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Preterm birth and subsequent risk of type 2 diabetes in black women

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Abstract

Background—Gestational diabetes is a precursor to type 2 diabetes. Little is known about the relation of other common pregnancy complications, such as preterm birth, to risk of type 2 diabetes.

Methods—We assessed preterm birth in relation to incident type 2 diabetes among 31,101 participants from the Black Women's Health Study. Preterm birth, defined as <37 weeks gestation, was reported at baseline (1995) and on subsequent biennial follow-up questionnaires. Self-reported type 2 diabetes diagnoses were ascertained on biennial questionnaires through 2009. We used Cox proportional hazards models to calculate incidence rate ratios (IRRs) and 95% confidence intervals (CIs), adjusting for potential confounders.

Results—At baseline, 5,162 participants (19%) reported a history of giving birth preterm, of which 16% occurred at <32 weeks gestation. A total of 3,261 cases of type 2 diabetes were ascertained during follow-up. Ever having had a preterm birth was associated with a 20% increased risk (95% CI=1.11-1.31) after adjusting for age at first birth, family history of diabetes, education, respondent having been born preterm, and body mass index. Gestational age <32 weeks was associated with the greatest risk (IRR=1.27 [95% CI=1.06-1.51]). Among women without a history of gestational diabetes, the IRR for type 2 diabetes among women who ever had a preterm birth was 1.17 (1.07-1.28).

Conclusion—Preterm birth was associated with an increased type 2 diabetes risk in black mothers, independent of gestational diabetes.

A growing body of evidence suggests that pregnancy complications may signal future chronic disease risk in mothers.¹⁻⁵ For example, it is well-known that gestational diabetes is a precursor of type 2 diabetes⁶⁻⁷; 50%-70% of women experiencing this pregnancy complication go on to develop type 2 diabetes.⁸ Interventions after a pregnancy complicated

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by gestational diabetes (such as weight reduction) have led to a substantial decrease in future development of type 2 diabetes.^{6, 9-12} Thus, evaluation of the association between other common pregnancy complications and type 2 diabetes risk is warranted, especially among black women, as they have one of the highest rates of type 2 diabetes in the U.S.¹³

A pregnancy complication that is of particular concern for black women is preterm birth, which affects up to 17% of pregnancies in this racial group.¹⁴⁻¹⁶ In fact, black women are almost twice as likely to experience a preterm birth compared with white women.¹⁷ Preterm birth and type 2 diabetes share several underlying risk factors, including higher levels of certain inflammatory markers, such as tumor necrosis factor α and interleukin-1 β .¹⁶⁻¹⁸ These shared factors suggest that preterm birth may be a signal for elevated inflammatory markers and possibly future development of type 2 diabetes in some women.

Given that black women have a higher prevalence of both preterm birth and type 2 diabetes,¹⁴⁻¹⁷ we evaluated the association between this pregnancy complication and type 2 diabetes in black mothers. This study was conducted in a large cohort of black women participating in the Black Women's Health Study. We accounted for a number of potential confounders, including maternal age, education, and body size. While the association of preterm birth with type 2 diabetes has been explored in predominantly white populations,³⁻⁴ to our knowledge, it has not been evaluated in black women. If an appreciable association is found, targeted interventions among black women experiencing a preterm birth could lead to a decrease in risk of type 2 diabetes.

Methods

Study population

Study participants were from the Black Women's Health Study, a prospective cohort study of 59,000 African-American women who were 21 to 69 years of age at baseline (1995).¹⁹ Black women enrolled in 1995 by completing mailed health questionnaires. The baseline questionnaire collected detailed information on reproductive, lifestyle, and demographic factors, as well as a medical history. Questionnaires are sent biennially to collect updated health information. In 2009, follow-up of the baseline cohort was 80%. This study was approved by the Boston Medical Center Institutional Review Board.

