square value of 0.487 suggests that approximately 48.7% of the variance in diabetes diagnosis can be explained by the combined effect of the independent variables included in the model. The Adjusted R-square, slightly lower at 0.469, accounts for the number of predictors in the model and provides a more accurate measure of model fit.

The ANOVA table shows that the regression model is statistically significant ($F(5, 141) = 26.80$, $p < 0.001$). This indicates that the overall regression model significantly predicts the incidence of diabetes diagnosis among the study population. The significance of the model implies that at least one of the independent variables has a meaningful relationship with the dependent variable (diabetes diagnosis).

Table 4: ANOVA Table

Source	Sum of Squares	Mean Square	df	F	Sig
Regression	28.189	5.638	5	26.800	0.001
Residual	29.661	0.210	141		
Total	57.850		146		

Table 5: Coefficients and Variance Inflation Factors for Predictors of Diabetes Diagnosis

Variables	Coefficients (β)	Standard error	t	sig	Variance inflation factor (VIF)
Intercept	2.14	0.135	15.689	0.001	
Gender	0.040	0.076	0.526	0.600	1.010
Birth order	0.000	0.017	-0.011	0.992	1.138
Maternal age	0.012	0.004	3.048	0.003	2.019
Paternal age	-0.021	0.004	-5.490	0.001	1.330
Child birth weight	0.145	0.030	4.874	0.001	1.772

Dependent variable: Diabetes diagnosis
Independent variables (predictors): Maternal age, paternal age, birth order, child birth weight, gender

Table 5 showed the Coefficients and Variance Inflation Factors (VIF). The Table provides detailed information about the individual predictors in the model. The intercept of 2.14 is the expected log odds of a diabetes diagnosis when all predictors are held at zero. The coefficients for gender and birth order are 0.040 ($p = 0.600$) and 0 ($p = 0.992$), respectively. These indicate no significant association in diabetes diagnosis between genders and birth order respectively. The coefficient for maternal age is 0.012, which is statistically significant ($p = 0.003$), suggesting that with each additional year of maternal age, the likelihood of a diabetes diagnosis increases. For paternal age, the coefficient is -0.021, which is statistically significant ($p = 0.001$), which indicates a negative association, meaning that with each additional year of paternal age, the likelihood of a diabetes diagnosis decreases by 0.021. Child birth weight has a coefficient of 0.145, ($p < 0.001$), which implies that higher birth weight is associated with an increased likelihood of diabetes diagnosis. To rule out a chance of collinearity between the predictors variables, we include in the results the variance inflation factor (VIF) values which measure the influence of collinearity on the variance of the coefficient estimates. The VIF values for all predictors range between 1.010 and 2.019, indicating no severe multicollinearity among the predictors. VIF values below 10 generally indicate that multicollinearity is not a concern, and the predictors do not excessively inflate the variance of the coefficient estimates.

Discussion

The results in Table 1 provide a snapshot of the sociodemographic characteristics of the mothers of children born between June 2022 and June 2023, focusing on their religion, marital status, ethnicity, and educational status. From the results obtained, 95.92% of the mothers identify as Muslim, and 81.63% and 9.52% as belonging to the Hausa and Fulani ethnicity respectively. This is unsurprising as it is well known that Bauchi is a state dominated by the Hausa-Fulani Muslims (Sarmiento *et al*., 2021). The vast majority of the mothers (97.96%) were married. This may indicate strong marital stability, which could potentially have positive implications for child-rearing practices and support systems available for mothers (Groele *et al*., 2019). The high proportion of mothers with informal education (74.83%) among the study population highlights potential challenges in health literacy. A study conducted in Bauchi State found that mothers with higher levels of education were more likely to have their children vaccinated and to practice good hygiene, as well as seek medical care for the children when sick (Omer *et al*., 2021). Lower educational levels could impact mothers' ability to access, understand, and utilize healthcare information and services effectively, underscoring the need for targeted educational and health promotion programs (Léniz-Maturana *et al*., 2023).

