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## Cardiometabolic health after first pregnancy: Associations with social determinants of health. A nuMoM2b-HHS study

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Declaration of competing interest

The content of this article is solely the responsibility of the authors and does not necessarily represent the official views of the National Heart, Lung, and Blood Institute, the National Institutes of Health, or the U. S. Department of Health and Human Services.

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## Abstract

**Study objective:** This study sought to evaluate the associations between social determinants of health (SDOH) at the time of first pregnancy and subsequent cardiometabolic health, defined as the development of metabolic syndrome.

**Design:** nuMoM2b-HHS (Nulliparous Pregnancy Outcomes Study- Monitoring Mothers-to-Be-Heart Health Study) is an ongoing prospective cohort study.

**Setting:** Eight academic medical centers enrolled and continue to follow participants.

**Participants:** 4484 participants followed a mean of 3.2 years from the time of their first pregnancy.

**Interventions:** N/a.

**Main outcome measure:** Unadjusted and adjusted Poisson regression models with robust standard errors were used to obtain relative risks and 95% confidence intervals estimating the risk of metabolic syndrome for each baseline SDOH. In secondary analyses we examined the associations between SDOH and incident hypertension, obesity, and diabetes mellitus.

**Results:** Metabolic syndrome developed in 13.6% of participants. Higher socioeconomic position at the time of pregnancy was associated with lower rates of metabolic syndrome [income > 200% poverty level aRR 0.55 (95% CI, 0.42–0.71), attainment of a bachelor's degree aRR 0.62 (0.46–0.84) or higher aRR 0.50 (0.35–0.71)], while being single [aRR 1.45 (95% CI, 1.18–1.77)] and having low health literacy were associated with a greater risk of metabolic syndrome [aRR 1.98 (95% CI, 1.28–3.07)].

**Conclusions:** Over a short interval following first pregnancy, participants accumulated high proportions of cardiovascular risk factors and metabolic syndrome, with some risk associated with SDOH. The impact of interventions addressing SDOH in pregnant people on cardiometabolic health should be tested as a means of reducing health inequities at the population level.

## Keywords

Metabolic syndrome; Pregnancy; Social determinants of health; Obesity; Diabetes mellitus; Hypertension

## 1. Introduction

Cardiovascular disease (CVD) is the leading cause of death in U.S. women [1,2]. Despite marked historical reductions in the burden of disease, since 2010 there has been a plateau in age-adjusted CVD mortality rates, particularly among non-Hispanic Black women [1,3,4]. This unfavorable trend is partially attributable to an increased burden of cardiometabolic risk factors, and there is a growing understanding of the upstream mechanisms through which social inequalities amplify cardiometabolic risk [5–7]. These factors, termed social determinants of health (SDOH), are the conditions under which people are born, grow,

live, work, and age [8]. Some examples of individual SDOH are language spoken at home, income, education attained, and access to medical care. Individual SDOH can also be grouped into broader, overarching domains such as socioeconomic position — a complex construct referring to the social and economic factors that influence what positions individuals or groups hold within the structure of a society [9].

There are few data on the influence of SDOH at the time of first pregnancy on the trajectory of future cardiometabolic health. Understanding the socio-cultural factors identifiable during pregnancy that are most associated with the short-term development of cardiometabolic risk factors (e.g., metabolic syndrome, obesity, diabetes, and hypertension) could be a useful first step towards developing targeted interventions to optimize health, prevent CVD, and eradicate disparities. The overall objective of this study was to examine the associations between individual SDOH identified during a first pregnancy and subsequent cardiometabolic health 2–7 years after delivery for pregnant individuals enrolled in the Nulliparous Pregnancy Outcomes Study-Monitoring Mothers-to-Be-Heart Health Study (nuMoM2b-HHS).

## 2. Methods

### 2.1. Study design

This is a secondary analysis of data collected during a multicenter prospective study (nuMoM2b) [10] of women followed from the first trimester of their first pregnancy for up to 7 years after delivery (nuMoM2b-HHS) [11]. All study procedures were approved by each site's local institutional review board and all participants provided written informed consent prior to participation in both studies. Data from the parent nuMoM2b study are currently publicly available through the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NICHD) National Institutes of Health Data and Specimen Hub (DASH; <https://dash.nichd.nih.gov/>); nuMoM2b-HHS data collection is ongoing.

### 2.2. Participants

Full details of the nuMoM2b and nuMoM2b-HHS observational cohort studies have been previously described [10,11]. Briefly, 10,038 people were enrolled in the parent nuMoM2b study at the time of their first pregnancy, between October 2010 and September 2013, and underwent a total of 4 in-person examinations. By design, a subset of 4508 participants attended a follow-up in-person nuMoM2b-HHS study visit approximately 2–7 years later (mean 3.2 years). For the current investigation, we examined SDOH data obtained during the index nuMoM2b pregnancy and cardiometabolic status at the time of the nuMoM2b-HHS visit. Participants were excluded from the current analysis if their index pregnancy lasted <20 weeks (N = 24). Of the 4484 participants with data available for analysis, the analytic sample size varied based on the endpoint (Fig. 1).

