Association between childbirth history and multiple health outcomes

Keywords
pregnancy, cholesterol, health outcome, childbirth, lipid

Abstract

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Material and methods
The cross-sectional study utilized data from NHANES from 2007 to 2020. Blood lipid indexes were included triglyceride,TC, LDL-C and HDL-C. Then, RC was calculated.

Results
A total of 3889 participants were included in this study. The incidence of most diseases among women who had childbirth were significantly increased ($p<0.05$), especially high blood pressure (40.77% vs 19.57%, $p<0.001$), diabetes (13.15% vs 5.86%, $p<0.001$), heart disease (7.75% vs 1.69%, $p<0.001$) and arthritis (35.22% vs 17.57%, $p<0.001$). The individuals with two diseases were the most common (29.1%), and overweight-high blood pressure-arthritis was the most important comorbidity mode. After additionally adjusting, the risks of seven kinds of medical conditions (heart disease, cancer, kidney stones, arthritis, thyroid problem, diabetes and high blood pressure) in the women who had given birth were significantly increased. The odds ratios (OR) were 1.57~3.54 and 95% confidence intervals (CIs) were 1.15~6.97 ($p<0.0001$), and birth number would increase the risks. In addition, the level of RC was significantly increased in the women who developed the seven kinds of medical conditions ($p<0.001$). A nonlinear (L-shaped) relationship of blood RC was observed in heart disease, arthritis, cancer, diabetes and high blood pressure, and mediation analysis demonstrated that blood RC accounted for 8.2%, 10.6%, 6.84%, 17.7%, 12.5% of observed association.

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Childbirth history leaves an indelible imprint on women’s multiple health outcomes, with RC serving as both a biomarker and mediator of long-term disease risk.

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To explore the association between childbirth experience and multiple health outcomes, and to discuss the role of blood lipids.

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The cross-sectional study utilized data from the National Health and Nutrition Examination Survey (NHANES) from 2007 to 2020. Blood lipid indexes were included triglyceride, total cholesterol (TC), LDL-cholesterol (LDL-C) and HDL-cholesterol (HDL-C). Then, remnant cholesterol (RC) was calculated.

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A total of 3889 participants were included in this study. The incidence of most diseases among women who had childbirth were significantly increased ($p<0.05$), especially high blood pressure (40.77% vs 19.57%, $p<0.001$), diabetes (13.15% vs 5.86%, $p<0.001$), heart disease (7.75% vs 1.69%, $p<0.001$) and arthritis (35.22% vs 17.57%, $p<0.001$). The individuals with two diseases were the most common (29.1%), and overweight-high blood pressure-arthritis was the most important comorbidity mode. After additionally adjusting, the risks of seven kinds of medical conditions (heart disease, cancer, kidney stones, arthritis, thyroid problem, diabetes and high blood pressure) in the women who had given birth were significantly increased. The odds ratios (OR) were 1.57~3.54 and 95% confidence intervals (CIs) were 1.15~6.97 ($p<0.0001$), and birth number would increase the risks. In addition, the level of RC was significantly increased in the women who developed the seven kinds of medical conditions ($p<0.001$). A nonlinear (L-shaped) relationship of blood RC was observed in heart disease, arthritis, cancer, diabetes and high blood pressure, and mediation analysis demonstrated that blood RC accounted for 8.2%, 10.6%, 6.84%, 17.7%, 12.5% of observed association.

CONCLUSIONS

Childbirth history leaves an indelible imprint on women's multiple health outcomes, with RC serving as both a biomarker and mediator of long-term disease risk.

KEY WORDS: childbirth; pregnancy; health outcome; lipid; cholesterol

Introduction

Pregnancy and childbirth represent pivotal biological and psychosocial milestones in a woman's life, profoundly influencing both short- and long-term health trajectories[1], including physiology, metabolism and psychology[2]. Beyond their direct role in

reproduction, these experiences are increasingly recognized for their dual impact on long-term health. On the one hand, some evidence suggested that the metabolic, hormonal, and vascular stresses inherent to pregnancy might predispose women to long-term health risks. The most concerned diseases include hypertension, cardiovascular disease and diabetes. Due to physiologic and/or pathophysiologic alterations in blood pressure (BP), hypertensive disorders of pregnancy (HDP) were associated with a heightened risk of cardiovascular disease. Timely recognition and modification of optimal BP range in peripartum and postpartum would contribute to improve their outcomes[3]. One systematic review showed gestational diabetes mellitus (GDM) and HDP were associated with the higher risk of type 2 diabetes mellitus (T2DM) and hypertension after pregnancy[4]. Nakimuli et al also reported that over one-third of women with pre-eclampsia would develop hypertension at one year postpartum[5]. However, previous studies have predominantly focused on the adverse effects of pregnancy complications on women's health. The influence of normal pregnancy and childbirth experience on women's health is still not clear. On the other hand, reproductive experiences have been associated with physiological adaptations that confer certain health advantages. For instance, pregnancy might lower the risks of hormone-sensitive malignancies, such as breast[6] and ovarian cancers[7]. Juang's group also found pregnancy had an impact on primary dysmenorrhea[8]. Of course, the study in this field is still very limited. Taken together, current pregnant studies have predominantly employed single-disease paradigms, which fail to reflect the clinical reality of the women's short- and long-term health.

It is well known that pregnancy imposes profound, lasting changes on lipid metabolism, whether peripartum or postpartum. These changes often affect the women's health[9,10]. Recently, remnant cholesterol (RC), defined as cholesterol other

than low-density lipoprotein cholesterol (LDL-C) and high-density lipoprotein cholesterol (HDL-C), was a robust predictor marker of perinatal diseases, especially GDM[11,12]. Gao *et al* reported RC, but not other cholesterol parameters, could be used as an early warning indicator of GDM at 12-14 weeks of gestation. The risk of developing GDM would significantly increase when the level of RC was more than 24.30 mg/dL[13]. In addition, remnant cholesterol was found to have a positive association with blood pressure and sustained hypertension in pregnancy and 6 and 9 years after pregnancy, and the effect was more significant than that of total cholesterol (TC), LDL-C and HDL-C.[14] However, the change track of RC in women with normal reproductive experience and its influence on women's health are still unclear.

Here, in order to explore the association between childbirth experience and multiple health outcomes, we investigated seven cycles of the National Health and Nutrition Examination Survey (NHANES, 2007~2020)[15,16]. We clarified their relationship firstly. The selected health outcomes included 16 chronic diseases and 26 subtypes, such as diabetes, heart disease, cancer, liver condition, failing kidney, kidney stones, thyroid problem, high blood pressure, sleep disorder, arthritis. Then we discussed the role of blood lipids (especially cholesterol). This study offers new insights into potential health risks associated with childbirth experience, and hopes to contribute to improving public health outcomes.

Materials and Methods

Data source and study population

The cross-sectional study was from seven cycles of NHANES (2007~2020). The participant's selection is illustrated in Figure 1. Of 66148 initial subjects, 32793 were excluded due to male gender. 16627 were excluded due to incomplete data of age,

education level, race, poverty ratio and body mass index (BMI). 5468 were excluded due to missing the data of blood lipid indexes.7371 were excluded due to missing the information of pregnancy, childbirth and multiple health outcomes. Finally, 3889 women were included. Among excluded female participants, 11,847 reported no pregnancy history but were excluded due to incomplete data on blood lipid indexes or health outcomes. To assess potential selection bias in this specific subgroup, we compared baseline characteristics between these excluded nulligravid women and included nulligravid women (n=649). No significant differences were observed in age (36.8±18.2 vs 37.2±17.7 years, p=0.62), racial composition, or education level (college graduate: 40.2% vs 41.5%), suggesting minimal selection bias in our nulligravid subgroup. Additionally, no substantial differences were observed in key confounding factors between the overall excluded female participants and included participants, indicating that the study population was representative of the target population.

Definition of pregnancy and childbirth history

Pregnancy history was measured by the following question: “Ever been pregnant? (RHQ131)”, including current pregnancy, live births, miscarriages, stillbirths, tubal pregnancies and abortions. While the participants who answer “no” were considered as never pregnancy (G1). Similarly, childbirth history and birth number were defined according to the question: “How many deliveries live birth result? (RHQ171)”. Women who answer the number of live births one or more were considered as having childbirth (G2). Next, the definition of age at first birth (AFB) and age at last birth (ALB) were based on the Questionnaire Data of “Age at first live birth (RHQ180)” and “Age at last live birth (RHD190)” respectively. Birth interval cycle was calculated as ALB-AFB.