Table 2 presents the maternal and child health characteristics. The data suggest that the majority of mothers are relatively young, with a significant portion in the 20-30-year age range,

which could be indicative of early childbearing practices within the population. This is consistent with the typical age range for childbearing in many societies (Ahmad *et al*., 2021). In Bauchi State, the median age at first sexual intercourse among women is 15.4 years, and 41% of teenagers have already begun childbearing (Sarmiento *et al*., 2021). Only 6.80% of fathers had a history of diabetes, however, the high percentage of unstated paternal history (65.99%) highlights a potential gap in the data collection process. This lack of information limits the ability to assess the full impact of paternal history on the health outcomes of children. The majority of children (36.73%) were born with a birth weight between 3.1 to 4 kg, which is within the normal range for newborns. This suggests that the majority of children were born with a healthy birth weight, which is a positive indicator of their overall health.

The children's parity or birth order provides insights into the family reproductive behavior and dynamics with a higher proportion of first-, and second-born, which reflects the differences in the size and composition of the family. In addition, it also explained the behavior of the Bauchi population towards seeking medical attention, for example, the delivery of firstborn constituted a high percentage (25.2%), indicating that the population believed first delivery is usually difficult and needs the attention of a qualified physician, however as the birth order increases through second, third and subsequent deliveries there is hesitancy in seeking antenatal care as well as delivery in the hospital (Swamy *et al*., 2012). This pattern of healthcare-seeking behavior has implications for maternal and child health outcomes. Encouraging hospital deliveries for all births, regardless of birth order, could help improve health indicators and reduce maternal and neonatal mortality in the region. Contrary to this finding, a previous study women population in Bauchi reported that they have more children, they are more likely to seek ANC services, possibly due to increased awareness and familiarity with the importance of ANC for their health and that of the children (Omer *et al*., 2014).

The regression analysis conducted in this study provides valuable insights into the factors that contribute to the risk of diabetes diagnosis in children. The model, which includes predictors such as maternal age, paternal age, birth order, child birth weight, gender, and parental history of diabetes, explains approximately 48.7% of the variance in diabetes diagnosis (R-square = 0.487). This high proportion suggests that nearly half of the variability in diabetes diagnosis can be attributed to the predictors used in the model, indicating a robust fit. The overall significance of the model is affirmed by the ANOVA results, showing an F-value of 26.800 with a p-value of less than 0.001. This statistical significance implies that the model reliably predicts diabetes diagnosis, and the set of predictors collectively contribute meaningfully to the model. Consequently, it can be inferred that at least one of the predictors has a substantial impact on the likelihood of diabetes diagnosis in children.

Among the individual predictors, maternal age and child birth weight emerged as significant positive factors. The coefficient for maternal age (B = 0.012, p = 0.003) indicates that as the age of the mother increases, the likelihood of her child being diagnosed with diabetes also increases. Similarly, the coefficient for child birth weight (B = 0.145, p < 0.001) suggests that higher birth weight is associated with a higher risk of diabetes diagnosis. These findings underline the importance of maternal health and birth weight as critical factors in the early prediction and potential prevention of diabetes in children. Conversely, paternal age shows a significant negative association with diabetes diagnosis (B = -0.021, p < 0.001), meaning that children with older fathers are less likely to be diagnosed with diabetes. This finding is intriguing and warrants further investigation to understand the underlying biological or environmental mechanisms that might contribute to this relationship.

The findings from this study align with previous research highlighting the influence of parental age and birth weight on diabetes risk (Harder *et al*., 2007; Lawlor *et al*., 2011). The result is further supported by the findings of (Huang *et al*., 2021) who reported an association between higher birth weight and incidence of type 1 diabetes, and also low birth weight as a protecting factor against type 1 diabetes. Similar associations between parental age and offspring glucose tolerance were reported in other studies, highlighting the intergenerational transmission of metabolic risk factors (Bhargava *et al*., 2004; Krischer *et al*., 2017; Rao, 2015). Additionally, research by Gesta *et al*. (2007) supports the role of developmental factors, including birth weight, in the pathogenesis of diabetes thus further supporting the findings of this study (Gesta *et al*., 2007). Previous studies have shown that maternal age at delivery is associated with the risk of diabetes in children, with older mothers having a higher risk. High intrauterine and rapid post-natal growth have been linked to a hyperinsulinemia state, suspected to trigger an autoimmune process of pancreatic B cell destruction leading to diabetes (Bingley *et al*., 2000; Cardwell *et al*., 2010; Choudhury & Devi Rajeswari, 2021; Robertson & Harrild, 2010). Some studies have reported conflicting results regarding the association between birth weight and the risk of type 1 diabetes, which may be influenced by geographical locations, ethnic and lifestyle variations, and the study sample size (Fagerudd *et al*., 2006; Zhao *et al*., 2018).