### 2.3. Study procedures

During the index pregnancy, demographic characteristics including self-reported race/ethnicity, medical and social histories (including smoking status, alcohol and drug use), and physical activity level were ascertained via standardized questionnaires. Diabetes and

hypertension history at baseline were based on self-report and medication use. Height and weight were measured following a standardized protocol and were used to calculate body mass index (BMI) as weight in kilograms (kg) divided by height in meters squared ( $m^2$ ). Adverse pregnancy outcomes (APOs) including hypertensive disorders of pregnancy (defined as antepartum gestational hypertension, preeclampsia, and/or eclampsia), preterm delivery (medically indicated or spontaneous live birth at <37 weeks gestational age), and delivery of a small for gestational age infant (<5th percentile by Alexander nomogram) were adjudicated by a panel of maternal-fetal medicine experts using data from the medical record obtained at least 30 days after delivery by trained and certified chart abstractors [10,12].

Information about individual SDOH [income, level of education attained, census classification of residence (rural/urban), place of birth and years lived in the United States, language spoken at home, marital and health insurance status] were obtained via standardized questionnaires administered by trained study staff. The Rapid Estimate of Adult Literacy in Medicine Short Form (REALM-SF), a validated tool, was administered to assess participant health literacy [13]. Individual SDOH were grouped into domains as follows: socioeconomic position included household income as a percent of the federal poverty level and education attained; residential environment consisted of rural/urban residence based on linkage of geocoded residential address to the USDA Food Access Research Atlas [14]; acculturation consisted of country of birth, years lived in the U.S., and primary language spoken at home; social support was comprised of marital status and report of a significant other; access to care/medical literacy consisted of type of health insurance and REALM-SF score.

At the nuMoM2b-HHS study visit, anthropometric measures including height, weight, and waist circumference were obtained. Waist circumference was measured in duplicate over the iliac crest to the nearest 0.1 cm, and if the difference between the two measurements was >0.5 cm, a third measurement was recorded. For all analyses, the third measurement (if performed) or mean of the first 2 was used. Blood pressure was measured in triplicate by a trained research coordinator using a standardized protocol and a validated oscillometric device (Omron-HEM-907XL, Omron Healthcare, Lake Forest, IL) [15]. The mean of the second and third measurements were used for all analyses. Glucose, high-density lipoprotein (HDL) cholesterol, and triglyceride levels were measured from sera that had been stored at  $-80^{\circ}C$  and batch processed at a core laboratory (The Lundquist Institute) using enzymatic assays on a Beckman AU480 [11].

#### 2.4. Outcomes

The primary outcome was the presence of metabolic syndrome at the time of the nuMoM2b-HHS visit. Metabolic syndrome was defined as having at least 3 of the following 5 criteria: 1. Abdominal obesity (waist circumference > 88 cm if non-Asian or >80 cm if Asian); 2. Triglyceride level  $\geq 150$  mg/dL or use of triglyceride lowering medication; 3. HDL cholesterol level < 50 mg/dL, or use of lipid modifying medication; 4. Blood pressure  $\geq 130$  mmHg systolic or 85 mmHg diastolic, or use of antihypertensive medication; and 5. Fasting glucose  $\geq 100$  mg/dL, or use of glucose lowering medication [16]. Secondary outcomes included incident hypertension defined using the metabolic syndrome criteria (SBP  $\geq 130$

mmHg or DBP  $\geq$  85 mmHg) or use of antihypertensive medication [16], diabetes (fasting plasma glucose  $\geq$  126 mg/dL or use of glucose-lowering medication) [17], and obesity (BMI  $\geq$  30 kg/m<sup>2</sup>) [18].

## 2.5. Statistical analysis

Participants' baseline characteristics at the time of index pregnancy were summarized as means and standard deviations (SD) or medians and interquartile ranges (IQR) for continuous variables, and frequencies and percentages for categorical variables. Baseline characteristics were stratified by the presence or absence of metabolic syndrome; continuous variables were compared using *t*-tests or Wilcoxon rank sum tests and categorical variables were compared using chi-square tests. We created Poisson regression models with robust standard errors to obtain relative risks and 95% confidence intervals estimating the risk of each health outcome of interest for each individual SDOH at baseline [19]. Referent groups for SDOH were defined as follows: 100–200% of the federal poverty level for household income; high school graduate/GED for education attained; urban for residential environment; US for country of birth; English for primary language spoken at home; married for marital status; commercial health insurance; REALM-SF score = 7. The fully adjusted models for primary and secondary outcomes included covariates that were selected a priori: age, self-reported race/ethnicity, BMI, tobacco use during the 3 months prior to pregnancy, and moderate or vigorous physical activity (hours per week) at baseline. Of note, although race/ethnicity is a social construct that influences SDOH through the lived experiences of racism and discrimination, it is not considered a SDOH and as such was included as covariate in adjusted models [8,20,21]. SAS Version 9.4 (Cary, NC) was used for all analyses. A two-sided *p*-value  $<$  0.05 was considered statistically significant. In this secondary analysis, no adjustments were made for multiple comparisons.

## 3. Results

### 3.1. Baseline characteristics

Characteristics of the 4484 participants included in one or more incident cardiometabolic analyses and the 3838 participants who were free from metabolic syndrome at baseline are displayed in Table 1. Despite being younger, the 521 participants (13.6%) who developed metabolic syndrome after pregnancy had higher blood pressure and BMI and were less physically active during early pregnancy than participants who did not develop metabolic syndrome. More participants who developed metabolic syndrome had baseline hypertension (6.7% vs. 1.0%) and diabetes (1.7% vs. 0.5%) before their nuMoM2b pregnancy and experienced an APO (36.8% vs. 21.9%) compared with participants who remained free from metabolic syndrome in follow-up.