We excluded women who were nulliparous at baseline and remained nulliparous throughout follow-up (n=15,741) and women who were lost to follow-up after 1997 (n=3,999). We also excluded women with missing or inconsistent preterm birth data (n=5,353); these women were slightly older and less educated than included women. To ensure that type 2 diabetes diagnosis did not precede preterm birth, we excluded women who were diagnosed with type 2 diabetes prior to 1995 (n=2,807). The analytic population consisted of 31,101 women.

Assessment of preterm birth

On the 1997 questionnaire, women were asked if, before 1995, they had ever given birth to a child three or more weeks before the due date, and if so, how much earlier: 3, 4, 5, 6, 7, 8, 9, or 10 weeks. If women had more than one preterm birth, they were asked to report on the birth that was most preterm. On the 1997 follow-up questionnaire and on the 1999, 2001,

and 2003 questionnaires, women were asked whether they had given birth to a live born or stillborn child in the past 2 years. If women responded yes, they were asked if a doctor said that this child was born at least 3 weeks early, and how early (using the aforementioned categories). A validation study of preterm birth among a subset of participants who delivered in Massachusetts, based on registry data from Massachusetts Department of Public Health, showed high validity for self-report of preterm birth (>90% of respondents reporting <3 weeks gestation had a preterm birth documented by state birth registry data).²⁰ We evaluated preterm birth as “ever” having had a preterm birth versus “never” having had a preterm birth, and also assessed gestational age as <32 weeks, 32-34 weeks, and 35-36 weeks.

Case definition

On each follow-up questionnaire, women were asked if a doctor had diagnosed diabetes within the last two years. In a validation analysis of the Black Women's Health Study, self-report of diabetes as an indicator of type 2 diabetes was highly accurate: 96% of self-reports for which medical record data were obtained were confirmed.²¹ A total of 3,261 women received a first diagnosis of type 2 diabetes during follow-up.

Assessment of covariates

We evaluated the following as potential confounders: age at first birth (<20, 20-24, 25 years), education (<12, 13-15, 16 years), and body mass index (BMI, weight in kg divided by height in meters squared, at 18 years: <20, 20-24, 25). We also assessed post-pregnancy BMI (<25, 25-29, 30), which was BMI after pregnancy, prior to the end of follow-up for women who did not develop type 2 diabetes and date of diagnosis of type 2 diabetes for those who developed type 2 diabetes. Self-reported weight and height were previously validated in the Black Women's Health Study, with Spearman correlations for weight and height being 0.93 and 0.97 for self-report versus technician measures.²²⁻²³ We also assessed smoking status (ever, never), place of birth (foreign-born, U.S.-born), if the participant had been born preterm (yes, no), if she had a family history of diabetes (yes, no), and if she ever had gestational diabetes (yes, no). Participants also provided information on hypertensive disorders of pregnancy, which was defined as a positive response to any of the following questions: (1) all women were asked about high blood pressure during pregnancy on the 1997 and 1999 questionnaires, (2) all women were asked about preeclampsia or toxemia of pregnancy on the 2009 questionnaire, or (3) women who reported an induced or Caesarean birth on the 1997, 1999, 2001, or 2003 questionnaire were asked if the reason was preeclampsia or toxemia of pregnancy.

Data analysis

Participants contributed person-time from baseline in 1995 (if already parous) or the questionnaire cycle during which they first became parous until self-report of incident type 2 diabetes, loss to follow-up, or the end of follow-up in 2009, whichever came first. Women who had a preterm birth after 1995 were censored if the occurrence of incident type 2 diabetes during follow-up preceded the preterm birth. We evaluated the association between preterm birth and incident type 2 diabetes using Cox proportional hazards models to calculate incidence rate ratios (IRR) and 95% confidence intervals (95% CI). We posited

that age at first birth, family history of diabetes, education, respondent being born preterm, BMI at age 18 years, and place of birth were potential confounders. Each potential confounder was added to a model containing preterm birth as an exposure; if the log of the incidence rate ratio for preterm birth changed by more than 10%, then we included it in our final models. Final model 1 adjusted for age, and final model 2 adjusted for age, age at first birth, family history of diabetes, BMI at age 18 years, education, and respondent having been born preterm. In a further model, we adjusted for post-pregnancy BMI, as defined above.