Definition of multiple health outcomes

Just as the previous study[17], multiple health outcomes were measured by the related questionnaire, mainly including medical conditions (MCQ), diabetes (DIQ), kidney conditions (KIQ), sleep disorders (SLQ) and blood pressure & cholesterol (BPQ). Women were considered as having the condition when they answered "yes" to the question "Has a doctor or other health professional ever told you that you have?". In this study, 16 conditions and 26 subtypes were included heart disease (heart attack, angina pectoris, coronary heart disease, congestive heart failure), stroke, emphysema, asthma, chronic bronchitis, liver condition, failing kidney, kidney stones, cancer (breast, cervix, ovary, uterus), overweight, arthritis (osteoarthritis, rheumatoid arthritis), gout, thyroid problem, diabetes, high blood pressure, sleep disorder.

Measurements of blood lipid indexes

Women's blood lipid **indexes** in questionnaire were obtained from laboratory data, including triglyceride (mmol/L), total cholesterol (TC, mmol/L), LDL-cholesterol (LDL-C, mmol/L) and HDL-cholesterol (HDL-C, mmol/L). According to the study[18], remnant cholesterol (RC) was calculated as deducting the levels of LDL-C and HDL-C from TC. According to the literature[19], we divided RC into four quartile levels: Q1(<0.43 mmol/L), Q2 (0.41~0.61 mmol/L), Q3 (0.61~0.88 mmol/L) and Q4 (>=0.88 mmol/L). Meanwhile, Q1 was defined as the reference in the follow-up study.

Other covariates

Similar to some other studies[20-22], age, race, education level, poverty ratio were obtained from demographics data. Gender was not included as a covariate since only female participants were enrolled.

Statistical Analysis

DecisionLinnc1.0 software[23] was employed for data analysis, which is a platform that integrates multiple programming language environments. Logistic regression analysis model was employed to analyze two distinct models to examine the relationship between childbirth experience and multiple health outcomes. Next, restricted cubic splines (RCS) was utilized to explore potential non-linear relationships between blood lipid indexes and the risk of multiple health outcomes caused by childbirth experience. Parallel mediation analysis was carried out to clarify whether blood RC plays an intermediary role between childbirth and multiple health outcomes. $P < 0.05$ was considered statistically significant.

Results

Baseline participant characteristics

A total of 3889 participants with complete data from NHANES (2007~2020) were included in this study. Table 1 presented the baseline characteristics of the participants according to childbirth history. Compared to never pregnancy women(G1), the participants who have childbirth experience showed higher age and BMI, but lower education level and poverty ratio ($p<0.001$). At the same time, they also showed abnormal levels of several blood lipid indexes, which were characterized by a significant decrease in HDL-C and a significant increase in other indexes (triglyceride, TC, LDL-C and RC).

The occurrence of multiple health outcomes

Table 2 compared the occurrence of multiple health outcomes according to childbirth history (Supplement Figure 1). The incidence of most chronic diseases among women who had given birth were significantly increased ($p<0.05$), except asthma, chronic bronchitis and liver condition. It was particularly noteworthy that the incidence of

high blood pressure (40.77% vs 19.57%, p<0.001), diabetes (13.15% vs 5.86%, p<0.001), heart disease (7.75% vs 1.69%, p<0.001) and arthritis (35.22% vs 17.57%, p<0.001) were significantly increased. The incidence of four common subtypes of cardiovascular diseases (congestive heart failure, coronary heart disease, angina pectoris, heart attack) increased significantly. Interestingly, the incidence of uterus, cervix and breast cancer in women with childbirth experience were significantly increased (p<0.001), but the incidence of ovarian cancer did not change significantly. For the 16 diseases of interest, individuals with no disease account for 21.5% (n = 697), those with one disease make up 22.9% (n = 741), with two diseases 19.8% (n = 641), with three diseases 11.9% (n = 385), and with four diseases 10.3% (n = 333). Among all comorbid patients, individuals with two diseases are the most common (29.1%), followed by those with three diseases (25.2%). In total, there are 74 combinations of two diseases. The top three combinations are overweight-high blood pressure (15.2%), arthritis-high blood pressure (12.3%), and overweight-arthritis (8.0%). There are 113 combinations of three diseases. The top three combinations are overweight-arthritis-high blood pressure (14.5%), overweight-high blood pressure-thyroid problems (4.7%), and overweight-high blood pressure-diabetes (4.4%) (Figure 2A). In addition, **a** network graph depicted the comorbidity relationships between diseases. The top three node size in the patient network diagram were overweight, high blood pressure and arthritis. The most significant link between nodes was overweight- blood pressure -arthritis (Figure 2B).

Associations between childbirth experience and multiple health outcomes

We have established two models before and after adjusting for confounding factors respectively. As shown in Figure 3, two models established a statistically significant association between childbirth experience and multiple health outcomes. After

additionally adjusting for general data confounding factors such as race, education, poverty income ratio, BMI (Model 2), the risks of seven kinds of medical conditions (heart disease, cancer, kidney stones, arthritis, thyroid problem, diabetes and high blood pressure) in women who had given birth were significantly increased. The odds ratios (OR) were 1.57~3.54 and 95% confidence intervals (CIs) were 1.15~6.97 ($p<0.0001$). The top three conditions of OR were heart disease (OR=3.54, $p<0.0001$), cancer (OR=3.12, $p<0.0001$), and high blood pressure (OR=2.25, $p<0.0001$). Next, we conducted the logistic regression analysis of disease subtypes (Supplement Figure 2). Childbirth experience could significantly increase the risk of breast cancer (OR=3.52, p=0.0016) and cervix cancer (OR=5.27, p=0.0223), but it did not affect uterus cancer (OR=2.39, p=0.2448) and ovarian cancer (OR=0.64, p=0.4961). Similarly, reproductive experience significantly increased the risk of osteoarthritis (OR=4.07, p=0.0004), but not affect rheumatoid arthritis. It could lead to the high risk of most types of cardiovascular diseases (congestive heart failure, coronary heart disease, heart attack), but not to an increase in the risk of angina pectoris.

Then, we carried out a follow-up analysis of seven diseases with significantly increased risk, including heart disease, cancer, kidney stones, arthritis, thyroid problem, diabetes and high blood pressure. We analyzed the relationship between reproductive indicators and health outcomes, including birth number, age at first birth, age at last birth and birth interval cycle. The birth number would increase the risks of heart disease, cancer, arthritis, diabetes and high blood pressure caused by childbirth experience (Figure 4). However, other indicators basically do not increase the risks, such as age at first birth, age at last birth and birth interval cycle.

Effects of blood lipid indexes

Firstly, RC levels were significantly higher in women who developed the seven medical conditions ($p<0.001$, Table 3). However, the levels of TC, LDL-C and HDL-C showed complex changes, which were different in different diseases. For instance, of the women with heart disease and diabetes, TC, LDL-C and HDL-C significantly reduced, while they increased in the women with cancer and arthritis. However, they eventually led to a significant increase in RC. Next, RCS curves were adopted to display the association between the levels of blood lipid indexes and the risk of multiple health outcomes caused by childbirth experience. After adjusting for multiple variables, evidence for a nonlinear (L-shaped) relationship of blood RC was observed in heart disease, arthritis, cancer, diabetes and high blood pressure (Figure 5). However, there was no nonlinear (L-shaped) relationship between blood TC, LDL-C, HDL-C and the odds ratio. Then, to clarify whether blood RC plays an intermediary role between childbirth and multiple health outcomes, the parallel mediation analysis was carried out. Mediation analysis demonstrated that blood RC accounted for 8.2%, 10.6%, 6.84%, 17.7%, 12.5% of observed association between childbirth and heart disease, arthritis, cancer, diabetes and high blood pressure, respectively ($p<0.001$, Figure 6). By receiver operating characteristic curves (ROC), RC had the best predictive value for diabetes, with AUC of 0.658 (Supplement Figure 3).

Discussion

This large cross-sectional study provided compelling evidence that childbirth history was associated with a heightened risk of multiple health outcomes in women, with remnant cholesterol (RC) emerging as a critical mediator in these associations. These findings extend the paradigm that reproductive milestones—from pregnancy through

menopause—constitute windows of vulnerability for cardiovascular and metabolic disease in women[24].By leveraging nationally representative data from NHANES, we demonstrated that women with childbirth experience exhibited significantly elevated risks of hypertension, diabetes, cardiovascular diseases, arthritis, and specific cancers (breast and cervix), independent of socioeconomic and anthropometric confounders. Notably, RC partially mediated these associations (8.2%~17.7%), underscoring its role as a metabolic bridge linking reproductive physiology to long-term morbidity. These findings advance our understanding of the dual legacy of pregnancy, where adaptive changes for fetal development may inadvertently predispose women to chronic diseases through persistent lipidomic alterations.