### 3.2. SDOH and the development of metabolic syndrome

Table 2 presents the frequency of individual SDOH, organized by domain, for the cohort at the time of the nuMoM2b pregnancy, overall and stratified by the presence of new metabolic syndrome diagnosed at nuMOM2b-HHS. A higher proportion of participants who developed metabolic syndrome were single/never married, had a low household income, and were covered by government or military health insurance rather than commercial insurance

compared with participants who did not develop metabolic syndrome at follow-up. Also, participants who went on to develop metabolic syndrome had attained less education and scored lowest on the health literacy assessment at the time of pregnancy. Measures of acculturation were similar between groups.

After adjustment for potential confounders (Fig. 2), higher income and educational attainment of at least a bachelor's degree were associated with lower rates of metabolic syndrome while being single, having government/military insurance, and having a lower level of health literacy at the time of nuMoM2b pregnancy were associated with a heightened risk of developing metabolic syndrome. There were no associations found between residential environment or measures of acculturation with metabolic syndrome.

### 3.3. SDOH and development of cardiometabolic risk factors

At 2–7 years follow-up after their first pregnancy, 455 of the 4070 (11.2%) participants without hypertension at baseline had developed hypertension, 71 of 4097 (1.7%) without diabetes at baseline had developed diabetes and 379 of 3350 (11.3%) without obesity at baseline had developed obesity. Fig. 3 displays the adjusted associations between each SDOH and the development of incident hypertension (Panel A), diabetes (Panel B), and obesity (panel C). After adjustment, there were no statistically significant associations between any SDOH at the time of first pregnancy and incident hypertension. For participants born outside of the U.S., fewer years lived in the U.S. at the time of first pregnancy was associated with a lower risk of developing diabetes, while lower health literacy scores were associated with heightened risk of developing diabetes. With respect to the development of obesity, higher household income and education achieved were associated with a lower risk of future obesity, while not being married or having government or military insurance were each associated with a higher risk even after adjustment for potential confounders.

## 4. Discussion

To our knowledge this is the first study examining multiple domains of SDOH ascertained at the time of first pregnancy and their associations with the subsequent development of metabolic syndrome and CVD risk factors. Despite being only 2–7 years after their first pregnancy, participants accumulated high proportions of CVD risk factors. Metabolic syndrome, hypertension, obesity, and diabetes developed in 13.6%, 11.2%, 11.3% and 1.7% of participants over a mean of 3.2 years. Higher socioeconomic position, determined according to household income and education attained at the time of pregnancy, was associated with lower rates of incident metabolic syndrome, and this association persisted after adjustment for potential confounders. In contrast, lower levels of social support, defined as being unmarried, having non-commercial (government or military) health insurance, and having lower levels of health literacy were associated with a greater risk of developing metabolic syndrome in both unadjusted and adjusted models. After adjustment for potential confounders, similar associations were found between these same SDOH and the development of obesity, while fewer years lived in the US and low health literacy were inversely associated with the development of diabetes. Despite similar trends, we did not find any SDOH to be independently associated with incident hypertension.

Income and education are two frequently examined indicators of socioeconomic position [22], and our findings are consistent with prior studies demonstrating a higher incidence of metabolic syndrome [1,23–27] and obesity [28,29] among women with lower socioeconomic position. Our findings extend upon this prior work and these associations persisted after adjustment for potential confounders including age, race/ethnicity, BMI, tobacco use and physical activity at baseline. Contrary to studies in different populations, we did not find a similar association between socioeconomic position and the development of either diabetes [30] or hypertension [31]. This discrepancy may be due in part to the relatively small sample size of individuals who developed diabetes and hypertension as evidenced by the wide confidence intervals around the point estimates. Additionally, the development of obesity, potentially accelerated by a lack of postpartum weight loss, may be the initial step in the development of a higher burden of cardiometabolic risk factors ultimately leading to hypertension and diabetes, but perhaps 3.2 years is not long enough to see the overt development of these downstream conditions. Income is considered the best indicator of material living standards and influences health both directly, by allowing access to services that improve wellbeing (such as better food, health services, and leisure activities) and indirectly, by enhancing educational opportunity and by fostering higher social standing and self-esteem [22]. Single-parent households, another SDOH associated with a heightened risk of incident metabolic syndrome in our study, are more likely to be low-income households and be food insecure [32]. Both the direct and indirect effects of higher income may protect against the development of metabolic syndrome and obesity after pregnancy, and the expansion of programs to address inequalities among pregnant and postpartum individuals with low household income are needed. The Supplemental Nutrition Assistance Program (SNAP) is one such intervention for low-income households that directly addresses food insecurity and has been shown to improve maternal and infant health outcomes through a variety of mechanisms [33]. Additional interventions targeting both the direct and indirect pathways through which income affects post-pregnancy maternal health are needed to reduce the rising rates of obesity and metabolic syndrome in low-income households [1].

