A1c in Pregnancy and Postpartum Linkage for Equity (APPLE) Cohort

A Compendium for APPLE Cohort

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Table of Contents

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Introduction

Gestational diabetes mellitus (GDM) is defined as glucose intolerance arising or first recognized during pregnancy. It is a growing public health crisis, with rates increasing across all maternal age groups. In NYC, women with GDM experience a more than 11 times higher risk of developing Type 2 Diabetes (T2DM) compared to those without GDM over 12 years, though this risk may be substantially higher among Black, Hispanic and South/Southeast Asian women.1 Given GDM's impact on life course health, pregnancy is an important window for intervention specially for racially and ethnically diverse, immigrant and low-income populations who bear a disproportionate burden on both GDM and subsequent T2DM.

The *A1c in Pregnancy and Postpartum Linkage for Equity* **(APPLE)** *Cohort* is a cohort that uses a novel linkage of SPARCS hospital discharge records, NYC birth records, HbA1c Registry data, and neighborhood-level social and built environment features. This makes it a unique dataset that tracks metabolic health trajectories among women with GDM: HbA1c >6.5% during pregnancy and the postpartum period. The R01-funded study also includes a qualitative component, which involves in-depth, semi-structured interviews with racially and ethnically diverse populations who have experienced a GDM pregnancy. By documenting their experiences across pregnancy, postpartum care, and diabetes management, the APPLE Cohort identifies opportunities to improve care pathways. The APPLE Cohort is guided by a conceptual framework in which structural racism, economic and gender inequality, and multi-level policies shape neighborhood and individual-level conditions including social and built environment features that drive the pathway from GDM to T2DM.

The APPLE Cohort would not be possible without the efforts and support of the **New York City Department of Health and Mental Hygiene (NYC DOHMH)** for the provision and linkage of birth certificate, A1c Registry, and hospital discharge datasets. Through this partnership and the expertise of the NYC DOHMH, the APPLE Cohort has published **6 peer-reviewed papers** and has **6 additional papers** currently under review. Our research has produced several key findings: 1) Racial and ethnic disparities in diabetes risk and glycemic control after GDM are substantial, and the neighborhood you live in shapes your metabolic health. Black and Hispanic women consistently face the highest risk of progression to T2DM. 2) Having GDM increases the risk (by more than 2 times) of gestational complications in adolescents and young adults, yet first-trimester HbA1c screening is not reaching those who need it most. 3) HbA1c transitions after GDM are gradual but persistent. Most women remained in the same disease state between years, but Black, Hispanic and South/Southeast Asian women were more likely to progress to higher A1c states.

Influence of Gestational Diabetes Mellitus on Diabetes Risk and Glycemic Control in a Retrospective Population-Based Cohort

Objective:

- To estimate racial and ethnic group differences in the influence of Gestational Diabetes (GDM) on Type 2 Diabetes (T2DM) risk and glycemic control, once diagnosed, using a large, ethnically diverse population-based cohort.
- To determine whether having a history of GDM makes it harder to achieve glycemic control (A1C <7.0%) once a woman is diagnosed with T2DM.

Methodology:

Population-based retrospective cohort of 336,276 women without pre-existing diabetes, drawn from linked NYC birth records (2009–2011), A1C Registry (2009–2017), and SPARCS hospital discharge data who received at least one A1C test during the 9-year follow-up. Primary analysis used time-varying exposure Cox regression stratified by race/ethnicity, with probabilistic bias analysis to account for differential screening and loss to follow-up.

Key Findings:

1. The cumulative incidence of diabetes was 11.8% among women with GDM and 0.6% among those without GDM over 9 years of follow-up.

2. The overall prevalence of GDM at baseline was 6.7% and the highest among South/Southeast Asian women (19.8%) and lowest among White women (4.2%).

3. Women with a history of GDM were 11.5 times more likely to develop T2DM compared to those without (aHR 11.5; 95% CI 10.8–12.3).

4. Racial/ethnic differences were slight; South/Southeast Asian women had the lowest risk (aHR 7.7) despite the highest GDM prevalence, while White and Hispanic women had the highest (aHR 12.5 and 12.2 respectively). Risk was highest in the first 12 weeks to 1 year postpartum and attenuated over time. See Table 1 in the Appendix for full race-stratified and time-interval aHRs.

5. GDM reduced the likelihood of glycemic control overall (aHR 0.85; 95% CI 0.79–0.92), with the largest negative influence among Black and Hispanic women. See Table 1 for full race-stratified glycemic control aHRs.

Conclusion:

GDM across multiple pregnancies raises diabetes risk by more than 11 times. This risk was observed across all racial and ethnic groups but was the lowest among South/Southeast Asian women even though they had the highest rates of GDM. Once diagnosed with diabetes, women with a GDM history were less likely to achieve glycemic control. Black and Hispanic women struggled the most with this, likely due to structural racism and lack of neighborhood resources. New diabetes cases peak in the first year of postpartum, and so does the difficulty in achieving glycemic control. This makes early and consistent postpartum care critical. A GDM diagnosis means more than managing pregnancy. It is an early warning sign that requires lifelong monitoring and a clear intervention plan.

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Racial and Ethnic Inequities in Development of Type 2 Diabetes After Gestational Diabetes Mellitus

Objective:

- To estimate racial and ethnic disparities on how quickly people develop T2DM after a GDM pregnancy, tracked over an 8-year follow-up period.
- Identify which pregnancy-related factors help explain the disparities; clinical factors (such as BMI and high blood pressure) versus social and structural factors (such as insurance status, education, and WIC participation).
- To examine whether the relative importance of these factors differs across racial and ethnic groups.

Methodology:

Retrospective cohort of 22,338 individuals with GDM, drawn from linked NYC birth and hospital data (2009–2011) and A1C Registry data (2009–2017). T2DM was defined as two HbA1C results ≥6.5% from 12 weeks postpartum onward. Pregnancy characteristics were split into clinical (BMI, hypertension, preeclampsia, delivery complications) and social/structural mediators (education, Medicaid insurance, early prenatal care, WIC participation). Cox proportional hazards models estimated 8-year T2DM incidence by race/ethnicity; mediation was assessed using inverse odds ratio weighting (IOW) with bootstrapping (5,000 iterations), and effect modification by race/ethnicity was tested with Holm-Bonferroni correction.

Key Findings:

1. The 8-year cumulative incidence of T2DM was 11.7% overall; highest among Black (18.5%) and South/Southeast Asian (16.8%) individuals, and lowest among East/Central Asian (5.5%) and White (5.4%) individuals.

2. Compared to White individuals, Black individuals had a four-fold increased risk (aHR 4.0, 95% CI: 2.4 - 3.9), South/Southeast Asian a 3.3-fold risk, and Hispanic a 2.9-fold risk. See Table 2 in the Appendix for more information.

3. Clinical and social/structural factors together explained the most disparity among Hispanic individuals (45.8%), followed by Black (26.7%) and South/Southeast Asian (14.1%) individuals. For South/Southeast Asian individuals, social/structural mediators explained more than clinical mediators and the reverse of the pattern seen in Black and Hispanic groups. See Table 2 in the Appendix for more information.

4. Even after accounting for all measured mediators, a large portion of the disparity remains unexplained, suggesting structural racism and chronic stress are likely at play.

5. Education, Medicaid insurance, WIC participation, and BMI were all more strongly associated with T2DM risk among White individuals than among Black, Hispanic, or South/Southeast Asian individuals. See Table 3 in the Appendix for race-stratified associations between pregnancy characteristics and T2DM risk.

Conclusion:

Racial and ethnic disparities in T2DM after GDM are substantial and not fully explained by clinical or social factors alone. Structural racism plays a major role. Closing these gaps will require more than better individual care. It will take policy-level changes that target the root causes of health inequality especially for Black, Hispanic, and South/Southeast Asian communities.

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Preconception HbA1C Levels in Adolescents and Young Adults and Adverse Birth Outcomes

Objective:

- To investigate whether prediabetes before pregnancy increases the risk of GDM and other pregnancy complications among teenagers and young adults.
- To determine the best HbA1c cutoff level for identifying individuals that are at risk for GDM and whether the cutoff differs based on BMI or race and ethnicity.

Methodology:

Retrospective cohort of 14,302 adolescents and young adults (aged 10–24) with no history of diabetes and at least one preconception HbA1c test, drawn from linked NYC birth registry, SPARCS hospital discharge, and HbA1c Registry data for first births (2009–2017). The cohort was predominantly Hispanic and Black with majority having either Medicaid or no insurance. Log-binomial regression estimated aRRs for GDM and secondary outcomes; ROC analysis with the Youden index identified the optimal HbA1c cut-off for GDM, stratified by BMI and race/ethnicity.

Key Findings:

1. Most individuals (79.7%) had normoglycemia before pregnancy; 20.2% had prediabetes. The cumulative incidence of GDM was 6.6%. South/Southeast Asian individuals had the highest preconception prediabetes prevalence (33.8%), followed by Black individuals (27.2%); White individuals had the lowest (9.3%). See Table 4 in the Appendix for full sociodemographic breakdown.

2. Young people with preconception prediabetes had more than twice the risk of developing GDM at their first pregnancy compared to those with normoglycemia (aRR 2.21; 95% CI 1.91–2.56).

3. Preconception prediabetes was also associated with a significant increase in hypertensive disorders of pregnancy (aRR 1.18; 95% CI 1.03–1.35) and preterm delivery (aRR 1.18; 95% CI 1.02–1.37). See Table 5 in the Appendix for all aRRs and CIs across all outcomes.

4. The existing adult threshold of 5.7% had poor sensitivity for identifying GDM in this population (sensitivity 38.9%, specificity 81.1%), meaning it missed over 60% of GDM cases. The optimal cut-off identified by the Youden index was 5.6% (sensitivity 47.9%, specificity 74.6%).

5. The 5.6% threshold did not vary by pre-pregnancy obesity status, though sensitivity was slightly higher among those with obesity/overweight.