Our observation of increased risks for hypertension, diabetes, and cardiovascular diseases aligns with prior studies implicating pregnancy as a metabolic stress test. Repeated hemodynamic demands during gestation may induce vascular remodelling and endothelial dysfunction, creating a substrate for later cardiometabolic disorders. Notably, linear increases in diabetes risk with higher birth numbers suggested cumulative metabolic burden in modern cohorts, which is similar to Moon's study. They found the women who delivered more than three times were more obese, and their plasma glucose concentrations were elevated at 2 months postpartum. The reason might be that multiple pregnancies induce cellular stress and aging features in β cells[25]. Intriguingly, childbirth history was associated with elevated risks of hormone-sensitive cancers (breast and cervix), but didn't significantly increase the risk of ovarian cancer and uterine cancer. These findings were contradicted the previous studies[7,26,27]. This discrepancy may reflect temporal shifts in risk factors, such as delayed age at first birth or increased prevalence of overweight, which could override protective effects of pregnancy.

The central role of RC in mediating childbirth-associated morbidity represents a key mechanistic insight. Pregnancy induces profound lipid remodelling, characterized by elevated RC levels derived from HDL subfraction shifts. Unlike LDL-C, which normalizes postpartum, RC persists at elevated levels for years, as evidenced by our findings. While we focused on remnant cholesterol as a potential modifiable mediator, we recognize that chronological age may confound these associations through biological aging pathways. Given that age is non-modifiable whereas RC represents a potential therapeutic target, elucidating the RC pathway remains clinically meaningful. The cross-sectional design precludes establishing temporal sequence; thus, our mediation analysis should be interpreted as exploratory rather than confirmatory.This "lipid memory" may drive chronic inflammation and insulin resistance through multiple pathways, consistent with evidence that lipid-lowering interventions can modulate inflammatory processes beyond their metabolic effects[28]. ~~This "lipid memory" may drive chronic inflammation and insulin resistance through multiple pathways.~~ The nonlinear (L-shaped) association between RC and disease risks suggests a threshold effect, where even modest RC elevations significantly increase morbidity—a finding with direct clinical implications for postpartum lipid monitoring.

Our findings advocate for integrating reproductive history into cardiovascular risk stratification tools. The 3.54-fold increased heart disease risk in parous women rivals traditional risk factors like smoking, necessitating targeted screening. Furthermore, RC's predictive value for diabetes (AUC=0.658) highlights its potential as a low-cost biomarker for postpartum metabolic surveillance. Clinically, interventions to mitigate RC elevation warrant exploration in high-parity populations.

Limitations

This study has limitations. First, the cross-sectional design precludes causal inference, and self-reported outcomes may introduce recall bias. While NHANES provides large, nationally representative samples, its continuous cross-sectional structure—independent samples per 2-year cycle without repeated individual measurements—precludes within-person trajectory analysis. Future longitudinal studies should employ prospective cohort designs with repeated measurements of the same women across reproductive milestones to establish temporal sequence and validate our findings. Second, residual confounding by unmeasured factors (e.g., gestational complications, lifestyle changes postpartum) cannot be excluded. The substantial age difference between nulligravid and parous women (approximately 15 years) represents a significant confounding factor. While our multivariable models adjusted for chronological age, residual confounding from age-related biological aging may persist. Future studies with age-matched controls are needed to disentangle these contributions. Third, several outcomes, including uterine cancer (0.72%), ovarian cancer (0.46%), and emphysema (1.72%), exhibited very low prevalence. While we retained these outcomes given their biological relevance to reproductive history, estimates for rare outcomes carry wide confidence intervals and limited statistical power. These findings should be considered exploratory. Fourth, we recognize that categorizing women into three distinct groups—(1) term live births, (2) pregnancy loss without live births, and (3) nulligravid—would provide finer mechanistic insights. However, the subgroup with pregnancy complications but no live births was too small (n=118, 3.0%) for reliable inference. We therefore retained the binary classification. Fifth, we acknowledge that obesity (BMI ≥30 kg/m²) represents a more severe clinical endpoint. However, we deliberately retained overweight (BMI ≥25 kg/m²) as the outcome based on current standards: (1) overweight and obesity remain

independent, standardized categories in contemporary national health surveys[29]; (2) recent reproductive epidemiology studies employ BMI ≥25 as a sensitive endpoint to capture postpartum metabolic deviation[30]; (3) metabolically unhealthy phenotypes are significantly prevalent in the BMI 25–29.9 range[31]. Future studies should employ standard BMI stratification to clarify dose–response relationships. Finally, we used complete case analysis for missing data, but this may lead to a slight loss of statistical power. Future studies could employ multiple imputation to verify robustness.To overcome the cross-sectional limitation, future research should employ prospective cohort designs with repeated measurements of the same women across reproductive milestones. Such designs would enable: (1) establishment of temporal sequence; (2) assessment of within-person metabolic changes; (3) evaluation of cumulative pregnancy effects using time-varying covariate analyses; (4) stratification by standard BMI categories to offer additional granularity. Potential data sources include established pregnancy cohorts or electronic health record linkages with longitudinal lipid monitoring.

In conclusion

Childbirth history leaves an indelible imprint on women's multiple health outcomes, with RC serving as both a biomarker and mediator of long-term disease risk. These findings underscore the need for lifespan approaches to women's health, where reproductive history informs personalized prevention strategies. Addressing pregnancy-associated lipid dysregulation may mitigate the hidden morbidity burden carried by millions of parous women worldwide.

CONFLICT OF INTEREST

None declared. The authors declare that they have no competing interests.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study is derived from the mining of the NHANES database and is deemed exempt from ethical review and informed consent. The National Center for Health Statistics (NCHS) Ethics Review Board (ERB) ensures that research involving human participants protects the rights and welfare of study participants and conforms to U.S. federal regulations. The NCHS ERB, and the formal review bodies that preceded it, have approved each NHANES study protocol since the survey began running continuously in 1999.

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AVAILABILITY OF DATA AND MATERIALS

The questionnaire and datasets used are available from the corresponding author on request.

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Figure 1. Flowchart of participants selection from the NHANES in present study.

Figure 2. The comorbidity patterns among diseases

Figure 2A. UpSet plot showing the comorbidity patterns among diseases.

Figure 2B. Network graph depicting comorbidity relationships between diseases.

Figure 3. The association between childbirth experience and multiple health outcomes

Model 1: unadjusted; Model 2: adjusted for age, race, education, poverty income ratio and BMI.

Figure 4. The relationship between reproductive indicators and health outcomes

Figure 5. Blood remnant cholesterol in the association between childbirth and health outcomes

RCS prediction plot; adjusted for confounders; reference = RC Q1 (<0.43 mmol/L); L-shaped nonlinear relationship, *p* for Nonlinear <0.05.

Figure 6. Mediation of remnant cholesterol in the association between childbirth and health outcomes

Percentage = mediating effect of RC (proportion of total association explained by RC); all mediating effects $p<0.001$; adjusted for confounders.

Supplement Figure 1. The occurrence of multiple health outcomes according to childbirth history

Blue = never pregnancy (G1); Red = having childbirth (G2); vertical axis = disease incidence rate (%); $p<0.05$ considered statistically significant.

