Pregnancy Complications and Calculated Cardiovascular Risk in Urban Women: Do We Envisage an Association?

Prerna Bhasin and Satwanti Kapoor

ABSTRACT Most researches related to pregnancy complications and future cardiovascular disease, and their risk factors have been equivocal. Existence and extent of these complications, as a contributing factor to CVD risks, with underlying mechanisms of these associations, still remain uncertain. Hence, the current study tends to examine associations between “complicated pregnancies” with obesity markers known to be coherent reflections of cardiovascular health in urban women. A cross-sectional sample of 631 Punjabi Khatri (mean age: 33 ± 5.58 years) urban women was studied for associations of pregnancy diabetes mellitus, hypertensive disorders, preterm delivery, and size for GA with calculated 10-year CVD risk (based on the Framingham score). A wide range of obesity markers (BMI, waist circumference (WC), WHR, and WHtR) were measured 3–8 years postpregnancy to determine its association with complications during pregnancy. The association with the calculated 10-year CVD risk ($\geq 10\%$) based on the Framingham prediction score was 3.01 OR (2.11–3.72 CI) for pregnancy DM, 4.52 (3.68–4.93 CI) for preeclampsia/gestational hypertension, 2.16 (2.01–2.79 CI) for size at GA (SGA and LGA), 2.25 (1.91–2.85 CI) for preterm births, and 2.48 (2.08–3.98 CI) for abnormal birth weight when compared with women without pregnancy diabetes mellitus, preeclampsia/gestational hypertension, appropriate gestational age, full-term babies, and normal birth weight, respectively, in completely adjusted models. Therefore, HDP, pregnancy diabetes mellitus, and pregnancy outcomes are all associated with an increased risk of CVD 10 years later. Pregnancy may provide an opportunity to identify women at increased risk of CVD relatively early in life.

KEYWORDS Pregnancy complications, CVD, Framingham score, Pregnancy outcomes, Obesity markers

Abbreviations: DM – Diabetes mellitus; BMI – Body mass index; WHR – Waist–hip ratio; WHtR – Waist–height ratio; GA – Gestational age; CVD – Cardiovascular disease; HDP – Hypertensive disorders of pregnancy

INTRODUCTION

Women's reproductive history can be an excellent prognosticator of a later chronic disease, so says the life course approach. Taking a life course approach to the study of reproductive health involves investigation of factors across life and also across generations. Researches support use of an integrated life course approach to study reproductive health, which examines the whole life course and considers continuity

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of reproductive health and interrelationship between different markers. It also recognizes the important influence of reproductive health on chronic disease risk in later life.¹ Cardiovascular disease (CVD) is the one of the foremost cause of deterioration in quality of life in women, taking a toll of about a quarter of deaths globally. This might add to the cruciality of understanding a chronic disease as a developmental process that evolves over the entire lifespan. Also, an important facet of women's reproductive health is their obstetrics and consequent pregnancy outcomes. Detailing of these pregnancy complications might not only influence future cardiovascular health of the mother but also her infant, independently or in unison with other covariates.²⁻⁴ Hence, it becomes essential to explore the fundamental trajectory driven by reproductive factors leading to conditions associated with future CVD risk. The strategy of incorporating obstetric history into cardiovascular risk assessment holds great potential in targeting, counteracting, and preventing chronic illnesses in women.

It has been established that women with certain pregnancy-related complications like hypertensive disorders of pregnancy (preeclampsia and gestational hypertension),⁵ pregnancy diabetes mellitus (gestational diabetes mellitus (GDM) and glycosuria),^{6,7} preterm delivery,⁸ intrauterine growth retardation,⁹ and low birth weight (LBW)¹⁰ are at increased risk of future CVD. This is because most of these conditions predispose women to exaggerated levels of hormones, inflammatory markers, fasting insulin, lipids concentrations, and coagulation factors in their blood streams resulting in metabolic and vascular changes.⁴ This further disturbs homeostasis and leads to endothelial dysfunction, at times posing a serious health risk in later life. Hence, women with adverse pregnancy outcomes and anomalous pregnancy period are seen to be at a greater risk of vascular and metabolic diseases in years to come.^{11,12} Though several studies have reported associations of pregnancy-related complications with other postpartum cardiovascular risk factors, the absolute associations have still not been understood in terms of long-term effects.