No significant associations were found between birth order and gender with diabetes diagnosis in this study. The coefficient for birth order was near zero and statistically insignificant (B = 0.000, p = 0.992), indicating no effect of the order of birth on diabetes risk. Similarly, the gender coefficient (B = 0.040, p = 0.600) reveals no significant difference in diabetes risk between boys and girls, despite a slightly higher incidence in boys. Nonetheless, this does not necessarily discount the relevance of these variables in the context of diabetes risk; rather, they underscore the complexity of diabetes etiology and the need for further investigation into the multifactorial nature of the disease.

Conclusion

This study conducted in Bauchi State provides valuable insights into the factors influencing diabetes diagnosis in children. From the regression analysis, maternal age and child birth weight were identified as significant predictors of type 1

diabetes in children. Specifically, higher maternal age and greater birth weight were associated with an increased risk of diabetes, while higher paternal age was linked to a reduced risk. These findings underscore the importance of monitoring maternal health and birth conditions to mitigate diabetes risk in children. The study did not find significant associations between birth order or gender and diabetes risk, indicating the multifactorial nature of the disease. Our results align with previous research and emphasize the need for tailored health interventions focusing on maternal and infant health to prevent type 1 diabetes. Further research could explore the interplay of genetic and environmental factors in diabetes risk among children in Bauchi State. Additionally, longitudinal studies tracking children's health outcomes over time would provide a deeper understanding of the progression of diabetes and the impact of early interventions.

Authors Contribution

Study concept and design: M. A. U. and M. M. J.; Data collection: K. A. K. and A. I.; Analysis and interpretation of data: A. I. and M. A. U.; Drafting the manuscript: M. M. J., M. A. U., and A. T.; Reviewing the manuscript: A. T., and M. A. M.; Statistical analysis: A. I. and M. A. M. All authors approved the final version of the manuscript.

Conflict of Interests

The authors declare no conflict of interest.

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References

Ahmad, K., Kabir, E., Keramat, S. A., & Khanam, R. (2021). Maternal health and health-related behaviours and their associations with child health: Evidence from an Australian birth cohort. *PLoS ONE*, *16*(9), e0257188. https://doi.org/10.1371/journal.pone.0257188

Ayati, M., Mosayebi, Z., & Movahedian, A. H. (2020). Association Between Perinatal Risk Factors and Development of Type 1 Diabetes in Children. *Journal of Comprehensive Pediatrics*, *11*(2), Article 2. https://doi.org/10.5812/compreped.82902

Bekkar, B., Pacheco, S., Basu, R., & DeNicola, N. (2020). Association of Air Pollution and Heat Exposure With Preterm Birth, Low Birth Weight, and Stillbirth in the US: A Systematic Review. *JAMA Network Open*, *3*(6), Article 6. https://doi.org/10.1001/jamanetworkopen.2020.8243

Bhargava, S. K., Sachdev, H. S., Fall, C. H. D., Osmond, C., Lakshmy, R., Barker, D. J. P., Biswas, S. K. D., Ramji, S., Prabhakaran, D., & Reddy, K. S. (2004). Relation of Serial Changes in Childhood Body-Mass Index to Impaired Glucose Tolerance in Young Adulthood. *New England Journal of Medicine*, *350*(9), Article 9. https://doi.org/10.1056/NEJMoa035698

Bingley, P. J., Douek, I. F., Rogers, C. A., & Gale, E. A. M. (2000). Influence of maternal age at delivery and birth order on risk of type 1 diabetes in childhood: Prospective population based family study. *BMJ : British Medical Journal*, *321*(7258), 420–424.

Cardwell, C. R., Stene, L. C., Joner, G., Bulsara, M. K., Cinek, O., Rosenbauer, J., Ludvigsson, J., Jané, M., Svensson, J., Goldacre, M. J., Waldhoer, T., Jarosz-Chobot, P., Gimeno, S. G. A., Chuang, L.-M., Parslow, R. C., Wadsworth, E. J. K., Chetwynd, A., Pozzilli, P., Brigis, G., … Patterson, C. C. (2010). Maternal Age at Birth and Childhood Type 1 Diabetes: A Pooled Analysis of 30 Observational Studies. *Diabetes*, *59*(2), Article 2. https://doi.org/10.2337/db09-1166