6. The optimal threshold was the same (5.6%) for Black, South/Southeast Asian, and White individuals. A slightly lower threshold of 5.5% was optimal for Hispanic individuals (sensitivity 60.4%, specificity 58.5%).

Conclusion:

The current HbA1c threshold of 5.7% misses too many at-risk young people. A lower cutoff of 5.6% or 5.5% for Hispanic individuals is suitable for this age group. Given alarming trends in adolescent obesity and diabetes risk, and the high prevalence of unplanned pregnancies in this age group, these findings support expanded preconception HbA1c screening integrated into routine health services (e.g., annual school checkups) as an opportunity to intervene on cardiometabolic risk earlier in the life course.

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Predictors and Trends in First-Trimester A1c Screening in New York City

Objective:

- To describe the trends in first-trimester HbA1c screening in New York City from 2009 to 2017.
- To identify the sociodemographic and clinical predictors associated with receiving a first-trimester HbA1c screening, and to assess whether screening was appropriately targeted to high-risk populations over time.

Methodology:

Population-based retrospective cohort of 798,312 NYC births (2009–2017), drawn from linked hospital discharge, vital registry, and NYC A1C Registry data (mandated since 2005). Predictors of first-trimester HbA1c screening were examined using adjusted logistic regression, including sociodemographic factors (age, race/ethnicity, nativity, insurance status) and clinical factors (pre-pregnancy BMI, pregestational T2DM, preexisting hypertension, parity, multiple gestation).

Key Findings:

Reference the Appendix: Table 8 -Predictors of A1c screening in first trimester (2009 – 2017) using adjusted multivariable logistic regression

1. The rate of first-trimester HbA1c screening has more than tripled between 2009 and 2017, from 2.3% to 7.7%. Despite rising screening rates, mean HbA1c values among those screened declined from 5.8% (95% CI: 5.8–5.9) in 2009 to 5.3% (95% CI: 5.3–5.4) in 2017, indicating that screening became less targeted to high-risk individuals over time.

2. Pre-pregnancy T2DM was the strongest predictor (aOR 9.5; 95% CI: 8.0 – 11.3), followed by obesity (aOR 2.0; 95% CI: 1.8 – 2.2), and pre-pregnancy hypertension (aOR 1.4; 95% CI: 1.1 – 1.7). Groups least likely to be screened included Hispanic women (aOR 0.86; 95% CI: 0.76 – 0.96), those with Medicaid/no insurance (aOR 0.85; 95% CI: 0.78 – 0.93), and adolescents aged 10–19 years (aOR 0.29; 95% CI: 0.21 – 0.42). See Table 8 in the Appendix for full aORs and CIs.

3. By 2017, pre-pregnancy T2DM, obesity, and older age were no longer significant predictors, indicating screening became less targeted to high-risk clinical factors. Foreign-born status became a positive predictor (aOR 1.3; 95% CI 1.2–1.5). Adolescents remained consistently the least likely to be screened across the entire study period. See Figure 1 in the Appendix for the full trend in predictor shifts from 2009 to 2017.

Conclusion:

While first trimester HbA1c screening expanded significantly over the study period, it shifted away from targeting high-risk patients, as shown by a steady decline in mean HbA1c values. As screening expanded, GDM rates rose, which indicated a missed opportunity to identify and intervene early. Adolescents, Hispanic women, and those on Medicaid remained consistently unscreened throughout the study period. Closing these gaps requires more targeted and equitable screening practices, especially for those at the highest risk.

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Prospective Transitions in Hemoglobin A1c following Gestational Giabetes using Multistate Markov Models

Objective:

- To characterize how HbA1c levels transition between normoglycemia, prediabetes, controlled diabetes, and uncontrolled diabetes over up to 9 years following a GDM pregnancy.
- To identify sociodemographic and perinatal predictors of these transitions to inform targeted postpartum monitoring.

Methodology:

Population-based retrospective cohort of 34,171 individuals with GDM (2009–2017) and at least 2 postpartum HbA1c tests after 12 weeks, drawn from linked NYC birth records, A1C Registry, and SPARCS data. 44% of GDM individuals lacked repeat postpartum testing. HbA1c states were defined as no diabetes (<5.7%), prediabetes (5.7–<6.5%), controlled diabetes (6.5–<7.0%), and uncontrolled diabetes (≥7.0%); reversion to a pre-disease state once in diabetes was not permitted. Multistate Markov models were used to track how individuals moved between HbA1c states every 12 months. The model estimated how likely each transition was, how long people stayed in each state on average, and which sociodemographic and perinatal predictors drive these changes.

Key Findings:

1. Baseline HbA1c Distribution (Year 1 Postpartum): 45.1% no diabetes, 43.1% prediabetes, 4.6% controlled diabetes, and 7.2% uncontrolled diabetes. See Table 9 in the Appendix for further information.

2. Mean Sojourn Times & Transition Probabilities: Most individuals stayed in the same state between years. Uncontrolled diabetes had the longest average stay (2.3 years), and large jumps between states were rare. See Table 10 and Figure 2 in the Appendix for sojourn times and full transition probabilities.

3. Sociodemographic Predictors: Black individuals had the highest risk of transitioning from prediabetes to uncontrolled diabetes (aHR 2.32; 95% CI: 1.21 – 4.47), noted to be the largest disparity in the study. Medicaid insurance was associated with a lower likelihood of advancing to diabetes. See Table 11 in the Appendix for all aHRs.

4. Perinatal Predictors: Pre-pregnancy obesity (aHR 1.48; 95% CI: 1.35 – 1.62) for No diabetes to Prediabetes) and hypertensive disorders of pregnancy (aHR 2.06; 95% CI: 1.39 – 3.05) for prediabetes to uncontrolled diabetes were the strongest risk factors. Exclusive breastfeeding was the only protective perinatal factor. See Table 11 in the Appendix for all aHRs across all transition stages.

Conclusion:

HbA1c transitions following a GDM pregnancy shift gradually, with most transitions occurring in small, incremental steps rather than large jumps. People of color were more likely to move to a higher HbA1c level and less likely to improve. Those with pre-pregnancy obesity or hypertension disorders faced the greatest risk and require closer postpartum monitoring. Intervening early at each stage of disease progression, rather than waiting for diabetes diagnosis, offers the best chance at better long-term health.

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Social Determinants of Health and Recommended HbA1c Monitoring Among Women with Postpartum-onset Diabetes: Results from a Retrospective Cohort

Objective:

- To explore the association between social determinants of health (SDOH) and receipt of recommended follow-up HbA1c testing among postpartum women with diabetes.

Methodology:

Retrospective population-based cohort of 5,590 women who delivered in NYC between 2009 – 2016 and developed postpartum-onset diabetes. The SDOH included race/ethnicity, nativity, insurance status, nutrition program enrollment, education, and parity. Cox proportional hazards regression estimated time to first follow-up HbA1c test and Poisson regression estimated rate of HbA1c testing over three years.

Key Findings:

1. Only 13.0% of women received biannual recommended follow-up HbA1c tests over the study period.

2. Non-Hispanic Black women were more likely to receive their first follow-up test later (aHR 0.90; 95% CI 0.80 - 1.00) and experienced a lower rate of testing over three years (aRR 0.92; 95% CI 0.84 - 0.99) compared to non-Hispanic White women. See Table 13 and 14 in the Appendix for more information.

3. Women with Medicaid Insurance at delivery had a higher likelihood of an earlier first follow-up test (aHR 1.14; 95% CI 1.06 - 1.22) and higher rates of testing (aRR 1.09; 95% CI 1.03 - 1.15) than those with private insurance.

4. Women with more children experienced lower rates of testing and longer time to first HbA1c test compared to those with no prior children.

Conclusion:

Most women with postpartum diabetes did not get the HbA1c follow-up testing they needed. Black women in particular faced the greatest gap in timely monitoring. Medicaid insurance showed a protective effect which may suggest that disparities in transition to primary care also affect privately insured women. It is possible that some programs within Medicaid-insured populations have improved access to A1C testing. Caring for children may act as a barrier to ongoing A1C monitoring. Further efforts are required to understand how structural interventions can improve access to routine diabetes care.

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**Neighborhood Walkability and the Development of Type 2 Diabetes Mellitus After Gestation Diabetes: A Longitudinal Study in New York City

Objective:

- To examine whether neighborhood walkability is associated with the risk of developing T2DM after a GDM pregnancy, and whether the association is modified by neighborhood economic deprivation.

Methodology:

Retrospective longitudinal cohort of 12,403 women with GDM drawn from linked NYC birth and hospital discharge data (2009 – 2011) and followed until end of 2021. T2DM was defined as two HbA1C tests >= 6.5% after 12 weeks postpartum. Women with pre-pregnancy diabetes were excluded. Neighborhood walkability was the primary exposure, with walkability comparison in disadvantaged versus affluent neighborhoods examined as an effect modifier. Cox regression was used to estimate aHRs.

Key Findings:

1. The 12-year cumulative incidence of T2DM was 20.6%

2. More walkable neighborhoods were associated with lower T2DM risk, but no consistent dose-response effect was observed. Adjusted hazard ratios of type 2 diabetes for those living in low-medium (aHR=0.89, 95% CI 0.76, 1.04), medium (aHR=0.85, 95% CI 0.74, 0.99), and high (aHR=0.88, 95% CI 0.76, 1.03) walkability neighborhoods compared to low walkability were protective or null. The protective association from high walkability was observed only in the most affluent neighborhoods (aHR=0.52, 95% CI 0.31, 0.89) but was not found in other socioeconomic condition strata.

3. The protective effect of high walkability was only significant in the most affluent neighborhoods and not in lower socioeconomic strata indicating that neighborhood economic deprivation can cancel out benefits of walking.

Conclusions:

Among women with GDM, higher neighborhood walkability was associated with lower rate of type 2 diabetes, particularly among those living in less economically deprived neighborhoods. However, the lack of a dose-response pattern and attenuation among participants with Medicaid coverage or greater neighborhood deprivation suggests that this benefit may be selective. Built environment improvements should be paired with efforts to address broader socioeconomic barriers to healthy behaviors.