Can pregnancy complications unveil predisposition to cardiovascular disease and serve as a predictor of CVD risk for women? Most researches related to pregnancy complications and future cardiovascular disease, and its risk factors have been equivocal. Because cardiovascular disease is one of the leading causes of death among women, an understanding of existence and extent of these complications and ways in which pregnancy complications augur risk needs to be comprehended. A perceptive understanding of associations between obstetric data, pregnancy outcomes, and CVD can possibly alter impending risk. Patients can be assessed and counseled regarding their need for any medical, interventional, or surgical treatment prior to occurrence of any adverse event in future. A multidisciplinary approach can be applied including obstetricians, cardiologists, anesthetists, and neonatologists with regular antenatal checks throughout pregnancy as soon as a complication is spotted. This will also ensure the continued well-being of the mother and fetus.¹³

The current study examines the associations between “complicated pregnancies”,⁴ i.e., hypertensive disorders of pregnancy (HDP) (preeclampsia and gestational hypertension), pregnancy diabetes mellitus (GDM and glycosuria), size for gestational age (small for gestational age (SGA) or large for gestational age (LGA)), preterm deliveries, and birth weight with obesity markers known to be coherent reflections of cardiovascular health. A calculated 10-year risk of CVD through Framingham Risk Score based on current health was used to understand the predisposition of women with anomalous obstetric history linking pregnancy-related complications to prospective cardiovascular risk in young urban women (Fig. 1).

FIGURE 1. Adapting a “complicated pregnancy” syndrome model to predict future cardiovascular risk in urban women.

METHODOLOGY

Target Population

The present study was conducted on Punjabi Khatri-Arora urban women (mean age: 33±5.58 years) of Delhi, India. This is an urbane caste group of Delhi. The INTERHEART study showed that CVD risk factors such as abdominal obesity, hypertension, and diabetes are higher among Indians, even at young ages, than among other ethnic groups. The prevalence rates of CVD risk factors have been rapidly rising within India over the past 25 years, particularly within urban communities.^{14,15} Literatures on Punjabi Khatri have revealed a consistent increase in measures of obesity markers over several decades;^{16–19} hence, a young urban group of women were recruited for the present study.

Khatri is the Punjabi adaptation of the Sanskrit word “Kshatriya.” The Khatri are a north Indian community that originated in the Potwar Plateau of Punjab. Occupations range from being businesswomen to employees providing services in government/private sectors. Many females are also homemakers. Khatri-Arora are known to share common ancestry and they cross marry; therefore, they have been combined for the study.

Data for the present cross-sectional research was collected by an epidemiological survey through a hospital and household study on 742 women using a complex multistage cluster sampling approach. A total of 631 women with a recorded live birth 3–8 years ago (mean age: 32±5.67 years ago) and who consented to have their obstetric data abstracted from medical records were measured. None of these women had any records of a CVD event prior to indexed pregnancy. Absence of obstetric data or consent, a recent pregnancy, a previous history of any chronic condition and unmatched socioeconomic status acted as the exclusion criteria for the study (N=111) (Fig. 2).

All women suffering from any pregnancy complications, gestational diabetes mellitus (GDM), hypertensive disorders, preterm delivery, anomalous size for gestational age (GA), and anomalous birth weight in the index pregnancy, were treated as one group (N=321). Women who had absolutely no pregnancy complication were treated as

FIGURE 2. Study design with inclusion and exclusion criteria.

another group ($N=310$). For multiparous women, the most recent pregnancy was indexed for records.

The study was conducted from December, 2011 to November, 2012, and the protocol for the study was reviewed and approved by the Ethical Committee of the Department of Anthropology, Faculty of Sciences, University of Delhi, India. A written informed consent was duly signed by those involved in the study.