Supplement Figure 2. The association between childbirth experience and subtypes of health outcomes

Supplement Figure 3. ROC curves for the remnant cholesterol

Acronyms

National Health and Nutrition Examination Survey (NHANES)

total cholesterol (TC)

LDL-cholesterol (LDL-C)

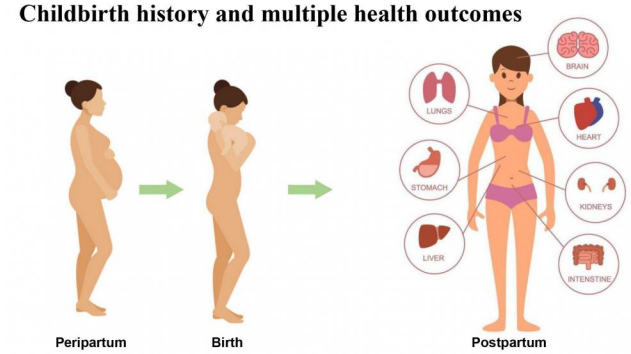
HDL-cholesterol (HDL-C)

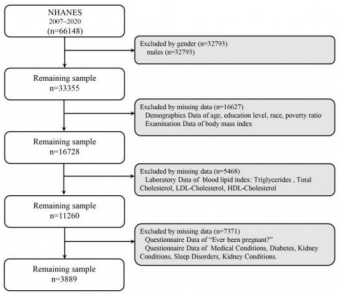
remnant cholesterol (RC)

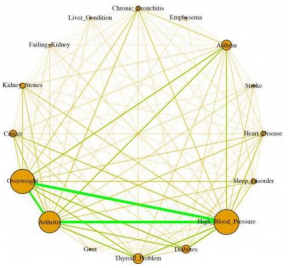
odds ratios (OR)

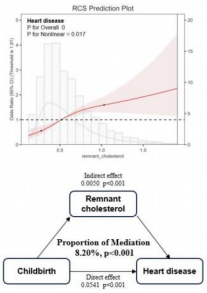
confidence intervals (CIs)

Childbirth history and multiple health outcomes









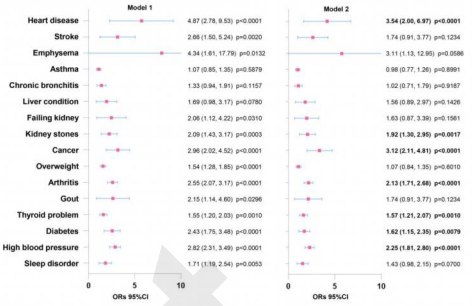


Table 1. Baseline participant characteristics according to childbirth history

Variable Names	Overall	Childbirth history		p-value
		G1 (no)	G2 (yes)	
n	3889	649	3240	
Age (year)	49.879±17.817	37.228±17.699	52.413±16.731	<0.001
Race (%)				
Mexican American	558 (14.35)	66 (10.17)	492 (15.19)	<0.001
Other Hispanic	392 (10.08)	60 (9.24)	332 (10.25)	
Non-Hispanic White	1835 (47.18)	312 (48.07)	1523 (47.01)	
Non-Hispanic Black	762 (19.59)	115 (17.72)	647 (19.97)	
Other Race	342 (8.79)	96 (14.79)	246 (7.59)	
Poverty income ratio	2.416±1.618	2.664±1.669	2.366±1.603	<0.001
<5.0	3272 (84.13)	516 (79.51)	2756 (85.06)	
>=5.0	617 (15.87)	133 (20.49)	484 (14.94)	
Education level (%)				<0.001
Less than 9th grade	347 (8.92)	21 (3.24)	326 (10.06)	
9-11th grade	586 (15.07)	36 (5.55)	550 (16.98)	
High school graduate	822 (21.14)	92 (14.18)	730 (22.53)	
Some college	1199 (30.83)	231 (35.59)	968 (29.88)	
College graduate or above	935 (24.04)	269 (41.45)	666 (20.56)	
BMI (kg/m2)	29.251±7.461	27.826±8.688	29.536±7.158	<0.001
Normal weight (%)	1229 (31.60)	307 (47.30)	922 (28.46)	
Overweight (%)	1529 (39.32)	191 (29.43)	1338 (41.30)	
Obesity (%)	1131 (29.08)	151 (23.27)	980 (30.25)	
Triglyceride	1.289±0.689	1.091±0.583	1.328±0.702	<0.001
Total-cholesterol	5.067±1.044	4.889±0.979	5.103±1.053	<0.001
LDL-cholesterol	2.962±0.905	2.831±0.848	2.988±0.914	<0.001
HDL-cholesterol	1.515±0.407	1.558±0.397	1.506±0.409	0.003
Remnant cholesterol	0.59±0.316	0.5±0.267	0.609±0.322	<0.001
Q1	1402 (36.05)	306 (47.15)	1096 (33.83)	
Q2	1022 (26.28)	175 (26.96)	847 (26.14)	
Q3	854 (21.96)	110 (16.95)	744 (22.96)	
Q4	611 (15.71)	58 (8.94)	553 (17.07)	

Table 2. Multiple health outcomes according to childbirth history [n(%)]

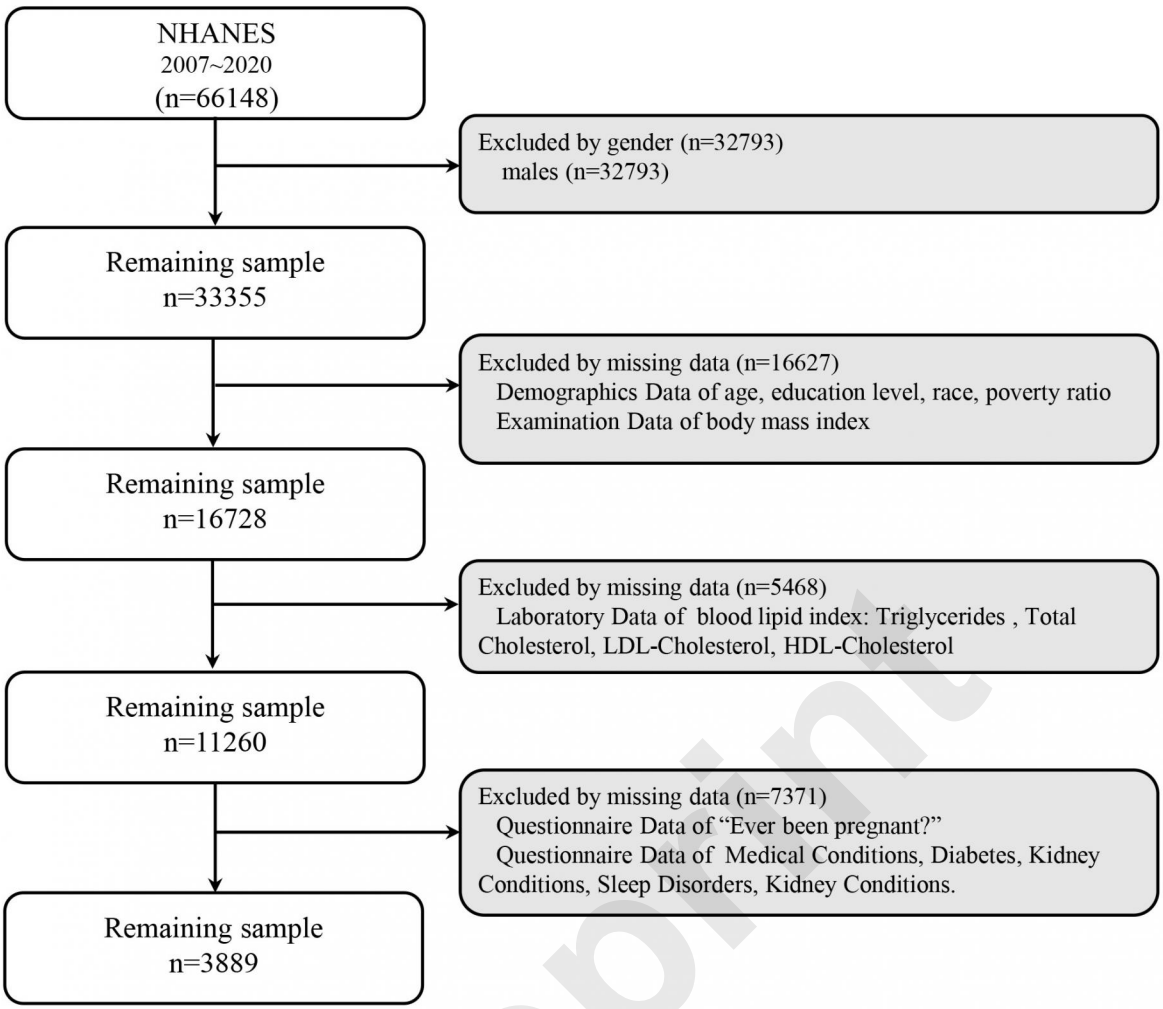
Variable Names	Overall	Childbirth history		p-value
		G1 (no)	G2 (yes)	
Heart disease				<0.001
No	3627 (93.26)	638 (98.31)	2989 (92.25)	
Yes	262 (6.74)	11 (1.69)	251 (7.75)	
Congestive heart failure				<0.001
No	3771 (96.97)	645 (99.38)	3126 (96.48)	
Yes	118 (3.03)	4 (0.62)	114 (3.52)	
Coronary heart disease				
No	3786 (97.35)	645 (99.38)	3141 (96.94)	
Yes	101 (2.60)	4 (0.62)	97 (2.99)	
Angina pectoris				0.022
No	3811 (97.99)	644 (99.23)	3167 (97.75)	
Yes	75 (1.93)	4 (0.62)	71 (2.19)	
Heart attack				<0.001
No	3773 (97.02)	644 (99.23)	3129 (96.57)	
Yes	116 (2.98)	5 (0.77)	111 (3.43)	
Stroke				0.002
No	3736 (96.07)	638 (98.31)	3098 (95.62)	
Yes	153 (3.93)	11 (1.69)	142 (4.38)	
Asthma				0.629
No	3262 (83.88)	549 (84.59)	2713 (83.73)	
Yes	627 (16.12)	100 (15.41)	527 (16.27)	
Emphysema				0.011
No	3822 (98.28)	646 (99.54)	3176 (98.02)	
Yes	67 (1.72)	3 (0.46)	64 (1.98)	
Chronic bronchitis				0.135
No	3604 (92.67)	611 (94.14)	2993 (92.38)	
Yes	285 (7.33)	38 (5.86)	247 (7.62)	
Liver condition				0.097
No	3768 (96.89)	636 (98.00)	3132 (96.67)	
Yes	121 (3.11)	13 (2.00)	108 (3.33)	
Failing kidney				0.038
No	3778 (97.15)	639 (98.46)	3139 (96.88)	
Yes	111 (2.85)	10 (1.54)	101 (3.12)	
Kidney stones				<0.001
No	3582 (92.11)	621 (95.69)	2961 (91.39)	
Yes	307 (7.89)	28 (4.31)	279 (8.61)	
Cancer				<0.001
No	3493 (89.82)	622 (95.84)	2871 (88.61)	
Yes	396 (10.18)	27 (4.16)	369 (11.39)	