Choudhury, A. A., & Devi Rajeswari, V. (2021). Gestational diabetes mellitus—A metabolic and reproductive disorder. *Biomedicine & Pharmacotherapy*, *143*, 112183. https://doi.org/10.1016/j.biopha.2021.112183

Crump, C., Sundquist, J., & Sundquist, K. (2020). Preterm birth and risk of type 1 and type 2 diabetes: A national cohort study. *Diabetologia*, *63*(3), Article 3. https://doi.org/10.1007/s00125-019-05044-z

Esposito, S., Toni, G., Tascini, G., Santi, E., Berioli, M. G., & Principi, N. (2019). Environmental Factors Associated With Type 1 Diabetes. *Frontiers in Endocrinology*, *10*, 592. https://doi.org/10.3389/fendo.2019.00592

Fagerudd, J., Forsblom, C., Pettersson-Fernholm, K., Saraheimo, M., Wadén, J., Rönnback, M., Rosengård-Bärlund, M., Björkesten, C.-G. A., Thorn, L., Wessman, M., & Groop, P.-H. (2006). Low birth weight does not increase the risk of nephropathy in Finnish type 1 diabetic patients. *Nephrology Dialysis Transplantation*, *21*(8), Article 8. https://doi.org/10.1093/ndt/gfl217

Gesta, S., Tseng, Y.-H., & Kahn, C. R. (2007). Developmental Origin of Fat: Tracking Obesity to Its Source. *Cell*, *131*(2), Article 2. https://doi.org/10.1016/j.cell.2007.10.004

Groele, B., Głąbska, D., Gutkowska, K., & Guzek, D. (2019). Influence of the socio-demographic characteristics of mothers of children aged 3-10 years on their at-home support of fruit and vegetable consumption. *Roczniki Państwowego Zakładu Higieny*, 277–285. https://doi.org/10.32394/rpzh.2019.0078

Gualdani, E., Di Cianni, G., Seghieri, M., Francesconi, P., & Seghieri, G. (2021). Pregnancy outcomes and maternal characteristics in women with pregestational and gestational diabetes: A retrospective study on 206,917 singleton live births. *Acta Diabetologica*, *58*(9), Article 9. https://doi.org/10.1007/s00592-021-01710-0

Harder, T., Rodekamp, E., Schellong, K., Dudenhausen, J. W., & Plagemann, A. (2007). Birth Weight and Subsequent Risk of Type 2 Diabetes: A Meta-Analysis. *American Journal of Epidemiology*, *165*(8), Article 8. https://doi.org/10.1093/aje/kwk071

Hidayat, K., Zou, S., & Shi, B. (2019). The influence of maternal body mass index, maternal diabetes mellitus, and maternal smoking during pregnancy on the risk of childhood-onset type 1 diabetes mellitus in the offspring: Systematic review and meta-analysis of observational studies. *Obesity Reviews*, *20*(8), Article 8. https://doi.org/10.1111/obr.12858

Huang, K., Si, S., Chen, R., Wang, C., Chen, S., Liang, Y., Yao, H., Zheng, R., Liu, F., Cao, B., Su, Z., Mireguli, M., Luo, F., Li, P., Du, H., Zhu, M., Yang, Y., Cui, L., Yu, Y., & Fu, J. (2021). Preterm Birth and Birth Weight and the Risk of Type 1 Diabetes in Chinese Children. *Frontiers in Endocrinology*, *12*, 603277. https://doi.org/10.3389/fendo.2021.603277

Katsarou, A., Gudbjörnsdottir, S., Rawshani, A., Dabelea, D., Bonifacio, E., Anderson, B. J., Jacobsen, L. M., Schatz, D. A., & Lernmark, Å. (2017). Type 1 diabetes mellitus. *Nature Reviews Disease Primers*, *3*(1), Article 1. https://doi.org/10.1038/nrdp.2017.16

Knorr, S., Juul, S., Bytoft, B., Lohse, Z., Clausen, T. D., Jensen, R. B., Damm, P., Beck-Nielsen, H., Mathiesen, E. R., Jensen, D. M., & Gravholt, C. H. (2018). Impact of type 1 diabetes on maternal long-term risk of hospitalisation and mortality: A nationwide combined clinical and register-based cohort study (The EPICOM study). *Diabetologia*, *61*(5), 1071–1080. https://doi.org/10.1007/s00125-018-4575-5