We hypothesized that having a preterm birth would be associated with earlier onset of type 2 diabetes, and we conducted a stratified analysis by age at baseline to evaluate this hypothesis (<50 years v. ≥50 years). Furthermore, we conducted a stratified analysis by post-pregnancy BMI (<25, 25-30, ≥30) to determine whether the association between preterm birth and type 2 diabetes differed by BMI status. We tested for interactions between age, preterm birth and type 2 diabetes, as well as post-pregnancy BMI, preterm birth and type 2 diabetes, by including an interaction term in our fully-adjusted models. Since gestational diabetes is one of the strongest risk factors for developing type 2 diabetes,^{7, 24} we conducted a restricted analysis for the association between preterm birth and type 2 diabetes among women without a history of gestational diabetes. We also conducted an analysis among women who had not reported hypertensive disorders of pregnancy, which is an established risk factor for type 2 diabetes and is associated with preterm birth.²⁵ Finally, we calculated rate differences, first adjusting for age at baseline only and then adjusting for age at baseline, age at first birth, BMI at age 18 years, education, family history of diabetes, and respondent having been born preterm (fully-adjusted). We use PROC NLMIXED to calculate these rate differences with 95% confidence intervals (CIs) using a Poisson distribution. All analyses were conducted using SAS 9.3 (Cary, NC).

Results

Table 1 provides baseline characteristics of the study population by preterm birth history at baseline. A total of 20% of the population in 1995 reported ever having had a preterm birth, with 16% of these being at <32 weeks. Women who had experienced a preterm birth were younger at the age of their first birth, more likely to have a family history of type 2 diabetes, and have lower educational attainment. Women with a preterm birth were also more likely to report having been born preterm and to have experienced a pregnancy complicated by gestational diabetes.

A total of 3,261 women were diagnosed with type 2 diabetes between 1995 and 2009. The median age at diagnosis was 52 years (standard deviation [SD]=10.0) and the age range was 25-83 years of age.

Preterm birth and type 2 diabetes

In the age-adjusted model (Table 2), women with a history of preterm birth had a 24% increased risk of developing type 2 diabetes (age adjusted 95% CI=1.14-1.34). After adjusting for pre-pregnancy factors (Model 2), the association was slightly attenuated (fully adjusted IRR=1.20 [95% CI=1.11-1.31]). The addition of post-pregnancy BMI also

attenuated the association slightly (fully adjusted IRR=1.17 [1.05-1.30]). Type 2 diabetes was inversely associated with gestational age, with the highest risk for gestational age of <32 weeks (age-adjusted IRR=1.32 [1.10-1.58]). Adjustments for potential confounders (Model 2) slightly attenuated the estimates. In terms of rate differences, after full adjustment 108/100,000 excess cases of type 2 diabetes occurred in women who had experienced a preterm birth compared with women who had never experienced a preterm birth (fully adjusted 95% CI=60/100,000-155/100,000). After full adjustment, women with a gestation length <32 weeks had 130/100,000 excess cases of type 2 diabetes compared with women who had never had a preterm birth (95% CI=21/100,000-239/100,000).

Preterm Birth, type 2 diabetes, Age and Post-pregnancy BMI

Table 3 presents associations between preterm birth and type 2 diabetes stratified by age at baseline and post-pregnancy BMI. There was a suggestion of an interaction between age at baseline and preterm birth, with a slightly stronger association between preterm birth and type 2 diabetes among women <50 years of age at baseline (fully adjusted IRR=1.29 [95% CI=1.14-1.45]) compared with women ≥50 years of age at baseline and (1.13 [1.01-1.27]) (test for interaction, $P = 0.09$). There were associations of preterm birth with increased type 2 diabetes risk within all categories of post-pregnancy BMI; post-pregnancy BMI did not interact with preterm birth and type 2 diabetes.