Data Collection

Mother's Current Assessment For each participant, a general questionnaire was filled with information related to demographic data, socioeconomic status,²⁰ family size, smoking, physical activity, ethnicity, systolic and diastolic blood pressures, and health records, especially those of cardiovascular risks and outcomes such as ischemia of heart, cerebral vascular events (CVA), hypertension, diabetes, and other history of diagnosed conditions. Anthropometry, physiological parameters, cardiometabolic health, and reproductive performance were recorded. Maternal ages at delivery and parity were obtained from obstetric records.

Anthropometric measurements including height, weight, skinfold thicknesses, and waist and hip circumferences were obtained using standardized procedures.²¹ Body weight was measured by using a spring balance to the nearest 500 g and stature with the help of Martin's anthropometer to the nearest millimeter. Waist circumference (WC) and hip circumference were measured with a nonstretchable flexible steel tape to the nearest millimeter. The percent body fat was recorded using a body composition analyzer employing bioelectric impedance technique. Nonfasting and fasting blood samples were collected from women and were later analyzed from serum for blood glucose by hexokinase method²² and measured for triglycerides (milligrams per deciliter) and cholesterol (milligrams per deciliter) using standard enzymatic methods (COBAS INTEGRA 400 plus biochemistry analyzer from Roche Germany) in pathology laboratories. Most these anthropometric measurements are known adiposity markers and are risk factors for CVD.²³ This current assessment was used to calculate the Framingham Risk Score.

Assessment Measures for Obesity Markers Body mass index was calculated as weight divided by height squared (kilograms per square meter) and categorized as normal (≤ 25.0), overweight (≥ 25.0 but ≤ 30.0), and obese (≥ 30.0).²⁴ Waist-to-hip ratio (WHR) was calculated by dividing waist circumference by hip circumference. For serum lipids, we referred to NCEP-ATP III Guidelines.^{25,26} According to these standard guidelines, hypercholesterolemia is defined as TC >200 mg/dL, LDL-C as >100 mg/dL, hypertriglyceridemia as TG >150 mg/dL, and HDL-C <40 mg/dL. ADA Guidelines were referred to for serum glucose levels.²⁷ Blood pressure levels were defined²⁸ based on the seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. For abdominal obesity among females, WHR cutoff points of 0.80 and above were followed,²⁹ WHtR (waist-height ratio) cutoff points were taken at 0.50.³⁰ Gender-specific cutoffs for abdominal obesity, as defined by WC, has been taken as 80 cm for women.³¹ Grand mean thickness (GMT) was calculated as mean of all the skinfold thicknesses measured.

Pregnancy Complications Data on pregnancy complications was extracted through medical records from antenatal clinic visits taken at the time of pregnancy

or through obstetric history. Obstetric data abstractions included clinical diagnosis of GDM and glycosuria, measurement of systolic and diastolic blood pressures for gestational hypertension, and preeclampsia (systolic blood pressure, i.e., SBP>140 mmHg; and diastolic blood pressure, i.e., DBP>90 mmHg; and presence of proteinuria),³² for the index pregnancy from the antenatal, pregnancy, and postnatal medical records of all women, as described previously.

Gestational age and birth weight of the infants were ascertained from medical records. Data on birth weight and size for gestational age were ascertained from birth cards. Preterm births have been defined as births <37 weeks of gestation. Size at gestational age lesser than 10th centile has been marked as small for gestational age (SGA), 10th–90th centile as appropriate for gestational age (AGA), and those >90th centile were large for gestational age babies (LGA). Birth weight was also taken as part of analysis. Neonates were categorized on basis of birth weight into three groups as follows: neonates with birth weight <2.5 kg were classified as low birth weight (LBW), macrosomic babies >4.0 kg, and infants with weights ≥ 2.5 kg and <4.0 kg were classified as normal weight babies.³³ LBW babies and macrosomic babies were then grouped together for further analyses; this was done as abnormal size at birth or in infancy has been associated with an increased propensity to adverse health outcomes in adulthood.³⁴