Krischer, J. P., Liu, X., Lernmark, Å., Hagopian, W. A., Rewers, M. J., She, J.-X., Toppari, J., Ziegler, A.-G., Akolkar, B., & on behalf of the TEDDY Study Group. (2017). The Influence of Type 1 Diabetes Genetic Susceptibility Regions, Age, Sex, and Family History on the Progression From Multiple Autoantibodies to Type 1 Diabetes: A TEDDY Study Report. *Diabetes*, *66*(12), Article 12. https://doi.org/10.2337/db17-0261

Lawlor, D. A., Lichtenstein, P., & Långström, N. (2011). Association of Maternal Diabetes Mellitus in Pregnancy With Offspring Adiposity

Into Early Adulthood: Sibling Study in a Prospective Cohort of 280 866 Men From 248 293 Families. *Circulation*, *123*(3), Article 3. https://doi.org/10.1161/CIRCULATIONAHA.110.980169

Leinonen, P. J., Hiilesmaa, V. K., Kaaja, R. J., & Teramo, K. A. (2001). Maternal Mortality in Type 1 Diabetes. *Diabetes Care*, *24*(8), 1501–1502. https://doi.org/10.2337/diacare.24.8.1501

Léniz-Maturana, L., Vilaseca, R., Leiva, D., & Gallardo-Rodríguez, R. (2023). Positive Parenting and Sociodemographic Factors Related to the Development of Chilean Children Born to Adolescent Mothers. *Children*, *10*(11), 1778. https://doi.org/10.3390/children10111778

Lin, S.-F., Kuo, C.-F., Chiou, M.-J., & Chang, S.-H. (2017). Maternal and fetal outcomes of pregnant women with type 1 diabetes, a national population study. *Oncotarget*, *8*(46), 80679–80687. https://doi.org/10.18632/oncotarget.20952

Ludvigsson, J. F., Neovius, M., Söderling, J., Gudbjörnsdottir, S., Svensson, A.-M., Franzén, S., Stephansson, O., & Pasternak, B. (2019). Maternal Glycemic Control in Type 1 Diabetes and the Risk for Preterm Birth: A Population-Based Cohort Study. *Annals of Internal Medicine*, *170*(10), Article 10. https://doi.org/10.7326/M18-1974

Magnusson, Å., Laivuori, H., Loft, A., Oldereid, N. B., Pinborg, A., Petzold, M., Romundstad, L. B., Söderström-Anttila, V., & Bergh, C. (2021). The Association Between High Birth Weight and Long-Term Outcomes—Implications for Assisted Reproductive Technologies: A Systematic Review and Meta-Analysis. *Frontiers in Pediatrics*, *9*, 675775. https://doi.org/10.3389/fped.2021.675775

McCance, D. R., & Cassidy, L. (2024). Diabetes in Pregnancy. In R. I. G. Holt & A. Flyvbjerg (Eds.), *Textbook of Diabetes* (1st ed., pp. 1034–1071). Wiley. https://doi.org/10.1002/9781119697473.ch71

Metsälä, J., Risnes, K., Persson, M., Veijola, R., Pulakka, A., Heikkilä, K., Alenius, S., Gissler, M., Opdahl, S., Sandin, S., & Kajantie, E. (2024). Gestational age at birth and type 1 diabetes in childhood and young adulthood: A nationwide register study in Finland, Norway and Sweden. *Diabetologia*. https://doi.org/10.1007/s00125-024-06139-y

Omer, K., Afi, N. J., Baba, M. C., Adamu, M., Malami, S. A., Oyo-Ita, A., Cockcroft, A., & Andersson, N. (2014). Seeking evidence to support efforts to increase use of antenatal care: A cross-sectional study in two states of Nigeria. *BMC Pregnancy and Childbirth*, *14*(1), 380. https://doi.org/10.1186/s12884-014-0380-4

Omer, K., Joga, A., Dutse, U., Hasan, K., Aziz, A., Ansari, U., Gidado, Y., Baba, M. C., Gamawa, A. I., Mohammad, R., Andersson, N., & Cockcroft, A. (2021). Impact of universal home visits on child health in Bauchi State, Nigeria: A stepped wedge cluster randomised controlled trial. *BMC Health Services Research*, *21*(1), 1085. https://doi.org/10.1186/s12913-021-07000-3

Qiu, J., Yin, W., Wang, R., Luo, S., & Zhou, Z. (2024). Fulminant type 1 diabetes: Focusing on triggering factors. *Diabetes/Metabolism Research and Reviews*, *40*(2), Article 2. https://doi.org/10.1002/dmrr.3731