Preterm birth, type 2 diabetes, and other pregnancy complications

Among women without gestational diabetes, the fully adjusted incidence rate ratio for the association of preterm birth with type 2 diabetes was 1.17 (95% CI=1.07-1.28); there was no evidence of a trend across decreasing length of gestation (Table 4). Among women without hypertensive disorders of pregnancy, the fully-adjusted IRR for the association of preterm birth with type 2 diabetes was 1.22 (1.11-1.34) (Table 4); the adjusted IRR was highest for <32 weeks gestation (1.25 [1.02-1.54]).

Preterm birth and type 2 diabetes—a sensitivity analysis

We conducted a sensitivity analysis among 8,601 women who delivered an infant during the follow-up period of the study. Among this subset, 1,745 women (20%) delivered a preterm birth and 531 women (6%) reported a subsequent diagnosis of type 2 diabetes. A total of 134 (7%) women who delivered preterm post-1995 were subsequently diagnosed with type 2 diabetes. After full adjustment, ever having had a preterm birth was associated with a 29% increased risk of type 2 diabetes (95% CI=1.05-1.57). The strongest association was for women who experienced a gestation length <32 weeks; these women had a 55% increased risk of type 2 diabetes (1.09-2.18).

We further restricted to 3,888 women who were nulliparous at baseline (1995) and delivered during study follow-up. Due to small numbers of women with both preterm birth and type 2 diabetes in this subgroup ($n=62$), we evaluated crude associations. Relative to term birth, there was a 51% increased risk of type 2 diabetes for women who ever delivered preterm (95% CI=1.01-2.25); for women delivering an infant at <32, 32-34, and 35-36 weeks, we found increases of 34% (0.67-2.66), 84% (0.80-4.22), and 52% (0.90-2.55), respectively.

Discussion

In this study of black women, preterm birth was associated with increased risk of type 2 diabetes, with risk increasing as gestational age decreased in the overall study population. Controlling for prepregnancy and postpregnancy factors did little to alter these associations. The strongest association was found among women who delivered at <32 weeks gestation, with an approximately 30% increased risk of type 2 diabetes. In addition, there was a suggestion of a stronger association for women experiencing a preterm birth who were younger at baseline. Finally, preterm birth was associated with an increased risk of type 2 diabetes among women who had not experienced gestational diabetes or hypertensive disorders of pregnancy, suggesting that preterm birth is an independent risk factor for type 2 diabetes.

In a previous cohort study of preterm birth and type 2 diabetes risk conducted in Denmark by Lykke et al,⁵ preterm birth was associated with a 2-fold increased risk of type 2 diabetes, with increasing risk for shorter gestational age. In a small cohort study conducted in women delivering at a single hospital in Pittsburgh (PA), Catov et al² found that having a preterm birth conferred a 2-fold increased risk of metabolic syndrome. In a recently published study of a predominantly white population of U.S. nurses, preterm birth was associated with an increased risk of type 2 diabetes, with an increase of 34% for births >32 weeks compared with 27% in the present study for <32 weeks.³ A possible reason for the weaker associations between preterm birth and type 2 diabetes in the present study compared with previous studies^{2-3, 5} is that the underlying incidence of type 2 diabetes is higher in black women.^{13, 26} In addition, women diagnosed with type 2 diabetes prior to 1995 were excluded from the study. If preterm birth confers a stronger risk of type 2 diabetes for women who would develop this disease in a shorter time interval, then exclusion of this group of women could result in an attenuated association between preterm birth and type 2 diabetes.

The mechanism by which preterm birth may increase the risk of type 2 diabetes could be through the shared pathway of inflammation.²⁷⁻³² Women who experience a preterm birth may have underlying chronic low-grade inflammation, signaling future risk of type 2 diabetes.^{28, 31, 33-34} Black women have higher inflammatory marker levels, suggesting more chronic inflammation.^{16, 34} High levels of chronic inflammation could be one of the reasons for the higher prevalence of preterm birth among this group. The fact that associations between preterm birth and type 2 diabetes held even among women without gestational diabetes or hypertensive disorder of pregnancy suggests that preterm birth may be another indicator of vascular dysfunction. Associations held even among overweight and obese women, and control for BMI explained only a small part of the association of preterm birth with increased risk of type 2 diabetes, which suggests that a mechanism other than weight gain or obesity is involved.