As previously noted, the level of education attained by an individual is closely tied to reported income. However, since formal education is often completed early in the life course, education provides insight not only into the likelihood of gaining additional economic resources in the short term, but also into the long-term influences of early life circumstances. We found that participants with a bachelor's degree or higher level of education were more likely to remain free from metabolic syndrome in follow-up, while only those with higher than a bachelor's degree had lower risk of developing obesity. There was no protective effect of education against the development of hypertension or diabetes. Although education can be measured continuously in years, that methodology assumes that each year contributes equally to a person's attained socioeconomic position. In this analysis we chose to examine educational milestones rather than years of education to capture the importance of educational achievements attained, and to facilitate the development of appropriately targeted programs and materials. We also found lower health literacy at the time of pregnancy was associated with the development of both metabolic syndrome and diabetes in follow-up. Health literacy lies on the causal pathway between education and



health status [34], and high health literacy scores have previously been associated with a lower frequency of metabolic syndrome in several Asian populations [35,36]. To our knowledge the role of health literacy and the development of metabolic syndrome has not been systematically examined in a U.S. population. Taken together, these findings suggest the development and implementation of health literacy programs for pregnant or postpartum individuals that are tailored to low literacy/education levels have the potential to improve future cardiometabolic health.

Our work additionally identified that having non-commercial health insurance at the time of first pregnancy was associated with a heightened risk of developing metabolic syndrome and obesity in follow-up. While the nature of public/government health insurance during the period of the participants' pregnancies (2010–2014) may differ from its current state in the US, the mechanistic milieu underpinning this association may not have substantially changed. The passage of the Affordable Care Act (ACA) in 2010, coincident with the start of nuMoM2b enrollment, expanded access to health insurance for several groups of people, including pregnant individuals with incomes up to at least 138% of the federal poverty level. While the ACA's passage resulted in a marked increase in insurance coverage for pregnant people [37,38], eligibility still varies widely from state to state, and Medicaid is now the single largest payer of maternity care. At the time of our study's initiation, and currently in the states which have not passed Medicaid expansion, ACA mandated pregnancy-related insurance coverage expires 60 days after delivery [39]. Thus, having non-commercial insurance at the time of pregnancy may identify individuals at high risk of becoming uninsured, having poor postpartum continuity of care, and losing access to primary care and screening for the development of cardiometabolic disarray. Recently the IMPACT to Save Moms Act and a provision in the American Rescue Plan Act of 2021 have been enacted to provide states with new options to extend postpartum Medicaid coverage to 12 months [40]. There is emerging evidence that Medicaid expansion may promote the use of postpartum outpatient care in high risk women [41,42], but future studies with longer follow-up are needed to examine whether expansion is associated with improved cardiometabolic health.

SDOH are in many cases the drivers of health inequity, and as such the Centers for Disease Control, World Health Organization, American College of Obstetricians and Gynecologists (ACOG), American College of Cardiology and American Heart Association as well as the National Institutes of Health all stress the importance of addressing SDOH as a strategy to reduce health inequities and improve the health of all humankind [2,8,43–45]. One explanation as to why current CVD risk models under-predict risk in young women [46] is that they do not account for SDOH. The potential clinical utility of using SDOH to identify pregnant and postpartum people at high risk for future cardiometabolic disease warrants further study. Pregnancy offers a unique opportunity in a person's lifespan to screen for and potentially modify the presence of social determinants associated with a high risk of future CVD for several reasons. First, pregnant people are frequently in contact with physicians and members of the healthcare team, thus there are ample opportunities to identify individuals at risk and provide support. Second, because most people of childbearing age are free from overt CVD, they stand to derive maximum long-term benefit from primary preventive strategies and even primordial prevention for their unborn child. Finally, pregnant

people are more motivated to optimize their health [47], making them especially receptive to interventions aimed to improve cardiometabolic health. Accordingly, ACOG recommends clinicians inquire about SDOH and maximize referrals to appropriate social services to help improve patients' wellbeing and reduce population level health inequities [2].

#### 4.1. Limitations

Although the nuMoM2b study is an ideal setting to examine the associations between SDOH and the development of cardiometabolic diseases, as it minimizes the potential selection bias of access to prenatal care during pregnancy, there are some limitations that must be taken into consideration when interpreting our results. First, due to differences in the distribution of the exposure and small sample sizes in some subsets, we were likely underpowered to examine all aspects of SDOH, in particular rural locale. Personal and household income are sensitive topics, and some individuals may be hesitant to provide it or report it inaccurately. In addition, income in young adults may be a less reliable indicator of true socioeconomic position as the relationship follows a curvilinear trajectory with age [22]. It is also important to consider that income may affect health status through reverse causality, given that preexisting illness negatively affects earnings [48]; however, research suggests that reverse causality in the association between income and health is more important for younger men than women, and forward causality is a stronger association than reverse causality for both sexes [48,49]. Also, measuring educational level does not provide information about the quality of the educational experience. Educational quality is especially important when trying to conceptualize the relationship between knowledge and analytical ability with health outcomes. This study did not examine the impact of change in SDOH over time, and thus the impact of change in income, health insurance, or educational attainment after giving birth cannot be extrapolated from this analysis. Finally, because this cohort is comprised of women followed after their first pregnancy, findings may not be generalizable to nulliparous individuals.

## 5. Conclusions

In this study we identified lower household income level, lower maternal educational achievement, public or government health insurance, and lower health literacy as a starting point for future interventions aimed at improving health in young pregnant people. Understanding and addressing the SDOH that most strongly modulate risk for developing metabolic syndrome and obesity, two highly prevalent and important risk factors for CVD and mortality [50], can inform potential disease interception strategies to improve cardiometabolic health and reduce health inequities at the population level [2,8,43–45].