**Pre-pregnancy BMI, Rate of Gestational Weight Gain, and type 2 diabetes after gestational diabetes

Objective:

- To examine if pre-pregnancy BMI and rate of gestational weight gain (GWG) are associated with T2DM after a GDM pregnancy.

Methodology:

Retrospective longitudinal cohort of 12,201 women with GDM drawn from linked NYC birth and hospital discharge, and HbA1c Registry data (2016 – 2017) followed until end of 2021. T2DM was defined as two HbA1C tests >= 6.5% after 12 weeks postpartum and prediabetes as two HbA1c tests >= 5.7%. Women with pre-pregnancy diabetes were excluded. The underweight group was also excluded due to the small sample size. Analyses were stratified by pre-pregnancy BMI categories (healthy weight, overweight, and obesity).

Key Findings:

1. The 6-year cumulative incidence of T2DM was 8.1% and the combined cumulative incidence of prediabetes and T2DM was 29.3%

2. There was no association observed between the rate of GWG (across all BMI strata) and risk of either T2DM or prediabetes after a GDM pregnancy.

Conclusions:

Among women with GDM, little association was found between rate of GWG and prediabetes and T2DM, or between rate of GWG and T2DM, within strata of pre-pregnancy BMI. Our findings indicate that long-term glycemic health may be shaped more by pre-pregnancy BMI than by weight gain during pregnancy. Supporting women's metabolic health before pregnancy may therefore be important for reducing future diabetes risk.

** Neighborhood Typology and Postpartum Glycemic Outcomes Among Women with GDM in New York City: A Longitudinal Study

Objective:

- To examine whether neighborhood profile is associated with postpartum HbA1c levels among women with a GDM pregnancy.

Methodology:

Retrospective longitudinal cohort of 13,231 women with GDM drawn from linked NYC birth and hospital discharge data (2009 – 2011) and followed until end of 2021. T2DM was defined as two HbA1C tests >= 6.5% after 12 weeks postpartum. Women with pre-pregnancy diabetes were excluded. Latent profile analysis was applied to 10 social and built environment characteristics to classify neighborhoods into 7 distinct profiles. The profile with the most average characteristics was used as the reference.

Key Findings:

1. The cumulative incidence rate for T2DM was 20.5% at the end of the study period.

2. Neighborhood profile were associated with postpartum HbA1c levels. Profile 7 had the lowest population-average HbA1c level (5.85; 95% CI 5.78 - 6.00) and Profile 3 had the highest (6.06; 95% CI: 5.96 - 6.15).
   See Figure 3 in the Appendix for more information.

3. Compared to Profile 5, HbA1c levels were significantly lower in 1.93 percentage points lower in Profile 1, 1.98 percentage points lower in Profile 4 and 2.48 percentage points lower in Profile 7.

Conclusions:

NYC census blocks were classified into seven distinct neighborhood profiles using LPA of social and built environment indicators. Linked with the APPLE cohort of women with GDM, findings showed that glycemic outcomes varied across multidimensional neighborhood profiles. Urban health strategies should therefore move beyond single-exposure interventions toward integrated approaches addressing combined social and built environmental conditions.

** Artificial Light at Night and Postpartum HbA1C Trajectories Among Women with Gestational Diabetes in New York City: A Longitudinal Study

Objective:

- To examine whether exposure to outdoor artificial light at night (ALAN) is associated with postpartum HbA1c levels among women with GDM pregnancy.
- To investigate if change in outdoor ALAN is an environmental risk factor to metabolic health.

Methodology:

Retrospective longitudinal cohort of 10,739 women with GDM drawn from linked NYC birth and hospital discharge, and HbA1c Registry data (2012 – 2013) followed until end of 2021. T2DM was defined as two HbA1C tests >= 6.5% after 12 weeks postpartum and prediabetes as two HbA1c tests >= 5.7%. Women with pre-pregnancy diabetes were excluded. Outdoor ALAN exposure (2012 – 2021) was derived from the Earth Observation Group VIIRS Annual VNL V2 nighttime light product. ALAN quintiles were defined using the pooled 10-year distribution across eligible census blocks with >30 residents.

Key Findings:

1. A dose response relationship was observed between outdoor ALAN exposure and postpartum HbA1c levels.

2. Population average HbA1c ranged from 5.84% in the lowest ALAN quintile to 5.93% in the highest quintile.

3. Compared with the highest ALAN quintile, lower quintiles had progressively lower A1C estimates (Low ALAN, percentage difference [β]: -1.54%, 95% CI -2.58%, -0.49%; Low-medium ALAN, β: -1.04%, 95% CI -1.87%, -0.21%; Medium ALAN, β: -0.98%, 95% CI -1.66%, -0.31%; Medium-high ALAN, β: -0.31%, 95% CI -0.88%, 0.27%).

4. Reducing excessive outdoor ALAN may represent a modifiable strategy to improve metabolic health at the population level.

Conclusions:

Among women with GDM in NYC, higher outdoor ALAN exposure was associated with higher postpartum A1C levels, with a slight dose-response pattern. Associations with both concurrent and prior ALAN suggest a potential sustained influence of light pollution exposure. Although measured outdoor ALAN levels may be too low to directly affect metabolism, they may reflect broader urban or lifestyle factors related to circadian disruption. Public health and urban policies should consider cumulative light pollution exposure among high-risk populations.

Appendix

Table 1 – Influence of time varying GDM on time to diabetes using time-varying exposure Cox regression, adjusted for sociodemographic and clinical covariates

	Diabetes risk		Glycemic control among women with postpartum-onset diabetes	
	GDM vs. non-GDM HR	95% CI	GDM vs. non-GDM HR	95% CI
Unadjusted model	16.3	15.4, 17.3	0.87	0.81, 0.93
Adjusted model	11.5	10.8, 12.3	0.85	0.79, 0.92
Adjusted model stratified by race/ethnicity				
Black	10.3	9.2, 11.5	0.77	0.68, 0.88
East/Central Asian	13.9	7.1, 12.2	1.45	0.95, 1.20
Hispanic	12.2	10.9, 13.5	0.84	0.74, 0.95
South/Southeast Asian	7.7	6.1, 9.6	0.96	0.76, 1.22
White	12.5	10.0, 15.6	0.90	0.70, 1.17
Adjusted model stratified by postpartum time interval				
12 weeks to 1 year	14.0	11.9, 16.6	0.88	0.80, 0.97
1.1–3 years	9.7	8.6, 10.9	0.93	0.68, 1.28
3.1–5 years	9.4	8.3, 10.6	0.93	0.68, 1.23
5.1–9 years	8.7	7.7, 9.8	1.25	0.65, 2.43

Adjusted covariates included time-varying GDM pregnancy, race/ethnicity, age (5-year age-groups), nativity, educational attainment, insurance status, whether prenatal care in the first trimester was received, prepregnancy BMI, parity at the time of the index pregnancy, preexisting/chronic hypertension, hypertensive disorders of pregnancy, macrosomia, infant shoulder dystocia during delivery, preterm birth, and cesarean delivery, as tests for interaction between GDM and race/ethnicity were significant in both models of diabetes.

Table 2 – Cumulative Incidence of Type 2 Diabetes Stratified by Race and Ethnicity and Percentage of Effect Explained by Pregnancy Characteristics

Race and Ethnicity	Type 2 Diabetes		Adjusted HR (95% CI) Effect of Race and Ethnicity*		Percentage of Disparity (95% CI) Explained by†		
	Total	Cumulative Incidence	Total Effect	Direct Effect Not Through Social or Structural and Clinical Mediators	Clinical Mediators‡	Social or Structural Mediators§	Social or Structural and Clinical Mediators
Black	4,687	866 (18.8)	4.0 (2.4–3.9)	2.8 (2.0–3.3)	23.8 (12.9–29.9)	9.3 (4.0–16.5)	26.7 (11.5–32.5)
East and Central Asian‖	2,450	143 (5.5)	1.0 (0.9–1.4)		NA	NA	NA
Hispanic	7,062	1,029 (14.6)	2.9 (2.4–3.3)	1.8 (1.4–2.2)	31.2 (15.4–39.4)	24.7 (13.9–36.7)	45.8 (28.6–58.0)
South or Southeast Asian	2,429	408 (16.8)	3.3 (2.7–4.2)	2.8 (2.1–3.8)	7.6 (1.8–18.8)	16.3 (9.6–23.8)	14.1 (3.9–24.8)
White	4,225	230 (5.4)	1.00	1.00	1.00	1.00	1.00

HR, hazard ratio; NA, not applicable.
Data are n or n (%) unless otherwise specified.
* All models are adjusted for age and nativity.
† Percentage of total effect explained by mediators was calculated using the following equation: [total effect−direct effect (weighted by inverse odds ratio weight)]/total effect, where the total effect is the effect estimate unadjusted by mediators, direct effect is the proportion of effect not explained through mediators (as applied in inverse odds ratio weight), and the difference between total and direct effect is the indirect effect (the decomposed effect operating through mediators). The percent effect mediated was measured on the log scale; bootstrapping was used to obtain SEs for 95% CI calculation.
‡ Preeclampsia, prepregnancy body mass index, prehypertension, gestational hypertension, preterm, caesarean vs vaginal delivery, exclusive breastfeeding at hospital discharge (yes or no), macrosomia, and neonatal shoulder dystocia during delivery.
§ Maternal education (less than college degree vs college or higher), Medicaid insurance or none vs private insurance, timely antenatal care (within first trimester), and enrollment in WIC (Special Supplemental Nutrition Program for Women, Infants, and Children).
‖ Mediation analysis not conducted on East and Central Asian vs White HR because of a lack of disparity.