The present study has several limitations. We were unable to date a woman's preterm birth if she delivered prior to 1995, and we excluded all women who developed type 2 diabetes before 1995. In a sensitivity analysis among the subset of women who delivered during the follow-up period (after 1995), we found stronger associations of preterm birth with type 2

diabetes than in the overall analysis, suggesting that associations in the overall study might be attenuated. Women who experienced a preterm birth may more frequently interact with the health care system, leading to more opportunity to receive a type 2 diabetes diagnosis. However, we might also expect this level of detection bias to be operating among women with a history of gestational diabetes or hypertensive disorder of pregnancy, yet in an analysis among women without these conditions; we found similar associations as that in our overall population. We had no validation data on history of gestational diabetes or hypertensive disorder of pregnancy. In the Nurses' Health Study, gestational diabetes was reported with adequate accuracy,³⁵ but the relevance of that finding to the present study is uncertain. Parous women with missing data on births, who were older and less educated than the included women, were excluded from our analysis. These women may have been at higher risk of type 2 diabetes and their exclusion may have led to underestimation of the association with preterm birth.

The study has several strengths. We assessed a population at high risk of both preterm birth and type 2 diabetes – black women. We were able to evaluate gestational age, not just ever-preterm-birth. We controlled for a variety of prepregnancy and postpregnancy factors. We also assessed the association between preterm birth and type 2 diabetes by restricting to women without a history of gestational diabetes or hypertensive disorder of pregnancy, in order to determine the extent to which preterm birth still affected type 2 diabetes risk. Furthermore, both preterm birth and type 2 diabetes are well-validated in our study population.²⁰⁻²¹

In conclusion, having had a preterm birth was associated with an increased incidence of type 2 diabetes among black women, with the greatest increase among women experiencing a preterm birth of <32 weeks. There was a suggestion of a stronger association among younger black women, which may indicate preterm birth is associated with earlier onset of the disease. Given that black women are disproportionately impacted by both preterm birth^{14-16, 36} and type 2 diabetes,¹³ further research is needed to evaluate this association and to determine whether black women who experience a preterm birth could benefit from clinical or lifestyle interventions to reduce future risk of type 2 diabetes.

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References

1. Rich-Edwards JW, McElrath TF, Karumanchi SA, Seely EW. Breathing life into the lifecourse approach: pregnancy history and cardiovascular disease in women. *Hypertension*. Sep; 2010 56(3): 331–4. [PubMed: 20679178]
2. Catov JM, Dodge R, Yamal JM, Roberts JM, Piller LB, Ness RB. Prior preterm or small-for-gestational-age birth related to maternal metabolic syndrome. *Obstet Gynecol*. Feb; 2011 117(2 Pt 1):225–32. [PubMed: 21252733]
3. James-Todd TM, Karumanchi SA, Mason SM, Hibert EL, Vadnais V, Hu FB, et al. Gestation Length, Birth Weight for First Pregnancy and Subsequent Risk of Type 2 Diabetes in Mothers: A Prospective Study. *Preventing Chronic Disease*. 2013 In Press.