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## Abbreviations:

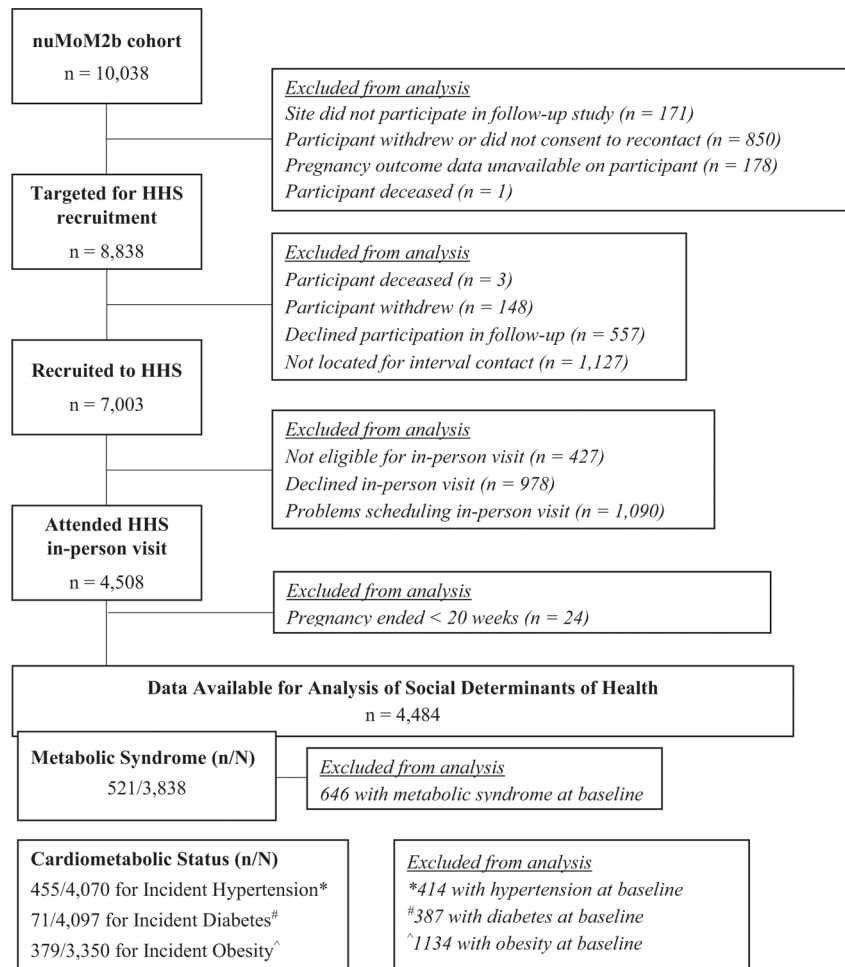
<b>aRR</b>	adjusted relative risk
<b>nuMoM2b-HHS</b>	Nulliparous Pregnancy Outcomes Study- Monitoring Mothers-to-Be-Heart Health Study
<b>SDOH</b>	social determinants of health

## References

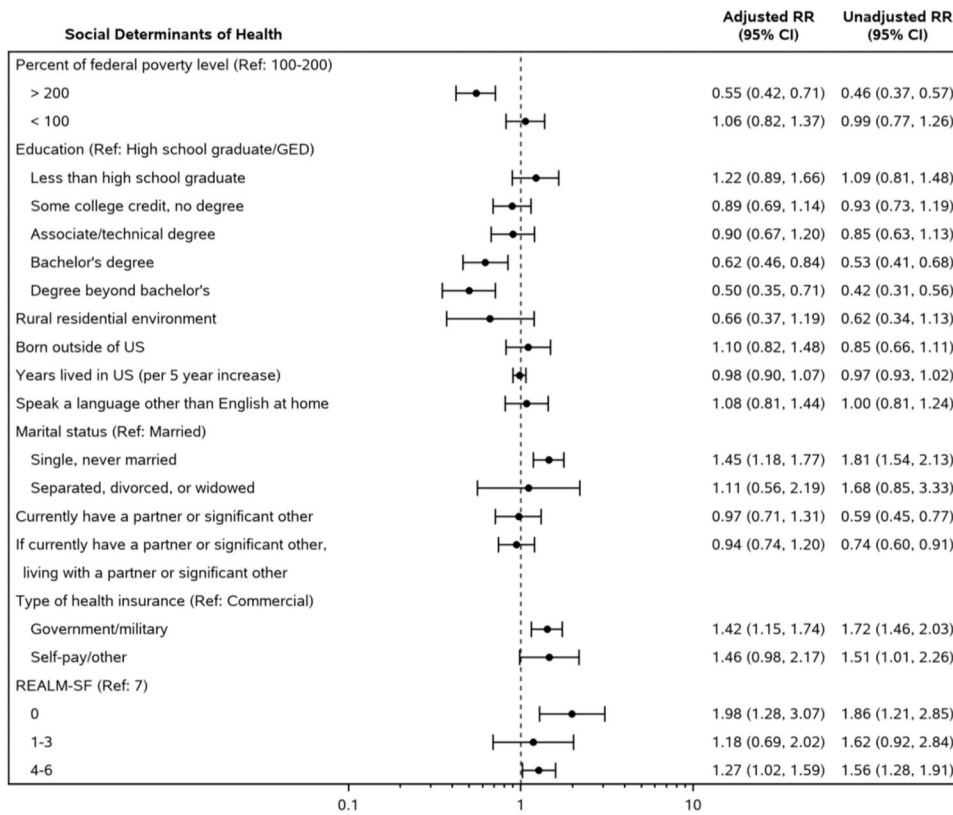
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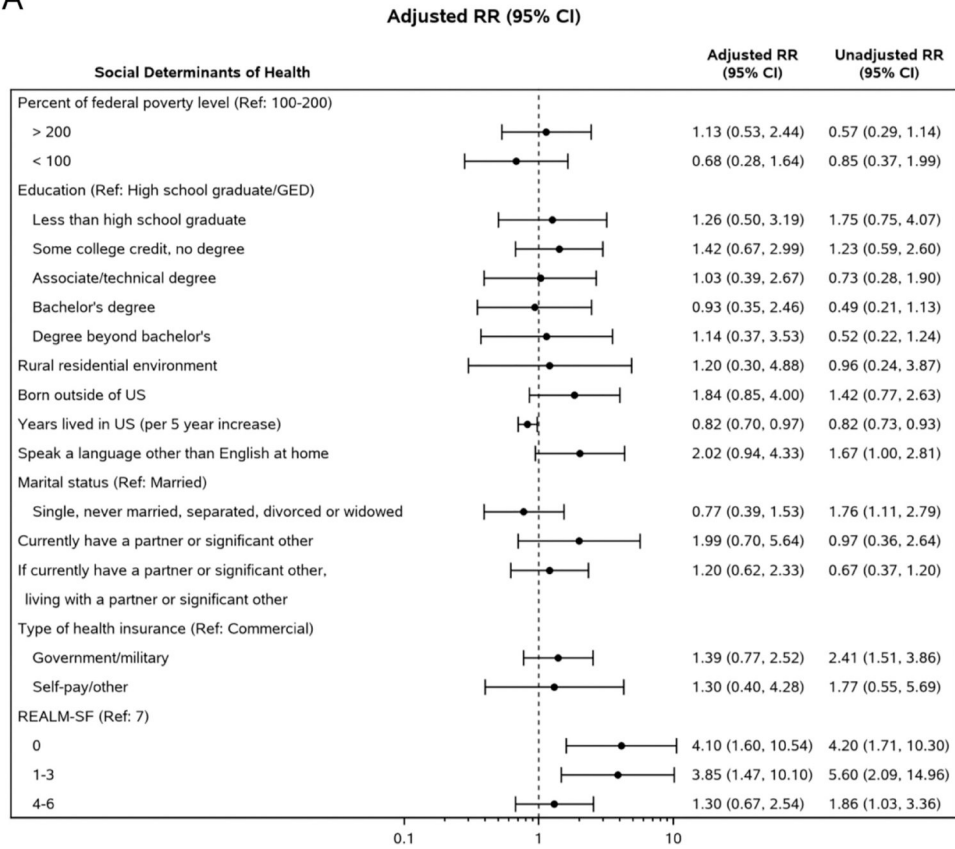