Table 3 – Associations Between Pregnancy Characteristics and Type 2 Diabetes After Gestational Diabetes for Characteristics for Which Effect Modification is Present by Race and Ethnicity

Characteristic	Adjusted HR (95% CI)*			
	Black	Hispanic	South or Southeast Asian	White
Education level				
Less than college degree	1.3 (1.1–1.5)	1.4 (1.2, 1.6)	1.7 (1.4–2.1)	2.7 (2.2–3.6)
College degree or higher	1	1	1	1
Insurance				
Medicaid or none	1.1 (0.9–1.3)	1.6 (1.3–1.9)	1.5 (1.1–1.9)	3.6 (2.6–4.9)
Private insurance	1	1	1	1
WIC participation				
Yes	1.3 (1.1–1.5)	1.5 (1.3–1.8)	1.5 (1.2–1.9)	2.8 (2.1–3.7)
No	1	1	1	1
BMI	1.05 (1.04–1.06)	1.07 (1.06–1.08)	1.10 (1.08–1.12)	1.13 (1.11–1.15)

HR, hazard ratio; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children; BMI, body mass index.
* All models adjusted for 5-year age group and nativity.

Table 4 – Sociodemographic Characteristics of Birth Control by Preconception HbA1c Risk Level

Characteristic	Participants, No. (%)		
	Normoglycemia (n = 11 407)	Prediabetes (n = 2895)	Total (N = 14 302)
HbA_{1c} level, mean (SD), %	5.29 (0.25)	5.83 (0.49)	5.4 (3.2)
Age, mean (SD), y	22.10 (1.55)	22.10 (1.56)	22.10 (1.55)
Time lapse, mo[b]	12.7 (12.0)	12.6 (12.3)	12.7 (12.1)
Age group, y			
10-19	693 (78.5)	190 (21.5)	883 (6.2)
20-24	10 714 (79.8)	2705 (20.2)	13 419 (93.8)
Race and ethnicity			
Asian (all)	1084 (71.5)	432 (28.5)	1516 (10.6)
Asian (South/Southeast)	569 (66.2)	291 (33.8)	860 (6.01)
Black	3019 (72.8)	1130 (27.2)	4149 (29.0)
Hispanic	4823 (82.2)	1046 (17.8)	5869 (41.0)
White	2342 (90.7)	241 (9.3)	2583 (18.1)
Other or unknown[c]	139 (75.1)	46 (24.9)	185 (1.3)
Nativity			
US born	7345 (80.7)	1759 (19.3)	9104 (63.7)
Born outside the US	4062 (78.2)	1136 (21.9)	5198 (36.3)
Education level			
Less than high school	2013 (78.3)	559 (21.7)	2572 (18.0)
High school completion	3777 (80.1)	939 (19.9)	4716 (33.1)
Some college	3426 (78.5)	941 (21.6)	4367 (30.6)
College degree or higher	2156 (82.8)	448 (17.2)	2604 (18.3)
Insurance			
Medicaid or none	9125 (79.3)	2381 (20.7)	11 506 (80.5)
Private insurance	2186 (81.8)	486 (18.2)	2672 (18.7)
Prepregnancy body mass index[d]			
Underweight (<18.5)	725 (85.6)	122 (14.4)	847 (5.9)
Normal weight (18.5 to <25.0)	5337 (84.3)	992 (15.7)	6329 (44.3)
Overweight (25.0 to <30.0)	2854 (79.2)	750 (20.8)	3604 (25.2)
Obesity (≥30.0)	2440 (70.6)	1014 (29.4)	3454 (24.2)
Prepregnancy hypertension			
No	11 216 (80.0)	2805 (20.0)	14 021 (98.0)
Yes	191 (68.0)	90 (32.0)	281 (2.0)
Gestational diabetes at first live birth			
No	10 833 (81.1)	2529 (18.9)	13 362 (93.4)
Yes	574 (61.1)	366 (38.9)	940 (6.6)
Smoking (3 mo before pregnancy)			
No	11 100 (79.8)	2816 (20.2)	13 916 (97.3)
Yes	296 (78.9)	79 (21.1)	375 (2.6)
Alcohol use (during this pregnancy)			
No	11 287 (79.8)	2858 (20.2)	14 145 (98.9)
Yes	79 (71.2)	32 (28.8)	111 (0.80)

Abbreviation: HbA_{1c}, hemoglobin A_{1c}.

SI conversion factor: To convert HbA_{1c} to proportion of total hemoglobin, multiply by 0.01.

[a] Sample consists of individuals who received an HbA_{1c} test before first pregnancy that resulted in live birth. Normoglycemia is defined as HbA_{1c} less than 5.7%. Prediabetes is defined as HbA_{1c} greater than or equal to 5.7% and less than 6.5%.

[b] Pregnancy start date to last preconception test date.

[c] Other or unknown categories includes Alaska Native, American Indian, Pacific Islander, multiple races, don't know, or not reported.

[d] Calculated as weight in kilograms divided by height in meters squared.

Table 5 – aRR of Gestational Diabetes and Adverse Birth Outcomes at First Birth Among Individuals by Preconception Diabetes Risk Threshold, Generalized Linear Models With Logit Link

Outcome	aRR (95% CI)			
	HbA_{1c} 5.7% to <6.5%	HbA_{1c} 5.6% to <6.5%	HbA_{1c} 5.5% to <6.5%	HbA_{1c} 5.1% to <6.5%
Gestational diabetes first birth	2.21 (1.91-2.56)	2.14 (1.86-2.46)	1.95 (1.69-1.26)	1.30 (1.01-1.66)
Hypertensive disorders of pregnancy	1.18 (1.03-1.35)	1.23 (1.09-1.39)	1.18 (1.05-1.32)	1.13 (0.94-1.37)
Preterm delivery	1.18 (1.02-1.37)	1.16 (1.02-1.32)	1.13 (1.00-1.28)	0.86 (0.72-1.04)
Cesarean delivery	1.09 (0.99-1.20)	(1.04 (0.95-1.13)	1.07 (0.99-1.15)	1.06 (0.94-1.20)
Macrosomia	1.13 (0.93-1.37)	1.21 (1.02-1.43)	1.22 (1.04-1.43)	1.23 (0.94-1.59)

Abbreviations: aRR, adjusted relative risk; HbA_{1c}, hemoglobin A_{1c}.

SI conversion factor: To convert HbA_{1c} to proportion of total hemoglobin, multiply by 0.01.

[a] Adjusted for age, race and ethnicity, nativity, education, insurance, prepregnancy body mass index category, chronic hypertension, smoking (3 months before pregnancy), alcohol use in pregnancy, and time lapse from last HbA_{1c} test.

Table 6 – Cutoff Point Estimates for Preconception HbA1c Levels in Estimation of Gestational Diabetes at First Birth Among Participants by pre-pregnancy Body Mass Index

Example lower bound HbA_{1c} cutoff points (upper bound <6.5%)	Overall[a]		Obesity or overweight[b]		Normal weight[c]		Underweight[d]	
	Sensitivity, %	Specificity, %	Sensitivity, %	Specificity, %	Sensitivity, %	Specificity, %	Sensitivity, %	Specificity, %
5.1%	92.2	12.5	94.8	10.7	89.1	14.2	79.4	13.5
5.5%	63.9	57.6	71.1	52.1	57.4	62.4	32.4	61.7
5.6%[e]	47.9[e]	74.6[e]	59.3[e]	65.0[e]	47.9[e]	74.6[e]	20.6[e]	76.3[e]
5.7%	38.9	81.1	42.2	46.2	34.3	85.3	17.7	85.7
5.9%	20.1	94.1	26.2	91.5	19.0	95.6	5.8	96.3

Abbreviation: HbA_{1c}, hemoglobin A_{1c}.

SI conversion factor: To convert HbA_{1c} to proportion of total hemoglobin, multiply by 0.01.

[a] Youden index, 1.23; closest top left, 0.336; and area under the curve, 0.648 (95% CI, 0.629-0.667).

[b] Youden index, 1.24; closest top left, 0.288; and area under the curve, 0.664 (95% CI, 0.641-0.678).

[c] Youden index, 1.23; closest top left, 0.336; and area under the curve, 0.634 (95% CI, 0.645-0.678).

[d] Youden index, 1.05; closest top left, 0.783; and area under the curve, 0.490 (95% CI, 0.388-0.593).

[e] Indicates optimal cutoff point, or the threshold that maximizes both sensitivity and specificity.

Table 7 – Cutoff Point Estimates for Preconception HbA1c Levels in Estimation of Gestational Diabetes at First Birth Among Participants by Race and Ethnicity

Example lower bound HbA_{1c} cutoff points (upper bound <6.5%)	Black[a]		Hispanic[b]		South and Southeast Asian[c]		White[d]	
	Sensitivity, %	Specificity, %	Sensitivity, %	Specificity, %	Sensitivity, %	Specificity, %	Sensitivity, %	Specificity, %
5.1%	93.0	11.3	90.4	12.8	96.9	4.5	89.0	17.3
5.5%	72.5	49.9	60.4	58.5	75.4	40.1	51.7	73.3
5.6%	62.0	62.1	47.2	71.5	66.2	57.4	42.4	84.0
5.7%	46.7	73.8	31.5	83.0	45.9	75.2	26.8	35.0
5.9%	31.9	89.9	19.5	94.6	29.2	90.5	13.6	97.9

Abbreviation: HbA_{1c}, hemoglobin A_{1c}.

SI conversion factor: To convert HbA_{1c} to proportion of total hemoglobin, multiply by 0.01.

[a] Youden index, 1.20; closest top left, 0.288; and area under the curve, 0.664 (95% CI, 0.625-0.703).

[b] Youden index, 1.19; closest top left, 0.329; and area under the curve, 0.626 (95% CI, 0.593-0.659).

[c] Youden index, 1.24; closest top left, 0.378; and area under the curve, 0.648 (95% CI, 0.602-0.695).

[d] Youden index, 1.26; closest top left, 0.358; and area under the curve, 0.664 (95% CI, 0.608-0.720).