4. Lykke JA, Langhoff-Roos J, Sibai BM, Funai EF, Triche EW, Paidas MJ. Hypertensive pregnancy disorders and subsequent cardiovascular morbidity and type 2 diabetes mellitus in the mother. *Hypertension*. Jun; 2009 53(6):944–51. [PubMed: 19433776]
5. Lykke JA, Paidas MJ, Damm P, Triche EW, Kuczynski E, Langhoff-Roos J. Preterm delivery and risk of subsequent cardiovascular morbidity and type-II diabetes in the mother. *BJOG*. Feb; 2010 117(3):274–81. [PubMed: 20015308]
6. Buchanan TA, Xiang AH. Gestational diabetes mellitus. *J Clin Invest*. Mar; 2005 115(3):485–91. [PubMed: 15765129]
7. Kim C, Newton KM, Knopp RH. Gestational diabetes and the incidence of type 2 diabetes: a systematic review. *Diabetes Care*. Oct; 2002 25(10):1862–8. [PubMed: 12351492]
8. Kjos SL, Buchanan TA. Gestational diabetes mellitus. *N Engl J Med*. Dec 2; 1999 341(23):1749–56. [PubMed: 10580075]
9. Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med*. Feb 7; 2002 346(6):393–403. [PubMed: 11832527]
10. Ratner RE. Prevention of type 2 diabetes in women with previous gestational diabetes. *Diabetes Care*. Jul; 2007 30(Suppl 2):S242–5. [PubMed: 17596479]
11. Ratner RE, Christophi CA, Metzger BE, Dabelea D, Bennett PH, Pi-Sunyer X, et al. Prevention of diabetes in women with a history of gestational diabetes: effects of metformin and lifestyle interventions. *J Clin Endocrinol Metab*. Dec; 2008 93(12):4774–9. [PubMed: 18826999]
12. Xiang AH, Peters RK, Kjos SL, Marroquin A, Goico J, Ochoa C, et al. Effect of pioglitazone on pancreatic beta-cell function and diabetes risk in Hispanic women with prior gestational diabetes. *Diabetes*. Feb; 2006 55(2):517–22. [PubMed: 16443789]
13. CDC. Centers for Disease Control and Prevention.. Age-Adjusted Percentage of Civilian, Noninstitutionalized Population with Diagnosed Diabetes, by Race and Sex, United States, 1980–2010. Data and Trends 2011 [cited 2011; Available from: <http://www.cdc.gov/diabetes/statistics/prev/national/figraceethsex.htm>
14. Culhane JF, Goldenberg RL. Racial disparities in preterm birth. *Semin Perinatol*. Aug; 2011 35(4):234–9. [PubMed: 21798403]
15. Dunlop AL, Kramer MR, Hogue CJ, Menon R, Ramakrishnan U. Racial disparities in preterm birth: an overview of the potential role of nutrient deficiencies. *Acta Obstet Gynecol Scand*. Dec; 2011 90(12):1332–41. [PubMed: 21910693]
16. Menon R, Dunlop AL, Kramer MR, Fortunato SJ, Hogue CJ. An overview of racial disparities in preterm birth rates: caused by infection or inflammatory response? *Acta Obstet Gynecol Scand*. Dec; 2011 90(12):1325–31. [PubMed: 21615712]
17. Behrman, RE.; Butler, AS. National Research Council. The National Academies Press; Washington, DC: 2007. Preterm birth: causes, consequences, and prevention..
18. Genc MR, Gerber S, Nesin M, Witkin SS. Polymorphism in the interleukin-1 gene complex and spontaneous preterm delivery. *Am J Obstet Gynecol*. Jul; 2002 187(1):157–63. [PubMed: 12114904]
19. Rosenberg L, Adams-Campbell L, Palmer JR. The Black Women's Health Study: a follow-up study for causes and preventions of illness. *J Am Med Womens Assoc*. Mar-Apr; 1995 50(2):56–8. [PubMed: 7722208]
20. Wise LA, Palmer JR, Heffner LJ, Rosenberg L. Prepregnancy body size, gestational weight gain, and risk of preterm birth in African-American women. *Epidemiology*. Mar; 2010 21(2):243–52. [PubMed: 20124904]
21. Krishnan S, Cozier YC, Rosenberg L, Palmer JR. Socioeconomic status and incidence of type 2 diabetes: results from the Black Women's Health Study. *Am J Epidemiol*. Mar 1; 2010 171(5):564–70. [PubMed: 20133518]
22. Carter-Nolan PL, Adams-Campbell LL, Makambi K, Lewis S, Palmer JR, Rosenberg L. Validation of physical activity instruments: Black Women's Health Study. *Ethn Dis*. 2006; 16(4):943–7. Autumn. [PubMed: 17061751]