**Fig. 1.** Enrollment and inclusion cascade. Abbreviations: HHS = heart health study; MetS = metabolic syndrome; nuMoM2b = Nulliparous Pregnancy Outcomes Study: Monitoring Mothers-to-Be; n/N indicates number with incident cardiometabolic condition/number at risk for developing that cardiometabolic condition.



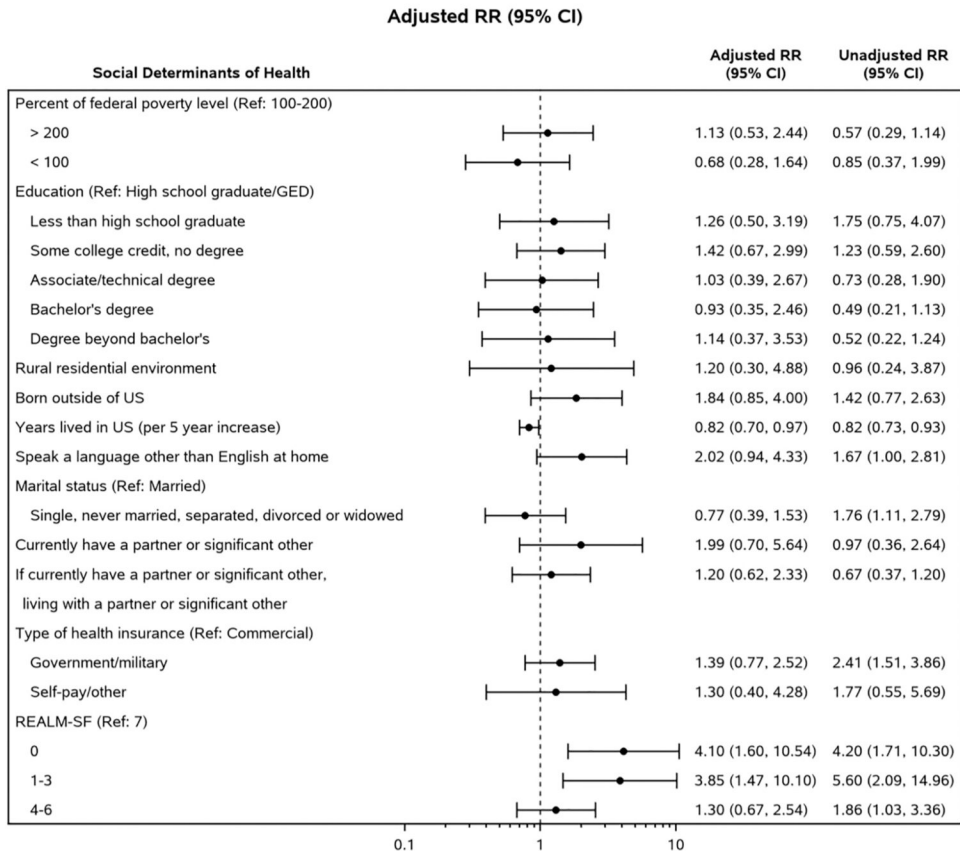
**Fig. 2.** Unadjusted and adjusted risk ratios relating social determinants of health at the onset of first pregnancy to the development of metabolic syndrome 2–7 years later. Abbreviations: CI = confidence interval; REALM-SF = Rapid Estimate in Adult Literacy in Medicine – Short Form; RR = relative risk. Adjusted RR are adjusted for age, self-reported race/ethnicity, body mass index, tobacco use and physical activity at baseline.