Table 8 – Predictors of HbA1C Screening in First Trimester Using Adjusted Multivariable Logistic Regression Among Pregnant Women in NYC, by Year (2009 – 2017)

	2009 aOR	2010 aOR	2011 aOR	2012 aOR	2013 aOR	2014 aOR	2015 aOR	2016 aOR	2017 aOR
Age group (y)									
20–29	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10–19	0.29 (0.21, 0.42)	0.38 (0.29, 0.51)	0.46 (0.38, 0.57)	0.48 (0.40, 0.58)	0.60 (0.51, 0.71)	0.51 (0.43, 0.61)	0.57 (0.48, 0.67)	0.52 (0.43, 0.62)	0.69 (0.55, 0.87)
30–39	1.26 (1.15, 1.38)	1.07 (0.99, 1.17)	0.96 (0.89, 1.03)	0.92 (0.86, 0.98)	0.90 (0.84, 0.96)	0.84 (0.78, 0.89)	0.79 (0.74, 0.84)	0.78 (0.73, 0.84)	0.72 (0.66, 0.79)
40+	1.34 (1.14, 1.59)	1.11 (0.95, 1.30)	1.09 (0.95, 1.25)	0.96 (0.84, 1.10)	0.88 (0.77, 1.01)	0.66 (0.57, 0.77)	0.67 (0.58, 0.77)	0.61 (0.53, 0.71)	0.49 (0.40, 0.61)
Race/ethnicity									
White NH	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Asian	1.47 (1.29, 1.67)	1.22 (1.08, 1.37)	1.09 (0.98, 1.21)	1.28 (1.16, 1.42)	1.21 (1.09,1.33)	1.05 (0.95, 1.15)	1.17 (1.07, 1.28)	1.08 (0.99, 1.18)	0.98 (0.87, 1.11)
Hispanic	0.86 (0.76, 0.96)	0.77 (0.69, 0.85)	0.83 (0.76, 0.91	1.14 (1.04, 1.24)	1.25 (1.15, 1.36)	1.07 (0.98, 1.16)	1.10 (1.01, 1.20)	0.98 (0.91, 1.07)	0.94 (0.84, 1.06)
Black NH	1.06 (0.94, 1.19)	0.83 (0.74, 0.93)	1.06 (0.96, 1.16)	1.40 (1.30, 1.56)	1.26 (1.15, 1.38)	1.08 (0.99, 1.18)	1.11 (1.01, 1.21)	0.98 (0.90, 1.07)	0.96 (0.85, 1.09)
Other/unknown	1.42 (1.23, 1.80)	1.32 (1.04, 1.66)	1.06 (0.80, 1.41)	1.24 (0.94, 1.64)	1.19 (0.91, 1.56)	0.86 (0.66, 1.13)	1.09 (0.85, 1.39)	1.00 (0.78, 1.29)	0.92 (0.66, 1.28)
Nativity									
U.S. born	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Foreign born	0.94 (0.86, 1.02)	1.00 (0.92, 1.09)	0.98 (0.91, 1.05)	1.04 (0.97, 1.11)	0.98 (0.92, 1.05)	1.05 (0.98, 1.12)	1.07 (1.00, 1.14)	1.16 (1.09, 1.24)	1.34 (1.22, 1.47)
Insurance									
Private	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Medicaid or none	0.85 (0.78, 0.93)	0.72 (0.66, 0.78)	0.82 (0.76, 0.88)	0.79 (0.73, 0.84)	0.84 (0.78, 0.90)	0.93 (0.87, 1.00)	1.02 (0.95, 1.10)	1.08 (1.00, 1.15)	1.07 (0.97, 1.18)
Previous live birth									
0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1	1.11 (1.01, 1.22)	1.10 (1.01, 1.20)	1.12 (1.04, 1.21)	1.09 (1.01, 1.17)	1.02 (0.94, 1.10)	1.03 (0.96, 1.12)	1.02 (0.94, 1.10)	1.04 (0.96, 1.12)	1.00 (0.90, 1.13)
2	1.16 (1.03, 1.31)	1.17 (1.04, 1.32)	1.15 (1.04, 1.28)	1.01 (0.91, 1.13)	1.00 (0.90, 1.11)	0.93 (0.83, 1.04)	0.89 (0.79, 1.00)	1.02 (0.91, 1.15)	0.98 (0.83, 1.16)
3+	0.98 (0.85, 1.13)	1.15 (1.01, 1.31)	1.04 (0.91, 1.18)	1.07 (0.94, 1.22)	0.97 (0.85, 1.12)	1.04 (0.90, 1.21)	0.87 (0.74, 1.03)	1.05 (0.89, 1.23)	1.10 (0.88, 1.37)
Multiple gestation pregnancy									
No	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Yes	0.98 (0.75, 1.28)	0.84 (0.64, 1.09)	0.94 (0.76, 1.17)	0.90 (0.73, 1.11)	0.92 (0.75, 1.13)	0.69 (0.54, 0.87)	0.97 (0.79, 1.19)	0.76 (0.61, 0.96)	0.80 (0.59, 1.09)
Prepregnancy T2DM									
No	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Yes	9.48 (7.96, 11.29)	3.45 (2.75, 4.34)	2.09 (1.63, 2.68)	1.61 (1.21, 2.13)	1.62 (1.22, 2.14)	1.54 (1.16, 2.04)	1.37 (1.02, 1.85)	1.08 (0.77, 1.50)	1.40 (0.94, 2.08)
Prepregnancy HT									
No	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Yes	1.38 (1.13, 1.69)	1.11 (0.88, 1.38)	1.14 (0.93, 1.40)	1.16 (0.94, 1.45)	1.01 (0.81, 1.26)	1.20 (0.98, 1.48)	0.90 (0.72, 1.13)	0.74 (0.59, 0.94)	0.94 (0.69, 1.27)
BMI categories									
Normal weight	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Underweight	0.87 (0.70, 1.07)	0.89 (0.74, 1.08)	0.81 (0.70, 0.95)	0.81 (0.70, 0.94)	0.79 (0.69, 0.92)	0.87 (0.76, 1.00)	0.93 (0.82, 1.05)	0.92 (0.81, 1.04)	1.09 (0.92, 1.30)
Overweight	1.48 (1.34, 1.64)	1.23 (1.12, 1.35)	1.12 (1.03, 1.21)	1.09 (1.01, 1.17)	1.20 (1.11, 1.28)	1.17 (1.09, 1.26)	1.10 (1.03, 1.18)	1.10 (1.02, 1.18)	1.11 (1.00, 1.22)
Obese	1.95 (1.75, 2.17)	1.75 (1.59, 1.94)	1.36 (1.24, 1.48)	1.21 (1.11, 1.32)	1.13 (1.04, 1.23)	1.13 (1.04, 1.23)	1.03 (0.94, 1.12)	1.06 (0.98, 1.16)	1.03 (0.91, 1.16)

Abbreviations: aOR, adjusted odds ratio; BMI, body mass index; HT, hypertension; NYC, New York City; T2DM, type 2 diabetes mellitus.

[a]Multivariable models mutually adjusted for all predictors to identify the predictors of largest relative influence on A1c screening in the first trimester. Reference categories were the following: age groups: 10–19, 30–39, and 40+ years compared to 20–29 years; parity: one, two, or three or more births compared to no prior births; insurance: Medicaid/none vs. private; nativity (foreign-born vs. US born); racial/ethnic groups: Black non-Hispanic (NH), Hispanic, Asian and other/unknown was White NH women; multiple gestation vs. singleton pregnancy; BMI: body mass index (kg/m^2) categories included underweight (<18.5), overweight (25.0–29.9), and obese (30+) as compared to the normal weight reference category (18.5–24.9); prepregnancy hypertension and prepregnancy T2DM were compared to the absence of either condition.

Figure 1 – Predictors of A1c screening in first trimester using unadjusted and multivariable logistic regression among pregnant women in NYC, by year (2009–2017).