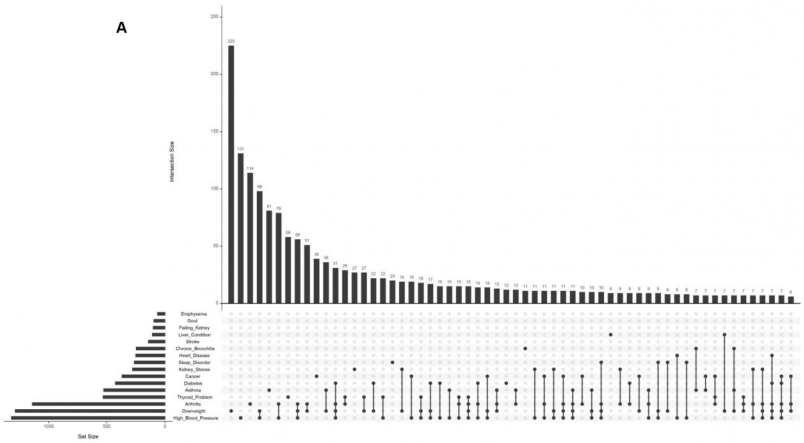
Uterus				<0.001
No	3493 (89.82)	622 (95.84)	2871 (88.61)	
Yes	28 (0.72)	2 (0.31)	26 (0.80)	
Ovary				0.280
No	3493 (89.82)	622 (95.84)	2871 (88.61)	
Yes	18 (0.46)	3 (0.46)	15 (0.46)	
Cervix				<0.001
No	3493 (89.82)	622 (95.84)	2871 (88.61)	
Yes	60 (1.54)	2 (0.31)	58 (1.79)	
Breast				<0.001
No	3493 (89.82)	622 (95.84)	2871 (88.61)	
Yes	111 (2.85)	7 (1.08)	104 (3.21)	
Overweight				<0.001
No	2406 (61.87)	454 (69.95)	1952 (60.25)	
Yes	1483 (38.13)	195 (30.05)	1288 (39.75)	
Arthritis				<0.001
No	2634 (67.73)	535 (82.43)	2099 (64.78)	
Yes	1255 (32.27)	114 (17.57)	1141 (35.22)	
Osteoarthritis				<0.001
No	2634 (95.30)	535 (98.71)	2099 (94.46)	
Yes	130 (4.70)	7 (1.29)	123 (5.54)	
Rheumatoid arthritis				0.033
No	2634 (97.77)	535 (99.07)	2099 (97.45)	
Yes	60 (2.23)	5 (0.93)	55 (2.55)	
Gout				0.036
No	3785 (97.33)	640 (98.61)	3145 (97.07)	
Yes	104 (2.67)	9 (1.39)	95 (2.93)	
Thyroid problem				0.001
No	3284 (84.44)	576 (88.75)	2708 (83.58)	
Yes	605 (15.56)	73 (11.25)	532 (16.42)	
Diabetes				<0.001
No	3425 (88.07)	611 (94.14)	2814 (86.85)	
Yes	464 (11.93)	38 (5.86)	426 (13.15)	
High blood pressure				<0.001
No	2441 (62.77)	522 (80.43)	1919 (59.23)	
Yes	1448 (37.23)	127 (19.57)	1321 (40.77)	
Sleep disorder				0.006
No	3593 (92.39)	617 (95.07)	2976 (91.85)	
Yes	296 (7.61)	32 (4.93)	264 (8.15)	

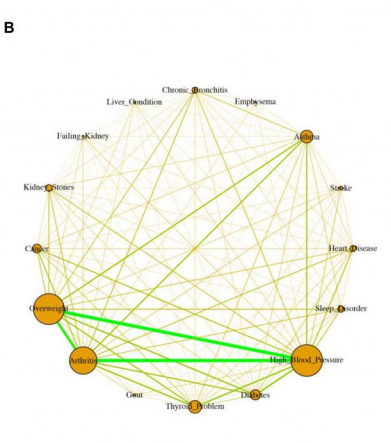
Table 3. Comparison of cholesterol levels

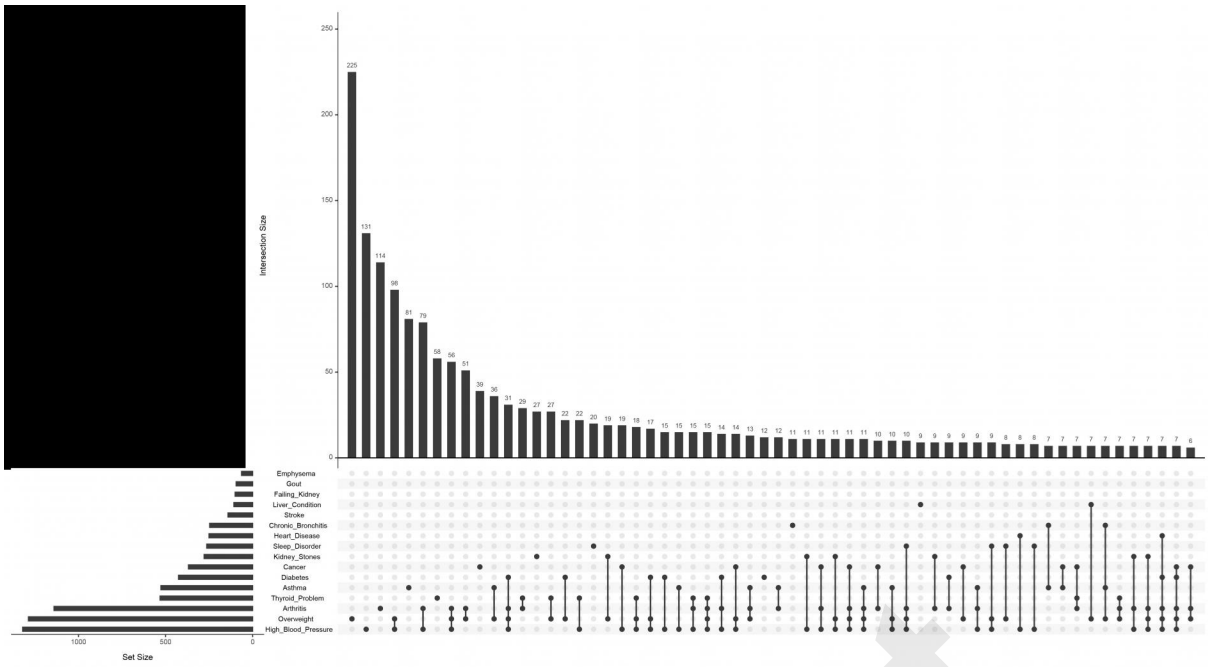
	n	TC (mmol/L)	LDL-C (mmol/L)	HDL-C (mmol/L)	Remnant cholesterol (mmol/L)
Heart disease					
No	3627	5.081±1.038	2.979±0.900	1.522±0.404	0.581±0.311
Yes	262	4.870±1.107	2.726±0.951	1.421±0.439	0.723±0.354
p-value		0.002	<0.001	<0.001	<0.001
Kidney stones					
No	3582	5.064±1.048	2.961±0.908	1.520±0.406	0.583±0.313
Yes	307	5.098±0.999	2.974±0.872	1.453±0.423	0.672±0.343
p-value		0.587	0.806	0.005	<0.001
Cancer					
No	3493	5.047±1.043	2.954±0.905	1.512±0.400	0.582±0.315
Yes	396	5.242±1.042	3.035±0.905	1.542±0.465	0.666±0.313
p-value		<0.001	0.092	0.163	<0.001
Arthritis					
No	2634	5.021±1.041	2.950±0.900	1.514±0.398	0.556±0.304
Yes	1255	5.164±1.046	2.986±0.915	1.516±0.426	0.662±0.329
p-value		<0.001	0.258	0.906	<0.001
Thyroid problem					
No	3284	5.051±1.046	2.956±0.906	1.516±0.405	0.579±0.308
Yes	605	5.153±1.032	2.992±0.903	1.509±0.419	0.652±0.349
p-value		0.027	0.370	0.715	<0.001