23. Wise LA, Palmer JR, Spiegelman D, Harlow BL, Stewart EA, Adams-Campbell LL, et al. Influence of body size and body fat distribution on risk of uterine leiomyomata in U.S. black women. *Epidemiology*. May; 2005 16(3):346–54. [PubMed: 15824551]
24. Feig DS, Zinman B, Wang X, Hux JE. Risk of development of diabetes mellitus after diagnosis of gestational diabetes. *CMAJ*. Jul 29; 2008 179(3):229–34. [PubMed: 18663202]
25. Feig DS, Shah BR, Lipscombe LL, Wu CF, Ray JG, Lowe J, et al. Preeclampsia as a risk factor for diabetes: a population-based cohort study. *PLoS medicine*. 2013; 10(4):e1001425. [PubMed: 23610560]
26. Mocarski M, Savitz DA. Ethnic differences in the association between gestational diabetes and pregnancy outcome. *Matern Child Health J*. Feb; 2012 16(2):364–73. [PubMed: 21365298]
27. Catov JM, Bodnar LM, Ness RB, Barron SJ, Roberts JM. Inflammation and dyslipidemia related to risk of spontaneous preterm birth. *Am J Epidemiol*. Dec 1; 2007 166(11):1312–9. [PubMed: 17906337]
28. Duncan BB, Schmidt MI. The epidemiology of low-grade chronic systemic inflammation and type 2 diabetes. *Diabetes Technol Ther*. Feb; 2006 8(1):7–17. [PubMed: 16472046]
29. Lowe LP, Metzger BE, Lowe WL Jr, Dyer AR, McDade TW, McIntyre HD. Inflammatory mediators and glucose in pregnancy: results from a subset of the Hyperglycemia and Adverse Pregnancy Outcome (HAPO) Study. *J Clin Endocrinol Metab*. Dec; 2010 95(12):5427–34. [PubMed: 20843942]
30. Wei SQ, Fraser W, Luo ZC. Inflammatory cytokines and spontaneous preterm birth in asymptomatic women: a systematic review. *Obstet Gynecol*. Aug; 2010 116(2 Pt 1):393–401. [PubMed: 20664401]
31. Wellen KE, Hotamisligil GS. Inflammation, stress, and diabetes. *J Clin Invest*. May; 2005 115(5):1111–9. [PubMed: 15864338]
32. Pradhan AD, Manson JE, Rifai N, Buring JE, Ridker PM. C-reactive protein, interleukin 6, and risk of developing type 2 diabetes mellitus. *JAMA*. Jul 18; 2001 286(3):327–34. [PubMed: 11466099]
33. Duncan BB, Schmidt MI, Pankow JS, Ballantyne CM, Couper D, Vigo A, et al. Low-grade systemic inflammation and the development of type 2 diabetes: the atherosclerosis risk in communities study. *Diabetes*. Jul; 2003 52(7):1799–805. [PubMed: 12829649]
34. Schmidt MI, Duncan BB, Sharrett AR, Lindberg G, Savage PJ, Offenbacher S, et al. Markers of inflammation and prediction of diabetes mellitus in adults (Atherosclerosis Risk in Communities study): a cohort study. *Lancet*. May 15; 1999 353(9165):1649–52. [PubMed: 10335783]
35. Solomon CG, Willett WC, Rich-Edwards J, Hunter DJ, Stampfer MJ, Colditz GA, et al. Variability in diagnostic evaluation and criteria for gestational diabetes. *Diabetes Care*. Jan; 1996 19(1):12–6. [PubMed: 8720526]
36. Hogue CJ, Menon R, Dunlop AL, Kramer MR. Racial disparities in preterm birth rates and short inter-pregnancy interval: an overview. *Acta Obstet Gynecol Scand*. Dec; 2011 90(12):1317–24. [PubMed: 21306339]

Table 1
Baseline characteristics of study population according to preterm status at baseline, Black Women's Health Study (1995-2009)