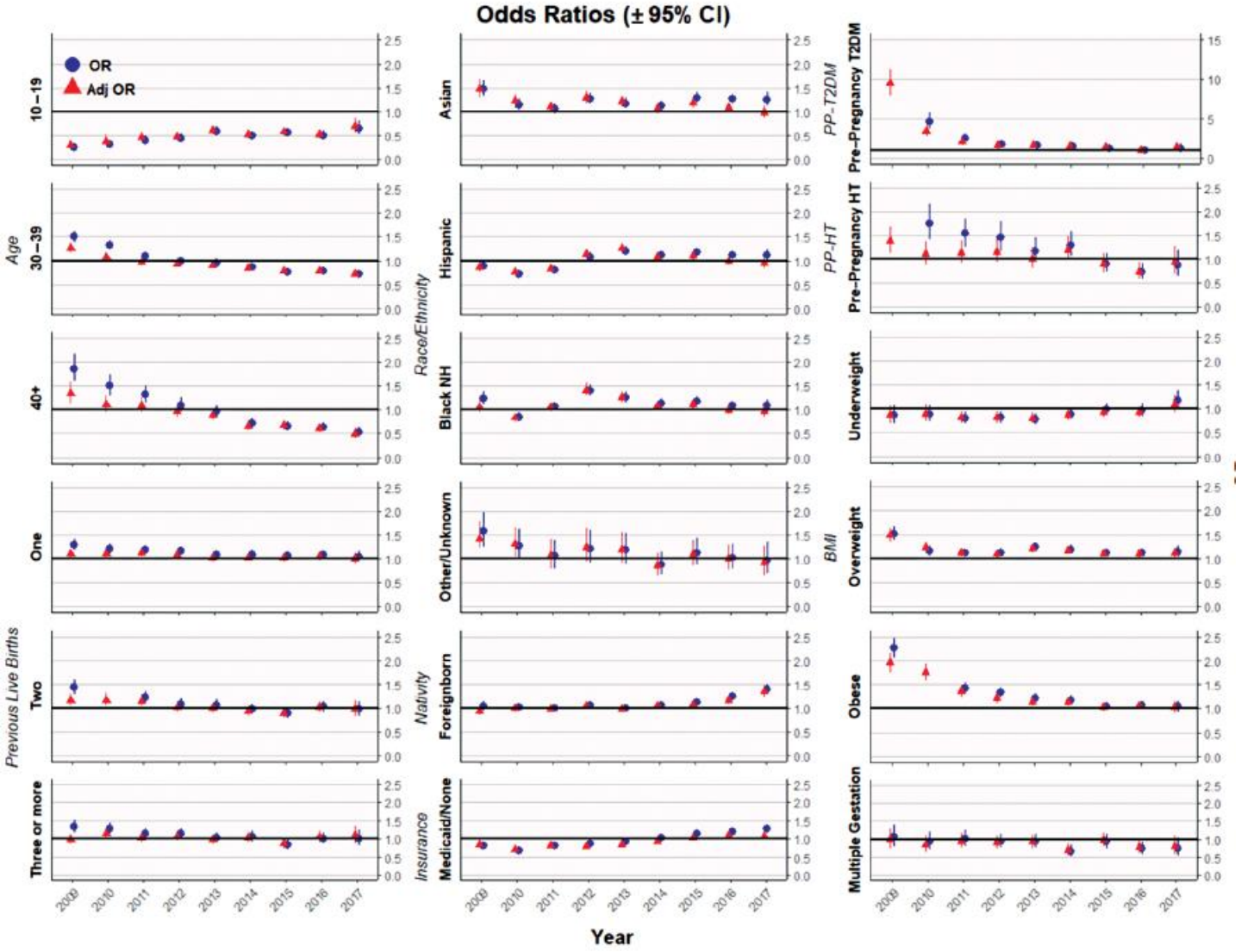

FIG. 1 PREDICTORS OF A1C SCREENING IN FIRST TRIMESTER USING UNADJUSTED AND MULTIVARIABLE LOGISTIC REGRESSION AMONG PREGNANT WOMEN IN NYC, BY YEAR (2009–2017). NOTES: 1MULTIVARIABLE MODELS MUTUALLY ADJUSTED FOR ALL PREDICTORS TO IDENTIFY THE PREDICTORS OF LARGEST RELATIVE INFLUENCE ON A1C SCREENING IN THE FIRST TRIMESTER. REFERENCE CATEGORIES WERE THE FOLLOWING: AGE GROUPS: 10 TO 19, 30 TO 39, AND 40Þ YEARS COMPARED TO 20 TO 29 YEARS; PARITY: ONE, TWO OR THREE, OR MORE BIRTHS COMPARED TO NO PRIOR BIRTHS; INSURANCE: MEDICAID/NONE VERSUS PRIVATE; NATIVITY (FOREIGN BORN VS. U.S. BORN); RACIAL/ETHNIC GROUPS: BLACK NON-HISPANIC (NH), HISPANIC, ASIAN, AND OTHER/UNKNOWN WERE WHITE NH WOMEN; MULTIPLE GESTATION VERSUS SINGLETON PREGNANCY; BMI: BODY MASS INDEX (KG/M2) CATEGORIES INCLUDED UNDERWEIGHT (<18.5), OVERWEIGHT, (25.0–29.9) AND OBESE (30Þ) AS COMPARED TO THE NORMAL WEIGHT REFERENCE CATEGORY (18.5–24.9); PRE-PREGNANCY HYPERTENSION AND PRE-PREGNANCY TYPE 2 DIABETES (T2DM) WERE COMPARED TO THE ABSENCE OF EITHER CONDITION.

Table 9 – Sociodemographic and clinical characteristics by diabetes state during the first year postpartum among persons with GDM at baseline, 2009 – 2017 (n = 34,171)

	No diabetes (A1c < 5.7%) n = 15425	Prediabetes (5.7 ≤ A1c < 6.5%) n = 14729	Controlled diabetes (6.5 ≤ A1c < 7%) n = 1565	Uncontrolled diabetes (A1c > 7.0%) n = 2452
State prevalence	45.1	43.10	4.58	7.20
Age group				
10-24 years	11.85	8.28	7.01	7.80
15-24 years	56.42	51.67	49.53	54.74
35+ years	31.73	40.05	43.46	37.46
Race/ethnicity				
Black	16.09	22.42	30.12	29.75
Hispanic	29.11	30.32	31.81	39.4
White	22.11	11.02	6.94	6.87
Asian	31.26	34.4	28.37	22.12
Other/unknown	1.48	1.91	2.14	2.39
Nativity				
US born	33.11	28.09	27.43	32.83
Foreign born	66.89	71.91	72.57	67.17
Insurance				
Public or none	63.77	68.88	72.64	73.6
Private	35.49	30.44	26.75	25.65
Missing	0.74	0.69	0.62	0.77
Educational attainment				
College or higher	55.31	50.51	44.28	39.89
Less than college degree	44.40	49.15	55.34	59.83
Missing	0.29	0.35	0.38	0.29
Subsequent births				
1	64.54	70.17	68.94	70.84
2	29.86	25.09	21.29	19.81
3+	5.61	4.74	9.77	9.36
Previous live births				
0	53.39	43.09	35.58	33.67
1	25.38	28.72	28.77	27.31
2+	8.45	11.96	16.11	17.33
Prepregnancy obesity				
No	77.64	65.60	50.10	47.19
Yes	21.58	33.4	48.43	51.31
Missing	0.78	0.92	1.47	1.51
Excessive gestational weight gain				
No	61.37	58.78	54.89	52.76
Yes	38.63	41.22	45.11	47.24
Preexisting hypertension				
No	97.01	94.94	88.34	87.4
Yes	2.99	5.06	11.66	12.6
Preterm birth				
No	88.95	86.44	83.6	79.52
Yes	11.05	13.56	16.4	20.48
Hypertensive disorders of pregnancy				
No	90.25	87.81	79.45	75.94
Yes	9.75	12.19	20.55	24.06
Cesarean delivery				
No	58.27	51.98	45.22	43.28
Yes	41.73	48.02	54.78	56.72
Macrosomia				
No	93.25	90.68	85.29	81.89
Yes	6.75	9.32	14.71	18.11
Infant shoulder dystocia				
No	99.31	99.04	98.52	98.1
Yes	0.69	0.96	1.48	1.9
Exclusive breastfeeding at delivery				
No	71.51	74.94	77.63	79.01
Yes	28.49	25.06	22.37	20.99

Table 10 – Average Sojourn Times(years) and 95% CI for average Woman with GDM at Baseline (n = 34,171)

Diabetes stage	Overall (N – 34171)
No diabetes	2.1 (2.0-2.1)
Prediabetes	2.2 (2.2-2.3)
Controlled diabetes	1.9 (1.8-1.9)
Uncontrolled diabetes	2.3 (2.2-2.4)

No diabetes (A1c < 5.7%), prediabetes (5.7 ≤ A1c < 6.5%), controlled diabetes (6.5 ≤ A1c < 7%), and uncontrolled diabetes (A1c ≥ 7%).
Average sojourn time refers to average time spent in a given state (in years) before transitioning to another stage.

Figure 2 – Estimated transition probabilities among GDM women, adjusted models (n = 34171). Adjusted for age group, race/ethnicity, insurance status, educational attainments, and nativity.

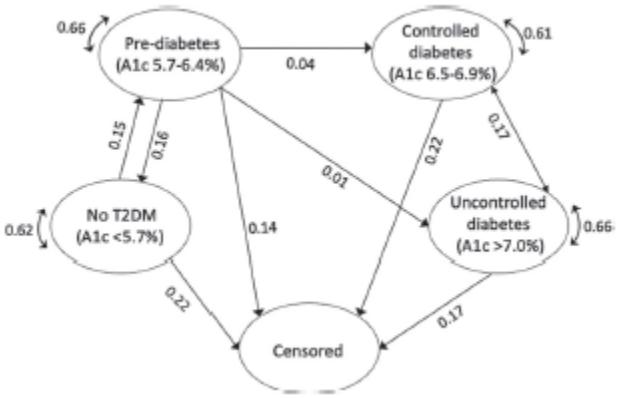

Table 11 – Adjusted hazard ratios for the influence of sociodemographic and perinatal characteristics on transition intensities between diabetes states following GDM, (N=34,171).