Diabetes					
No	3425	5.098±1.038	2.994±0.897	1.534±0.408	0.569±0.302
Yes	464	4.839±1.060	2.721±0.931	1.372±0.374	0.746±0.367
p-value		<0.001	<0.001	<0.001	<0.001
High blood pressure					
No	2441	5.032±1.035	2.955±0.898	1.537±0.406	0.541±0.289
Yes	1448	5.126±1.058	2.974±0.917	1.477±0.407	0.674±0.341
p-value		0.007	0.524	<0.001	<0.001


NHANES
2007~2020
(n=66148)
Excluded by gender (n=32793)
males (n=32793)
Remaining sample
n=33355
Excluded by missing data (n=16627)
Demographics Data of age, education level, race, poverty ratio
Examination Data of body mass index
Remaining sample
n=16728
Excluded by missing data (n=5468)
Laboratory Data of blood lipid index: Triglycerides , Total Cholesterol, LDL-Cholesterol, HDL-Cholesterol
Remaining sample
n=11260
Excluded by missing data (n=7371)
Questionnaire Data of "Ever been pregnant?"
Questionnaire Data of Medical Conditions, Diabetes, Kidney Conditions, Sleep Disorders, Kidney Conditions.
Remaining sample
n=3889


A
Intersection Size
Set Size
Emphysema
Gout
Failing_Kidney
Liver_Condition
Stroke
Chronic_Bronchitis
Heart_Disease
Sleep_Disorder
Kidney_Stones
Cancer
Diabetes
Asthma
Thyroid_Problem
Arthritis
Overweight
High_Blood_Pressure


B
Chronic_Bronchitis
Liver_Condition
Emphysema
Failing_Kidney
Asthma
Kidney_Stones
Stroke
Cancer
Heart_Disease
Overweight
Sleep_Disorder
Arthritis
High_Blood_Pressure
Gout
Diabetes
Thyroid_Problem