Framingham Risk Score for CVD

The Framingham Risk Score is a gender-specific algorithm used to estimate the 10-year cardiovascular risk of an individual. The Framingham Risk Score was first developed based on data obtained from the Framingham Heart Study to estimate the 10-year risk of developing coronary heart disease,³⁵ <http://hp2010.nhlbi.nih.gov/atpiii/calculator.asp>. The risk of occurrence of a CVD event can be expressed as a score (i.e., percentage) by 10-year CVD Framingham Risk Score. It is calculated with information on sex, age, total cholesterol (TL), high-density lipoprotein (HDL) cholesterol, SBP, diabetes mellitus (based on fasting glucose), treatment for hypertension obtained at the follow-up assessment, and smoking status reported on a questionnaire completed 3–8 years after pregnancy with the use of the predetermined equations.³⁶ The Framingham score was analyzed in two categories as follows: <10 and ≥ 10 % [<http://www.patient.co.uk/health/Cardiovascular-Health-Risk-Assessment.htm>]. The score is strictly based on current maternal assessment as taken by researchers in the recent study.

Statistical Analysis

Data was analyzed using IBM Statistical Package for Social Sciences (SPSS), version 19.0. The results between the two groups of women, with and without pregnancy complications, are given as means. A *t* test was used to further compare the measurements between groups. Multivariable regression models were used to assess associations of pregestational diabetes mellitus (GDM and glycosuria), HDP, size for gestational age, and preterm delivery with obesity markers as outcomes. We assessed potential effect modification in the relationship between the risk score and each pregnancy complication outcome by other models. Cross products were added, one at a time, to fully adjusted models; no cross products were statistically significant. In both analyses, Model 1 was the crude model with no adjustments, while in model 2, parity, maternal age, and time since indexed pregnancy along with all other exposures. For HDP being used as the dependent, the term “other exposures” will

be pregnancy DM, size of gestational age, and birth weight. Similarly, when pregnancy diabetes mellitus (GDM and glycosuria) was used as a predictor, outcome was also controlled for other exposures like hypertension and pregnancy outcomes. This signifies that for each time a complication was used as an assessor, the other conditions were being controlled for. The models can be viewed in Tables 2 and 3 with subsequent results.

RESULTS

Table 1 shows means and SDs for all anthropometric, physiological, and biochemical variables between two groups of women as follows: one with presence of any pregnancy complications or adverse outcomes and the other signifying complete absence of any condition in the indexed pregnancy. The current anthropometric assessment of two groups showed that women associated with pregnancy complication and adverse pregnancy outcomes were seen to be heavier than their counterparts. Blood pressure, lipid profiles, and glucose levels were all significantly exaggerated in women with a complex pregnancy. All adiposity indicators (BMI, WC, WHR, and WHtR) were also significantly higher in women 3–8 years post the given pregnancy. Except for

TABLE 1 Cohort characteristics for women with and without pregnancy complications and adverse pregnancy outcomes in the indexed pregnancy

Variables	Mean (SD) N=631		t test
	Absence of pregnancy complications or adverse outcome (N=310)	Presence of pregnancy complications or adverse outcome (N=321)	
Age (years)	33.87±2.81	32.76±3.36	–
Body weight (kg)	55.21±2.11	56.76±1.93	12.94**
Height (cm)	155.83±7.81	156.21±4.65	–
Biceps Skft (mm)	5.51±2.31	5.94±4.66	–
Triceps Skft(mm)	13.71±5.11	13.63±5.41	–
Subscapular Skft (mm)	12.51±7.16	13.21±5.51	16.38*
Suprailliac Skft (mm)	11.86±6.24	12.94±3.87	12.77*
Waist circumference (cm)	80.87±08.11	82.97±10. 19	9.28*
Hip circumference (cm)	96.27±6.61	97.61±5.89	–
BMI (kg/m ²)	23.94±6.33	25.73±7.57	12.82*
Waist stature ratio	0.51±0.07	0.52±1.32	11.44**
Waist–hip ratio	0.83±0.06	0.86±11.08	11.78**
Grant mean thickness (mm)	10.45±4.52	12.87±2.67	14.09**
SBP (mmHg)	122.84±12.23	128.78±11.47	7.48*
DBP (mmHg)	84.23±14.52	88.45±10.65	5.14*
Glucose (mg/dL)	95.64±18.26	104.68±10.88	18.21**
Total cholesterol (mg/dL)	180.32±10.56	194.24±17.82	14.56**
Triglycerides (mg/dL)	84.67±11.98	98.54±12.64	18.56**
HDL (mg/dL)	44.46±3.32	48.36±4.81	14.23**
LDL (mg/dL)	92.48±10.21	94.23±12.43	12.76**
SES	75.3±5.89	74.6±7.23	–

p*<0.05; *p*<0.01

biceps and triceps skinfold, all other skinfolds were also significantly higher in these women.