	No Diabetes to Prediabetes	Prediabetes to No Diabetes	Prediabetes to Controlled Diabetes	Prediabetes to Uncontrolled Diabetes	Controlled to Uncontrolled Diabetes	Uncontrolled to Controlled Diabetes
Sociodemographic Characteristics						
Race/ethnicity						
Black	1.56 (1.37 ,1.77)	0.64 (0.56 ,0.73)	1.51 (1.24 ,1.85)	2.32 (1.21 ,4.47)	0.96 (0.79 ,1.17)	0.77 (0.63 ,0.95)
Hispanic	1.60 (1.42 ,1.81)	0.82 (0.73 ,0.92)	1.26 (1.03 ,1.53)	1.76 (0.91 ,3.39)	1.22 (1.01 ,1.48)	0.9 (0.73 ,1.1)
Asian	1.62 (1.44 ,1.82)	0.9 (0.8 ,1.01)	1.25 (1.03 ,1.52)	0.44 (0.18 ,1.1)	1.03 (0.84 ,1.26)	1.09 (0.88 ,1.35)
White	1.0	1.0	1.0	1.0	1.0	1.0
Nativity						
Foreign born	1.16 (1.06 ,1.28)	0.96 (0.87 ,1.06)	0.87 (0.76 ,1)	0.83 (0.57 ,1.21)	0.98 (0.86 ,1.11)	1.16 (1.01 ,1.34)
US born	1.0	1.0	1.0	1.0	1.0	1.0
Education						
Less than college degree	1.21 (1.1 ,1.32)	1.09 (1 ,1.18)	0.9 (0.8 ,1.01)	0.51 (0.35 ,0.76)	1.06 (0.94 ,1.19)	0.95 (0.84 ,1.07)
College or higher	1.0	1.0	1.0	1.0	1.0	1.0
Insurance						
Medicaid or none	0.97 (0.88 ,1.07)	1.12 (1.02 ,1.24)	0.77 (0.67 ,0.88)	0.61 (0.38 ,0.99)	0.93 (0.82 ,1.06)	0.96 (0.84 ,1.1)
Private insurance	1.0	1.0	1.0	1.0	1.0	1.0
Age group						
24-25 years	1.18 (1.03 ,1.37)	0.83 (0.72 ,0.96)	1.28 (1.01 ,1.62)	0.65 (0.4 ,1.04)	1.0 (0.8 ,1.25)	1.11 (0.88 ,1.39)
35+ years	1.31 (1.13 ,1.52)	0.68 (0.59 ,0.8)	1.43 (1.13 ,1.82)	0.5 (0.29 ,0.86)	0.99 (0.79 ,1.25)	1 (0.79 ,1.27)
<24 years	1.0	1.0	1.0	1.0	1.0	1.0
Perinatal Characteristics						
Pre-pregnancy hypertension	1.13 (0.95,1.35)	0.72 (0.59,0.88)	2.24 (1.86,2.7)	2.78 (1.63,4.74)	1.32 (1.13,1.54)	1.04 (0.88,1.23)
Pre-pregnancy obesity	1.48 (1.35,1.62)	0.83 (0.76,0.91)	1.76 (1.56,1.98)	1.56 (1.09,2.25)	1.02 (0.91,1.14)	0.87 (0.78,0.98)
Excess gestational weight gain	0.99 (0.92,1.08)	0.95 (0.88,1.03)	1.09 (0.98,1.22)	0.82 (0.57,1.17)	1.02 (0.91,1.14)	0.82 (0.73,0.92)
Hypertensive disorder of pregnancy	0.93 (0.82,1.05)	0.92 (0.81,1.04)	1.96 (1.71,2.25)	2.06 (1.39,3.05)	0.98 (0.86,1.12)	0.82 (0.71,0.94)
Cesarean section	1.06 (0.99,1.15)	0.99 (0.92,1.07)	1.21 (1.09,1.35)	1.4 (1,1.98)	1.02 (0.92,1.13)	0.85 (0.76,0.95)
Preterm	0.98 (0.88,1.1)	0.95 (0.85,1.06)	1.28 (1.11,1.47)	1.32 (0.87,2)	0.88 (0.77,1.01)	0.7 (0.6,0.81)
Macrosomia	1.19 (1.03,1.36)	0.87 (0.75,1)	1.63 (1.38,1.92)	1.41 (0.81,2.46)	1.15 (0.98,1.33)	0.84 (0.71,0.99)
Shoulder dystocia	1.08 (0.71,1.65)	0.87 (0.56,1.34)	2.13 (1.4,3.24)	0.45 (0,50.85)	1.22 (0.82,1.81)	0.61 (0.39,0.97)
Exclusive breastfeeding	1.01 (0.92,1.1)	1.06 (0.97,1.15)	1.03 (0.91,1.17)	1.05 (0.71,1.57)	0.91 (0.8,1.03)	1.12 (0.98,1.28)

Note: No diabetes (A1c<5.7%), Pre-diabetes (5.7≤A1c<6.5%), Controlled diabetes(6.5≤A1c<7%) and Uncontrolled diabetes (A1c >7%). Sociodemographic characteristics mutually adjust for all other sociodemographic characteristics in model. Perinatal characteristics examined individually in models that also control for age group, nativity, race/ethnicity, educational attainment and insurance status. Reference group for all perinatal characteristics is the absence of the condition.

Table 12 – Unadjusted hazard ratios for influence of sociodemographic and perinatal characteristics on transition intensities between diabetes states following GDM, (N=34,171).

	No Diabetes to Prediabetes	Prediabetes to No Diabetes	Prediabetes to Controlled Diabetes	Prediabetes to Uncontrolled Diabetes	Controlled to Uncontrolled Diabetes	Uncontrolled to Controlled Diabetes
	Sociodemographic Characteristics					
Race/Ethnicity						
Black	1.08 (0.99 ,1.18)	0.74 (0.67 ,0.81)	1.22 (1.09 ,1.38)	2.14 (1.52 ,3.03)	0.86 (0.76 ,0.97)	0.78 (0.69 ,0.88)
Hispanic	1.16 (1.08 ,1.26)	1.05 (0.97 ,1.14)	0.99 (0.89 ,1.11)	1.45 (1.01 ,2.07)	1.24 (1.11 ,1.39)	0.98 (0.87 ,1.10)
Asian	1.29 (1.2 ,1.38)	1.13 (1.05 ,1.21)	0.95 (0.85 ,1.06)	0.33 (0.18 ,0.6)	0.96 (0.86 ,1.08)	1.35 (1.19 ,1.52)
White	1.0	1.0	1.0	1.0	1.0	1.0
Education						
Less than college degree	1.38 (1.28 ,1.49)	1.06 (0.98 ,1.14)	0.95 (0.85 ,1.05)	0.96 (0.67 ,1.38)	1.08 (0.97 ,1.2)	1.01 (0.9 ,1.13)
College or higher	1.0	1.0	1.0	1.0	1.0	1.0
Nativity						
Foreign born	1.39 (1.29 ,1.5)	1.03 (0.95 ,1.11)	0.99 (0.88 ,1.12)	0.55 (0.39 ,0.77)	1.05 (0.93 ,1.18)	1.22 (1.08 ,1.38)
US born	1.0	1.0	1.0	1.0	1.0	1.0
Insurance						
Medicaid or none	0.76 (0.71 ,0.82)	1.01 (0.94 ,1.08)	0.84 (0.75 ,0.95)	0.75 (0.5 ,1.13)	0.88 (0.78 ,0.99)	0.95 (0.84 ,1.08)
Private insurance	1.0	1.0	1.0	1.0	1.0	1.0
Age group						
25-34 years	1.1 (0.97 ,1.25)	0.85 (0.74 ,0.96)	1.35 (1.08 ,1.68)	0.55 (0.35 ,0.85)	1.04 (0.84 ,1.29)	1.15 (0.92 ,1.44)
35 or more years	1.17 (1.03 ,1.33)	0.7 (0.61 ,0.8)	1.46 (1.17 ,1.83)	0.50 (0.31 ,0.82)	0.98 (0.78 ,1.22)	1.03 (0.82 ,1.29)
<24 years	1.0	1.0	1.0	1.0	1.0	1.0
	Perinatal Characteristics					
Chronic hypertension	1.22 (1.04,1.43)	0.75 (0.63,0.89)	2.23 (1.86,2.67)	3.96 (2.52,6.21)	1.3 (1.12,1.52)	0.94 (0.8,1.11)
Pre-pregnancy obesity	1.42 (1.32,1.53)	0.84 (0.77,0.9)	1.66 (1.5,1.84)	2.5 (1.75,3.58)	1.01 (0.91,1.12)	0.83 (0.74,0.92)
Excess gestational weight gain	0.97 (0.90,1.04)	0.97 (0.9,1.04)	1.05 (0.94,1.16)	1.24 (0.87,1.78)	0.99 (0.88,1.10)	0.78 (0.7,0.88)
Hypertensive disorder of pregnancy	0.98 (0.88,1.10)	0.94 (0.84,1.06)	1.89 (1.65,2.16)	2.25 (1.47,3.43)	1.03 (0.91,1.17)	0.77 (0.68,0.89)
Cesarean section	1.09 (1.01,1.16)	0.98 (0.91,1.05)	1.2 (1.09,1.33)	1.5 (1.04,2.15)	1.01 (0.91,1.12)	0.83 (0.74,0.93)
Preterm	1.03 (0.93,1.14)	0.91 (0.82,1.01)	1.31 (1.14,1.5)	1.33 (0.85,2.09)	0.89 (0.78,1.02)	0.68 (0.59,0.79)
Macrosomia	1.16 (1.02,1.31)	0.87 (0.76,0.99)	1.58 (1.35,1.85)	2.03 (1.27,3.24)	1.12 (0.97,1.3)	0.83 (0.71,0.97)
Shoulder dystocia	1.23 (0.84,1.79)	1.05 (0.71,1.57)	1.83 (1.19,2.8)	1.4 (0.24,8.25)	1.13 (0.76,1.69)	0.6 (0.38,0.95)
Exclusive breastfeeding	0.89 (0.82,0.96)	1.04 (0.96,1.12)	0.95 (0.84,1.08)	1.28 (0.88,1.84)	0.88 (0.77,1.00)	1.13 (0.99,1.29)

Notes: No diabetes (A1c<5.7%), Pre-diabetes (5.7≤A1c<6.5%), Controlled diabetes(6.5≤A1c<7%) and Uncontrolled diabetes (A1c >7%). Reference group for all perinatal characteristics is the absence of the condition.