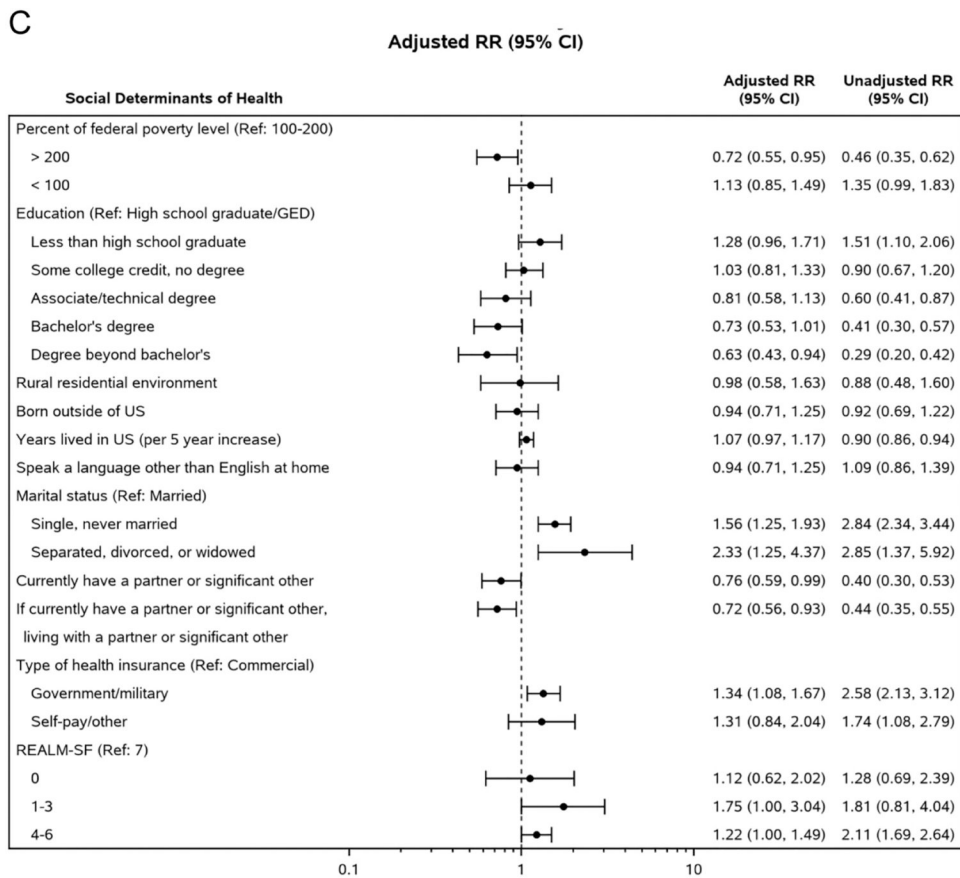
A





B





**Fig. 3.** Unadjusted and adjusted risk ratios relating social determinants of health at the onset of first pregnancy to the development of hypertension (a), obesity (b) and diabetes (c) 2–7 years later.

Abbreviations: CI = confidence interval; REALM-SF = Rapid Estimate in Adult Literacy in Medicine — Short Form; RR = relative risk.

Adjusted RR are adjusted for age, self-reported race/ethnicity, body mass index, tobacco use and physical activity at baseline.

**Table 1**

Participant characteristics during index pregnancy, overall and according to incident metabolic syndrome at 2–7 years postpartum.