Intersection Size
250
200
150
100
50
0
225
131
114
98
81
79
58
56
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7
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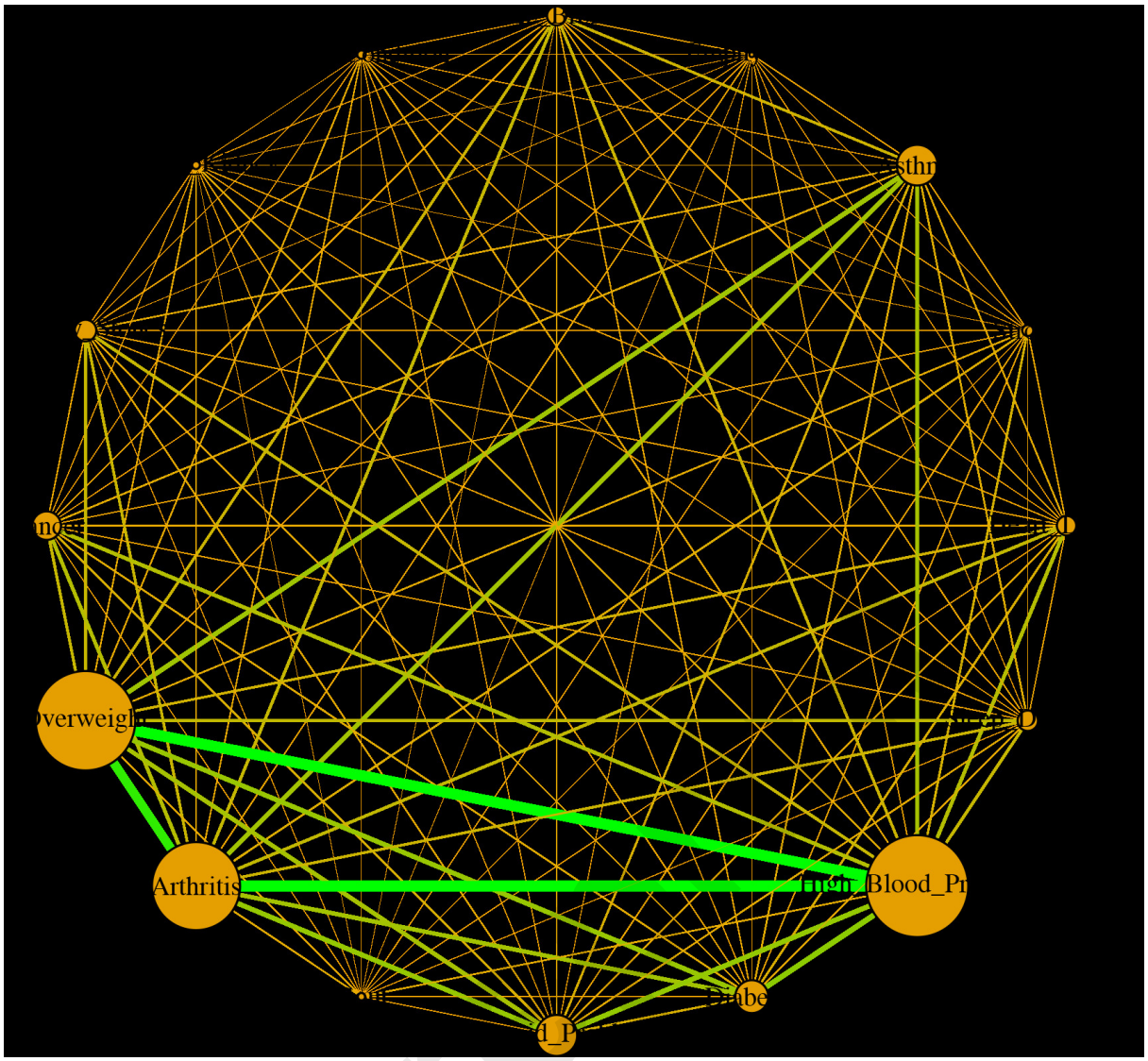
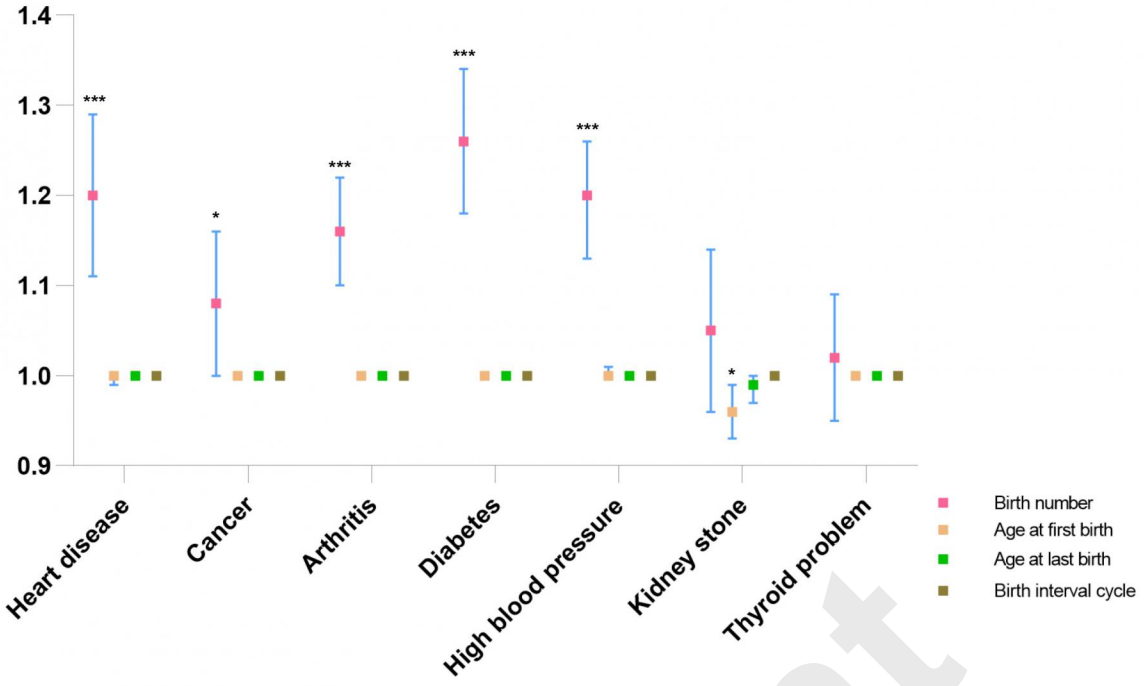
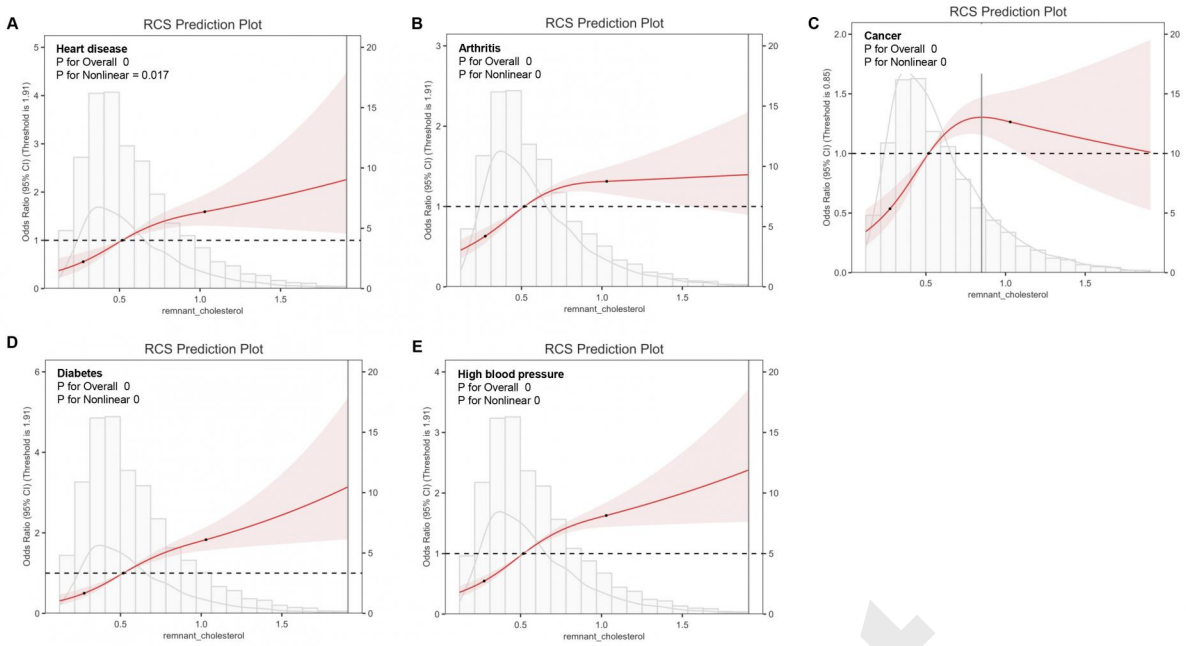
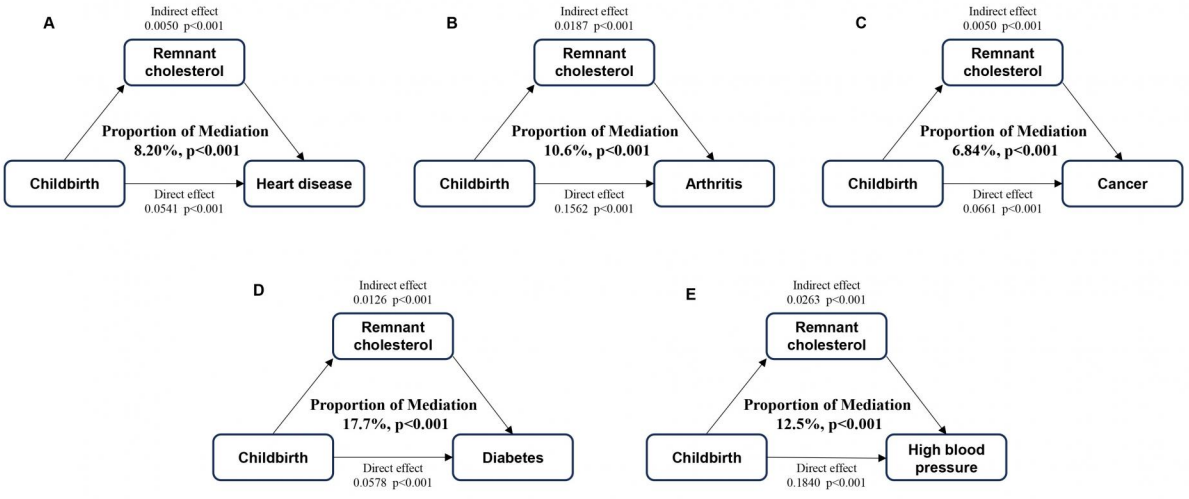
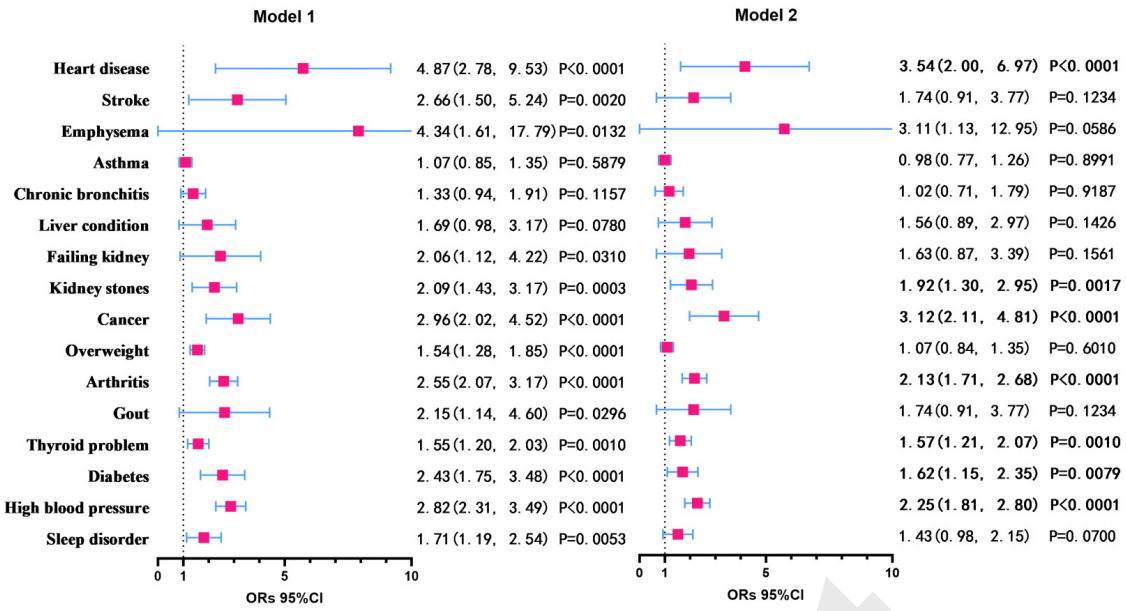
7
6
Emphysema
Gout
Failing_Kidney
Liver_Condition
Stroke
Chronic_Bronchitis
Heart_Disease
Sleep_Disorder
Kidney_Stones
Cancer
Diabetes
Asthma
Thyroid_Problem
Arthritis
Overweight
High_Blood_Pressure
1000
500
0
Set Size