Figure 3 – NYC Map of 7 Distinct Neighborhood Profiles

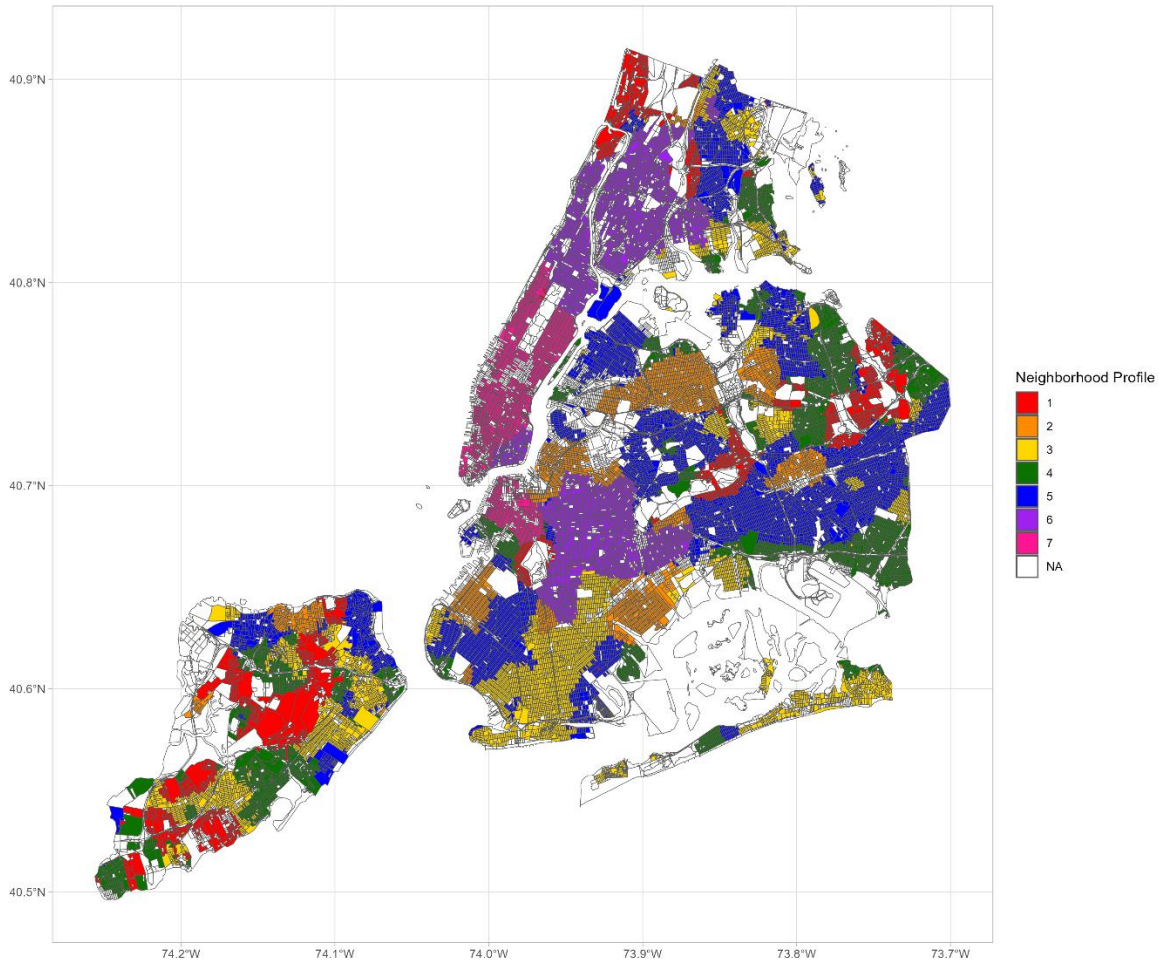

Table 13 – Social determinants of time to follow-up HbA1c tests (months) after diabetes diagnosis among postpartum women who gave birth in NYC from 2009-2016 using Cox Proportional Hazards Model. N = 5,590

	Median A1C % at test (IQR)	Median time to test, months (IQR)	HR (95% CI)	aHR* (95% CI)	aHR † (95% CI)
Total	6.8 (6.4-7.8)	5.2 (3.1-10.0)			
Race-ethnicity					
NH White	6.8 (6.4-8.0)	4.9 (2.8-9.8)			
NH Black	6.9 (6.4-7.8)	5.7 (3.0-11.2)	0.89 (0.81, 0.99)	0.88 (0.80, 0.98)	0.90 (0.80, 1.00)
Hispanic Black	6.9 (6.4-8.1)	5.6 (3.1-10.5)	0.92 (0.79, 1.06)	0.89 (0.77, 1.03)	0.91 (0.79, 1.06)
Other Hispanic	7.0 (6.4-8.5)	4.8 (3.0-9.4)	0.99(0.89, 1.10)	0.96 (0.86, 1.07)	0.98 (0.88, 1.09)
NH South/ Southeast Asian	6.7 (6.4-7.2)	5.3 (3.4-8.6)	1.02 (0.91, 1.15)	0.97 (0.86, 1.10)	0.99 (0.87, 1.12)
NH Central or East Asian	6.7 (6.4-7.3)	5.2 (3.2-9.5)	0.95 (0.84, 1.08)	0.93 (0.81, 1.06)	0.93 (0.81, 1.06)
Other/Unknown	6.8 (6.4-7.6)	4.2 (2.7-8.0)	1.11 (0.90, 1.38)	1.07 (0.87, 1.33)	1.09 (0.88, 1.35)
Nativity					
US-born	6.9 (6.4-8.2)	5.4 (3.0-11.0)			
Foreign-born	6.8 (6.4-7.6)	5.1 (3.2-9.5)	1.07 (1.01, 1.13)	1.05 (0.99, 1.11)	1.01 (0.95, 1.08)
Education					
Less than High School	6.9 (6.4-8.1)	5.0 (3.0-8.9)	1.05 (0.99, 1.12)	1.01 (0.94, 1.08)	1.01 (0.94, 1.09)
High School	6.8 (6.4-7.7)	5.4 (3.1-10.2)	1.01 (0.95, 1.08)	0.99 (0.92, 1.06)	0.99 (0.92, 1.06)
Some College or Higher	6.8 (6.4-7.7)	5.3 (3.0-10.7)			
Insurance					
Private/other	6.8 (6.4-7.7)	5.7 (3.2-11.7)			
Medicaid	6.9 (6.4-7.9)	5.1 (3.0-9.5)	1.12 (1.05, 1.19)	1.12 (1.04, 1.20)	1.14 (1.06, 1.22)
WIC					
No	6.9 (6.4-7.9)	5.3 (3.1-10.6)			
Yes	6.8 (6.4-7.8)	5.2 (3.0-9.7)	1.03 (0.97, 1.09)	0.99 (0.92, 1.05)	1.00 (0.94, 1.07)
Parity					
0	6.9 (6.4-8.0)	5.2 (3.0-10.1)			
1	6.8 (6.4-7.6)	5.3 (3.1-10.0)	0.97 (0.90, 1.03)	0.96 (0.90, 1.03)	0.93 (0.87, 1.00)
2	6.8 (6.4-7.7)	5.3 (3.2-9.9)	1.00 (0.93, 1.08)	0.99 (0.92, 1.07)	0.95 (0.87, 1.02)
3+	6.9 (6.5-8.0)	5.2 (3.0-10.0)	0.98 (0.91, 1.06)	0.96 (0.89, 1.04)	0.89 (0.82, 0.97)

NH = Non-Hispanic; IQR = Interquartile range; HR = Hazard Ratio; aHR = Adjusted Hazard Ratio; CI = Confidence interval

***Mutually adjusts for social determinants of health: race-ethnicity, education, insurance, WIC enrollment, nativity, and family size**

† Mutually adjusts for social determinants of health: race-ethnicity, education, insurance, WIC enrollment, nativity, and family size and further adjusted for maternal characteristics: BMI, gestational diabetes, and age at diagnosis

Table 14 – Social determinants of biannual HbA1c testing over three years of follow-up using Poisson regression among postpartum women with diabetes who gave birth between 2009-2016 in NYC and who were not lost to follow-up within 3 years of diagnosis, n = 2,638

Categories	Proportion meeting testing guidelines (%)*	RR(95% CI)	aRR † (95% CI)	aRR ‡ (95% CI)
Total	13.0			
Race-ethnicity				
NH White	12.1			
NH Black	8.1	0.92 (0.85, 1.00)	0.91 (0.84, 0.99)	0.92 (0.84, 0.99)
Hispanic Black	7.8	0.92 (0.82, 1.04)	0.90 (0.80, 1.01)	0.92 (0.81, 1.03)
Other Hispanic	16.2	1.01 (0.94, 1.10)	0.97 (0.90, 1.06)	0.99 (0.91, 1.08)
NH South Asian	15.4	1.08 (0.99, 1.18)	1.02 (0.93, 1.12)	1.04 (0.94, 1.14)
NH Central or East Asian	18.8	1.07 (0.97, 1.18)	1.03 (0.93, 1.13)	1.02 (0.92, 1.12)
NH Other/Unknown	14.3	1.01 (0.86, 1.18)	0.97 (0.83, 1.14)	0.99 (0.85, 1.16)
Nativity				
US-born	9.5			
Foreign-born	14.9	1.11 (1.06, 1.16)	1.07 (1.02, 1.12)	1.04 (0.99, 1.09)
Education				
Less than High School	15.8	1.09 (1.04, 1.14)	1.05 (1.00, 1.11)	1.07 (1.01, 1.12)
High School	12.1	1.04 (0.99, 1.10)	1.03 (0.98, 1.09)	1.04 (0.98, 1.10)
Some College or Higher	11.2			
Insurance				
Private/other insurance	10.5			
Medicaid insurance	13.8	1.09 (1.04, 1.15)	1.07 (1.01, 1.13)	1.09 (1.03, 1.16)
WIC				
No	12.9			
Yes	13.1	1.01 (0.97, 1.06)	0.98 (0.93, 1.03)	0.98 (0.93, 1.03)
Parity				
0	13.6			
1	12.9	1.01 (0.96, 1.07)	1.00 (0.95, 1.05)	0.97 (0.92, 1.03)
2	11.8	0.99 (0.94, 1.05)	0.98 (0.92, 1.04)	0.94 (0.88, 1.00)
3+	13.6	1.00 (0.95, 1.06)	0.99 (0.93, 1.05)	0.93 (0.87, 0.99)

NH = Non-Hispanic; RR = Rate ratio; aRR= Adjusted Rate Ratio; CI = Confidence Interval

*Defined as having attended all 6 recommended A1c testing visits with three years of onset

†Mutually adjusts for social determinants of health: race-ethnicity, education, insurance, WIC enrollment, nativity, and family size

‡ Mutually adjusts for social determinants of health: race-ethnicity, education, insurance, WIC enrollment, nativity, and family size and further adjusts for maternal characteristics: BMI, gestational diabetes, and age at diagnosis