Characteristics during nuMoM2b Index Pregnancy	All participants N = 4484	Incident Metabolic Syndrome at nuMoM2b-HHS N = 3838	
		No metabolic syndrome N = 3317	Metabolic syndrome N = 521
Age in years, mean (SD)	27.0 (5.6)	27.0 (5.5)	26.2 (5.6)
Category: n (%)			
13–21	905 (20.2)	654 (19.7)	128 (24.6)
22–35	3272 (73.0)	2456 (74.0)	360 (69.1)
>35	307 (6.9)	207 (6.3)	33 (6.3)
Maternal race: n (%)			
White Non-Hispanic	2786 (62.1)	2122 (64.0)	300 (57.6)
Black Non-Hispanic	618 (13.8)	438 (13.2)	90 (17.3)
Hispanic	735 (16.4)	506 (15.3)	98 (18.8)
Asian	135 (3.0)	105 (3.2)	7 (1.3)
Other	210 (4.7)	146 (4.4)	26 (5.0)
BMI, kg/m <sup>2</sup> , mean (SD)	26.6 (6.5)	25.2 (5.5)	30.9 (7.1)
Systolic blood pressure, mm Hg, mean (SD)	109.5 (10.9)	108.0 (10.1)	112.4 (10.1)
Diastolic blood pressure, mm Hg, mean (SD)	67.3 (8.4)	66.5 (7.9)	69.4 (8.4)
Chronic hypertension: n/N (%)	127/4480 (2.8)	33/3201 (1.0)	35/521 (6.7)
Diabetes: n/N (%)	62/4482 (1.4)	15/3315 (0.5)	9/521 (1.7)
Smoked during 3 months prior to pregnancy: n/N (%)	718/4478 (16.0)	475/3312 (14.3)	117/521 (22.5)
Consumed alcohol during 3 months prior to pregnancy: n/N (%)	2789/4478 (62.3)	2105/3313 (63.5)	315/521 (60.5)
Any prior drug use: n/N (%)	1460/4484 (32.6)	1064/3317 (32.1)	181/3317 (34.7)
Physical activity (hours per week of moderate or vigorous), median (IQR)	1.0 (0, 36.8)	1.0 (0, 30.0)	0 (0, 29)
APO/gestational diabetes: n (%)	1149 (25.9)	721 (21.9)	190 (36.8)
Hypertensive disorders of pregnancy: n (%)	612 (13.7)	363 (11.0)	114 (21.9)
Gestational hypertension: n (%)	314 (7.0)	196 (5.9)	61 (11.7)
Preeclampsia/eclampsia: n (%)	298 (6.7)	167 (5.0)	53 (10.2)
Gestational diabetes: n (%)	191 (4.3)	89 (2.7)	40 (7.8)
Preterm birth: n (%)	387 (8.6)	242 (7.3)	67 (12.9)
Small for gestational age: n (%)	187 (4.2)	136 (4.3)	19 (3.7)

Abbreviations: APO = adverse pregnancy outcome; SD = standard deviation; n = number in category; BMI = body mass index; N = sample size; IQR = interquartile range.

Any APO defined as: any hypertensive disorder of pregnancy, gestational diabetes, any pretermbirth, or small for gestational age. Individual APOs are not mutually exclusive.

**Table 2**

Social determinants of health by domain at index pregnancy, overall and according to incident metabolic syndrome at 2–7 years postpartum.

Characteristics during nuMoM2b index pregnancy	All participants N = 4484	Incident metabolic syndrome at nuMoM2b-HHS N = 3838	
		No metabolic syndrome N = 3317	Metabolic syndrome N = 521
<b>Socioeconomic position</b>			
Percent of the federal poverty level: n/N (%)			
>200	2533/3683 (68.8)	1993/2759 (72.2)	208/406 (51.2)
100–200	551/3683 (15.0)	372/2759 (13.5)	97/406 (23.9)
<100	599/3683 (16.3)	394/2759 (14.3)	101/406 (24.9)
Education attained: n/N (%)			
Less than high school graduate	327/4482 (7.3)	212/3316 (6.4)	56/521 (10.7)
High school graduate or GED completed	508/4482 (11.3)	350/3316 (10.6)	83/521 (15.9)
Some college credit, no degree	889/4482 (19.8)	611/3316 (18.4)	133/521 (25.5)
Associate/technical degree	501/4482 (11.2)	351/3316 (10.6)	68/521 (13.1)
Bachelor's degree	1261/4482 (28.1)	988/3316 (29.8)	111/521 (21.3)
Degree beyond bachelor's	996/4482 (22.2)	804/3316 (24.2)	70/521 (13.4)
<b>Residential environment</b>			
Rural: n/N (%)	137/4285 (3.2)	109/3190 (3.4)	10/491 (2.0)
<b>Acculturation</b>			
Born outside of US: n/N (%)	566/4467 (12.7)	419/3305 (12.7)	56/519 (10.8)
Years lived in US, median (IQR)	26 (21,30)	26 (21, 30)	25 (21, 29)
Speak a language other than English at home: n/N (%)	800/4453 (18.0)	577/3298 (17.5)	90/513 (17.5)
<b>Social support</b>			
Marital status: n/N (%)			
Single, never married	1670/4478 (37.3)	1144/3312 (34.5)	266/521 (51.1)
Married	2759/4478 (61.6)	2135/3312 (64.5)	248/521 (47.6)
Separated, divorced, or widowed	49/4478 (1.1)	33/3312 (1.0)	7/521 (1.3)
Currently have a partner or significant other: n/N (%)	4226/4477 (94.4)	3152/3312 (95.2)	474/520 (91.2)
<b>Access to care/medical literacy</b>			
Type of health insurance: n/N (%)			
Commercial	3087/4458 (69.2)	2364/3298 (71.7)	299/519 (57.6)
Government/military	1219/4458 (27.3)	831/3298 (25.2)	199/519 (38.3)
Self-pay/other	152/4458 (3.4)	103/3298 (3.1)	21/519 (4.0)
<b>REALM-SF score: n/N (%)</b>			
0	93/4324 (2.2)	57/3212 (1.8)	17/506 (3.4)
1–3	58/4324 (1.3)	40/3212 (1.2)	10/506 (2.0)
4–6	581/4324 (13.4)	401/3212 (12.5)	96/506 (19.0)
7	3592/4324 (83.1)	2714/3212 (84.5)	383/506 (75.7)

Abbreviations: SD = standard deviation; n = number in category; N = sample size; GED = general educational development certificate; IQR = interquartile range; REALM-SF = Rapid Estimate in Adult Literacy in Medicine — Short Form. Adjusted RR are adjusted for age, self-reported race/ethnicity, body mass index, tobacco use and physical activity at baseline.

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