Rao, P. V. (2015). Type 2 diabetes in children: Clinical aspects and risk factors. *Indian Journal of Endocrinology and Metabolism*, *19*(Suppl 1), S47–S50. https://doi.org/10.4103/2230-8210.155401

Robertson, L., & Harrild, K. (2010). Maternal and neonatal risk factors for childhood type 1 diabetes: A matched case-control study. *BMC Public Health*, *10*(1), Article 1. https://doi.org/10.1186/1471-2458-10-281

Rydahl, E., Declercq, E., Juhl, M., & Maimburg, R. D. (2019). Cesarean section on a rise—Does advanced maternal age explain the increase? A population register-based study. *PLOS ONE*, *14*(1), Article 1. https://doi.org/10.1371/journal.pone.0210655

Sarmiento, I., Ansari, U., Omer, K., Gidado, Y., Baba, M. C., Gamawa, A. I., Andersson, N., & Cockcroft, A. (2021). Causes of short birth interval (kunika) in Bauchi State, Nigeria: Systematizing local knowledge with fuzzy cognitive mapping. *Reproductive Health*, *18*, 74. https://doi.org/10.1186/s12978-021-01066-2

Stone, R. G., Scully, P., Troy, E., Moloney, Y., Quinn, A., Noctor, E., Neylon, O., Slevin, J., Murphy, A., & O'Gorman, C. (2020). Pregnancy outcomes in women with onset of type 1 diabetes mellitus less than 18 years of age. *BMJ Open Diabetes Research and Care*, *8*(1), e001080. https://doi.org/10.1136/bmjdrc-2019-001080

Swamy, G. K., Edwards, S., Gelfand, A., James, S. A., & Miranda, M. L. (2012). Maternal age, birth order, and race: Differential effects on birthweight. *Journal of Epidemiology and Community Health*, *66*(2), 136–142. https://doi.org/10.1136/jech.2009.088567

Tanoey, J. (2022). *Early-Life and Childhood Factors' Association with Diabetes: Caesarean Section, Birth Order and Daycare Attendance on Type 1 Diabetes Risk, and Childhood Developmental Conditions and Education on Early-onset Adult Diabetes Risk* [doctoralThesis, Staats- und Universitätsbibliothek Hamburg Carl von Ossietzky]. https://ediss.sub.uni-hamburg.de/handle/ediss/10377

Venyo, A. K.-G. (2023). Diabetes Mellitus: A Review and Update. *Journal of Ophthalmology Research Reviews & Reports*, *4*(4), 1–24.

Wang, H., Li, N., Chivese, T., Werfalli, M., Sun, H., Yuen, L., Hoegfeldt, C. A., Elise Powe, C., Immanuel, J., Karuranga, S., Divakar, H., Levitt, Na., Li, C., Simmons, D., & Yang, X. (2022). IDF Diabetes Atlas: Estimation of Global and Regional Gestational Diabetes Mellitus Prevalence for 2021 by International Association of Diabetes in Pregnancy Study Group's Criteria. *Diabetes Research and Clinical Practice*, *183*, 109050. https://doi.org/10.1016/j.diabres.2021.109050

White, P. A., Faresjö, T., Jones, M. P., & Ludvigsson, J. (2023). Low maternal education increases the risk of Type 1 Diabetes, but not other autoimmune diseases: A mediating role of childhood BMI and exposure to serious life events. *Scientific Reports*, *13*(1), Article 1. https://doi.org/10.1038/s41598-023-32869-x

Zhang, X., Anser, M. K., Ahuru, R. R., Zhang, Z., Peng, M. Y.-P., Osabohien, R., & Mirza, M. (2022). Do Predictors of Health Facility Delivery Among Reproductive-Age Women Differ by Health Insurance Enrollment? A Multi-Level Analysis of Nigeria's Data. *Frontiers in Public Health*, *10*, 797272. https://doi.org/10.3389/fpubh.2022.797272

Zhao, H., Song, A., Zhang, Y., Zhen, Y., Song, G., & Ma, H. (2018). The association between birth weight and the risk of type 2 diabetes mellitus: A systematic review and meta-analysis. *Endocrine Journal*, *65*(9), Article 9. https://doi.org/10.1507/endocrj.EJ18-0072.

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