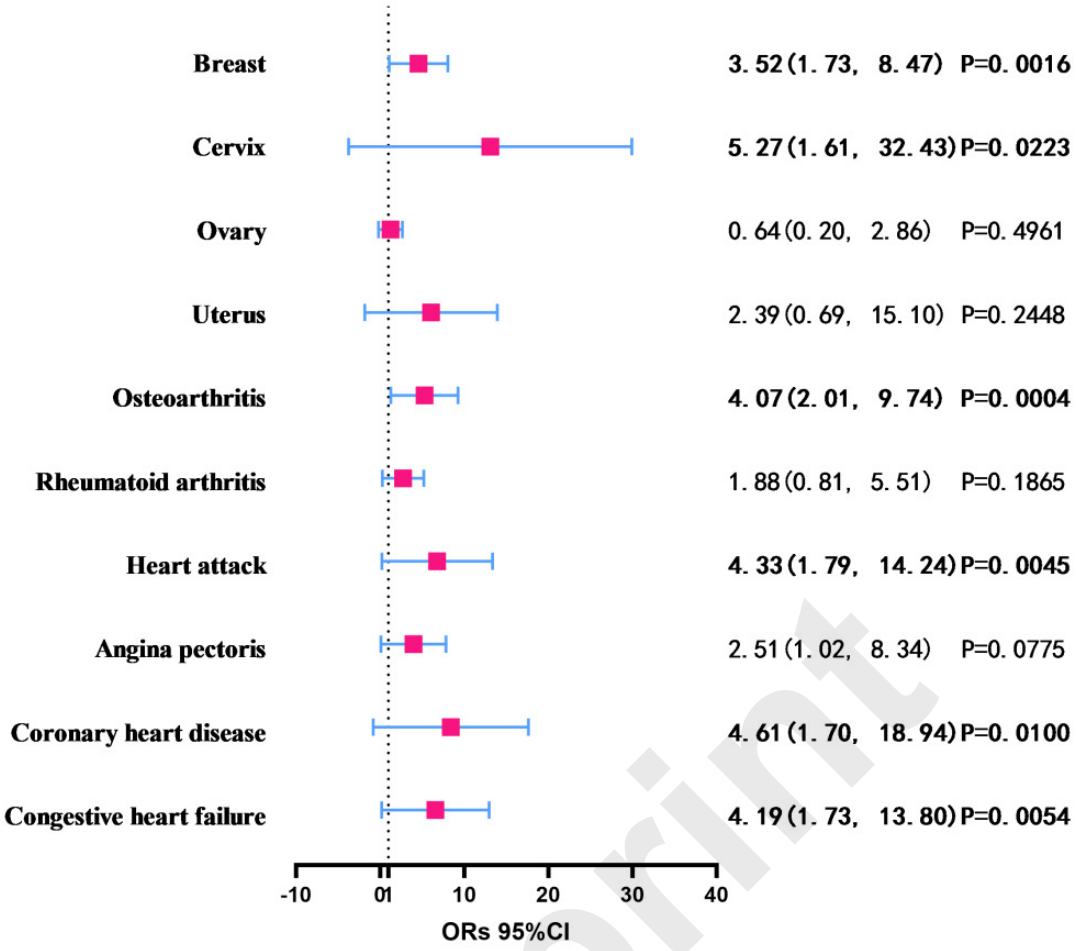

sthr
Arthritis
High_Blood_Pr


1.4
1.3
1.2
1.1
1.0
0.9
***
*
***
***
***
*
Heart disease
Cancer
Arthritis
Diabetes
High blood pressure
Kidney stone
Thyroid problem
Birth number
Age at first birth
Age at last birth
Birth interval cycle


A
RCS Prediction Plot
Heart disease
P for Overall 0
P for Nonlinear = 0.017
Odds Ratio (95% CI) (Threshold is 1.91)
remnant_cholesterol
B
RCS Prediction Plot
Arthritis
P for Overall 0
P for Nonlinear 0
Odds Ratio (95% CI) (Threshold is 1.91)
remnant_cholesterol
C
RCS Prediction Plot
Cancer
P for Overall 0
P for Nonlinear 0
Odds Ratio (95% CI) (Threshold is 0.85)
remnant_cholesterol
D
RCS Prediction Plot
Diabetes
P for Overall 0
P for Nonlinear 0
Odds Ratio (95% CI) (Threshold is 1.91)
remnant_cholesterol
E
RCS Prediction Plot
High blood pressure
P for Overall 0
P for Nonlinear 0
Odds Ratio (95% CI) (Threshold is 1.91)
remnant_cholesterol


A
Indirect effect
0.0050 p<0.001
Remnant cholesterol
Proportion of Mediation
8.20%, p<0.001
Childbirth
Heart disease
Direct effect
0.0541 p<0.001
B
Indirect effect
0.0187 p<0.001
Remnant cholesterol
Proportion of Mediation
10.6%, p<0.001
Childbirth
Arthritis
Direct effect
0.1562 p<0.001
C
Indirect effect
0.0050 p<0.001
Remnant cholesterol
Proportion of Mediation
6.84%, p<0.001
Childbirth
Cancer
Direct effect
0.0661 p<0.001
D
Indirect effect
0.0126 p<0.001
Remnant cholesterol
Proportion of Mediation
17.7%, p<0.001
Childbirth
Diabetes
Direct effect
0.0578 p<0.001
E
Indirect effect
0.0263 p<0.001
Remnant cholesterol
Proportion of Mediation
12.5%, p<0.001
Childbirth
High blood pressure
Direct effect
0.1840 p<0.001


Model 1
Heart disease
Stroke
Emphysema
Asthma
Chronic bronchitis
Liver condition
Failing kidney
Kidney stones
Cancer
Overweight
Arthritis
Gout
Thyroid problem
Diabetes
High blood pressure
Sleep disorder
4. 87 (2. 78, 9. 53) P<0. 0001
2. 66 (1. 50, 5. 24) P=0. 0020
4. 34 (1. 61, 17. 79) P=0. 0132
1. 07 (0. 85, 1. 35) P=0. 5879
1. 33 (0. 94, 1. 91) P=0. 1157
1. 69 (0. 98, 3. 17) P=0. 0780
2. 06 (1. 12, 4. 22) P=0. 0310
2. 09 (1. 43, 3. 17) P=0. 0003
2. 96 (2. 02, 4. 52) P<0. 0001
1. 54 (1. 28, 1. 85) P<0. 0001
2. 55 (2. 07, 3. 17) P<0. 0001
2. 15 (1. 14, 4. 60) P=0. 0296
1. 55 (1. 20, 2. 03) P=0. 0010
2. 43 (1. 75, 3. 48) P<0. 0001
2. 82 (2. 31, 3. 49) P<0. 0001
1. 71 (1. 19, 2. 54) P=0. 0053
0
1
5
10
ORs 95%CI
Model 2
3. 54 (2. 00, 6. 97) P<0. 0001
1. 74 (0. 91, 3. 77) P=0. 1234
3. 11 (1. 13, 12. 95) P=0. 0586
0. 98 (0. 77, 1. 26) P=0. 8991
1. 02 (0. 71, 1. 79) P=0. 9187
1. 56 (0. 89, 2. 97) P=0. 1426
1. 63 (0. 87, 3. 39) P=0. 1561
1. 92 (1. 30, 2. 95) P=0. 0017
3. 12 (2. 11, 4. 81) P<0. 0001
1. 07 (0. 84, 1. 35) P=0. 6010
2. 13 (1. 71, 2. 68) P<0. 0001
1. 74 (0. 91, 3. 77) P=0. 1234
1. 57 (1. 21, 2. 07) P=0. 0010
1. 62 (1. 15, 2. 35) P=0. 0079
2. 25 (1. 81, 2. 80) P<0. 0001
1. 43 (0. 98, 2. 15) P=0. 0700
0
1
5
10
ORs 95%CI


Breast
3. 52 (1. 73, 8. 47) P=0. 0016
Cervix
5. 27 (1. 61, 32. 43) P=0. 0223
Ovary
0. 64 (0. 20, 2. 86) P=0. 4961
Uterus
2. 39 (0. 69, 15. 10) P=0. 2448
Osteoarthritis
4. 07 (2. 01, 9. 74) P=0. 0004
Rheumatoid arthritis
1. 88 (0. 81, 5. 51) P=0. 1865
Heart attack
4. 33 (1. 79, 14. 24) P=0. 0045
Angina pectoris
2. 51 (1. 02, 8. 34) P=0. 0775
Coronary heart disease
4. 61 (1. 70, 18. 94) P=0. 0100
Congestive heart failure
4. 19 (1. 73, 13. 80) P=0. 0054
-10
01
10
20
30
40
ORs 95%CI