	Never Preterm (n=21333)		Preterm			
	Ever (n=5162)	<32 wks (n=824)	32-34 wks (n=1251)	35-36 wks (n=3087)		
Age at baseline (years); mean	42	42	41	42	42	
Age at first birth (years); mean	23	22	23	23	22	
BMI at baseline (kg/m ²); mean	28	28	29	28	28	
BMI age 18 yrs (kg/m ²); mean	21	21	20	21	21	
Highest level of education (yrs); %						
12	21	22	23	23	21	
13-15	39	40	41	41	39	
16	41	38	36	35	40	
U.S. born; %	91	92	91	92	92	
Respondent was preterm; %	4	8	8	8	7	
Family history of diabetes; %	27	30	32	29	30	
History of gestational diabetes; %	5	6	6	6	6	

Table 2

Associations between preterm birth and type 2 diabetes, Black Women's Health Study (1995-2009)

Preterm birth	No. Cases type 2 diabetes	Person-years	Age-adjusted IRR (95% CI)	Age-adjusted rate difference (95% CI) ^a	Fully-adjusted IRR (95% CI) ^b	Fully-adjusted rate difference (95% CI) ^{a, b}
Ever	746	66939	1.24 (1.14-1.34)	142 (84-200)	1.20 (1.11-1.31)	108 (60-155)
<32 weeks	126	11602	1.32 (1.10-1.58)	177 (32-302)	1.27 (1.06-1.51)	130 (21-239)
32-34 weeks	188	15367	1.26 (1.08-1.46)	168 (56-280)	1.22 (1.05-1.42)	124 (34-213)
35-36 weeks	432	39970	1.21 (1.09-1.34)	125 (53-197)	1.18 (1.07-1.31)	95 (37-153)
Never^c	2515	279023	1.00	0	1.00	0

^a per 100,000 person-years

^b Adjusted for pre-pregnancy factors: age at first birth, family history of diabetes, education, BMI at age 18 years, and respondent was born preterm

^c Reference category

Table 3

Associations between preterm birth and type 2 diabetes stratified by age at baseline and postpregnancy BMI, Black Women's Health Study (1995-2009)

	Age at baseline (yrs)		Postpregnancy BMI			
	<50	50	<25	25-29	30	
Preterm birth	IRR (95% CI) ^a	IRR (95% CI) ^a	IRR (95% CI) ^a	IRR (95% CI) ^a	IRR (95% CI) ^a	IRR (95% CI) ^a
Ever	1.29 (1.14-1.45)	1.13 (1.01-1.27)	1.29 (0.94-1.75)	1.23 (1.05-1.44)	1.18 (1.07-1.31)	
<32 weeks	1.36 (1.11-1.66)	1.19 (0.91-1.54)	0.85 (0.38-1.95)	1.11 (0.77-1.60)	1.33 (1.08-1.65)	
32-34 weeks	1.27 (1.06-1.52)	1.18 (0.97-1.44)	1.42 (0.84-2.40)	1.17 (0.87-1.55)	1.22 (1.01-1.47)	
35-36 weeks	1.22 (1.09-1.34)	1.10 (0.95-1.27)	1.35 (0.93-1.96)	1.29 (1.06-1.57)	1.13 (0.99-1.28)	
Never ^b	1.00	1.00	1.00	1.00	1.00	1.00

^a Adjusted for prepregnancy factors: age at first birth, family history of diabetes, education, BMI at age 18 years, and respondent was born preterm

^b Reference category

Table 4

Associations between preterm birth and type 2 diabetes among women without a history of gestational diabetes or hypertensive disorders of pregnancy, Black Women's Health Study (1995-2009)

	No gestational diabetes	No hypertensive disorder of pregnancy
Preterm birth	Adj. IRR (95% CI) ^a	Adj. IRR (95% CI) ^a
Ever	1.17 (1.07-1.28)	1.21 (1.10-1.32)
<32 weeks	1.20 (0.98-1.47)	1.25 (1.02-1.54)
32-34 weeks	1.22 (1.04-1.43)	1.19 (1.00-1.40)
35-36 weeks	1.15 (1.03-1.29)	1.20 (1.07-1.35)
Never ^b	1.00	1.00

^a Adjusted for pre-pregnancy factors: age at first birth, family history of diabetes, education, BMI at age 18 years, and respondent was born preterm

^b Reference category