Table 2 displays results for multivariable regressions models showing significant associations between obesity markers (cardiovascular risk factors) and pregnancy complications through beta coefficients. These beta coefficients signify risk of an event (obesity through BMI; risk categories of WC, WHR, and WHtR; hypertension; and high levels of sugar in the blood). For the present analysis, each obesity marker was taken as an outcome variable, while all pregnancy complications were added as independent variables. The model constants were higher in regional indices (WC, WHR, and WHtR) than general adiposity markers (BMI). All age-adjusted means were higher in women with registered pregnancy complication or an adverse pregnancy outcome. HDP tends to pose the highest risk (five to seven times) through all cardiovascular factors amongst other pregnancy complications. Birth weight, a preterm birth, and inappropriate size at gestational age tend to pose a nearly twice a risk of entering risk levels of BMI, WC, WHR, and WHtR independently and in combination with other pregnancy outcomes. The results were lucid in controlled model (Model 2). With pregestational diabetes mellitus (GDM or glycosuria), the risk varies between two and four times approximately. The risk (6.24 times) was apparent in associations with glucose levels and pregnancy diabetes, nearly six to seven times in associations between HDP with SBP and DBP levels.

Table 3 shows associations of various pregnancy complications (predictor variables) with predicted 10-year CVD risk based on the Framingham score (outcome variable) through odds of falling in categories beyond the $\geq 10\%$ risk. For crude unadjusted model, the odds of increased risk ($\geq 10\%$) for a future CVD varied from 3.10 (pregnancy diabetes mellitus), 4.69 (HDP or preeclampsia) for pregnancy complication, while for adverse pregnancy outcomes, it varied from 1.66 to 2.42. An adverse BW infant can increase the threat of future CVD event beyond the 10% risk category by 2.42 times for the mother, while for a preterm birth, the risk is nearly 2.31 times. The association with the calculated 10-year CVD risk ($\geq 10\%$) based on the Framingham prediction score was 3.01 OR (2.11–3.72 CI) for pregnancy DM, 4.52 (3.68–4.93 CI) for preeclampsia/gestational hypertension, 2.16 (2.01–2.79 CI) for size at GA (SGA and LGA), 2.25 (1.91–2.85 CI) for preterm births, and 2.48 (2.08–3.98 CI) for abnormal birth weight when compared with women without pregnancy diabetes mellitus, preeclampsia/gestational hypertension, appropriate gestational age, full term babies, and normal birth weight, respectively, in completely adjusted models.

DISCUSSION

The greatest burdens on global health are being posed by vascular and metabolic diseases, which are far from eradication. The crux of this lies in the fact that there is a great difficulty in early identification of individuals predisposed to this risk. An early detection might lead to a modification in lifestyle, acting as a timely intervention and prevention, further reducing the death toll and economic burden which chronic illnesses are causing. The present study provides glimpses of how pregnancy complications and its outcomes can serve as prognosticators of chronic disease courses at an early phase of life, especially in those adult years when these pathways are actually being set.⁴ Pregnancy can also serve as an important time for clinical identification and

TABLE 2 Multivariable associations between obesity markers (cardiovascular risk factors) and pregnancy complications

Risk factor	Diabetes mellitus		Hypertension		Size for gestational age		Gestation period		Birth weight	
	No. of pregnancy complication (reference)	Pregnancy diabetes mellitus (CIs)	No. of HDP (reference)	HDP or preeclampsia (CIs)	AGA (reference)	SGA or LGA (CIs)	>37 weeks (reference)	<37 weeks (preterm) (CIs)	Normal (reference)	BW (≤2,500 g or 4,000 g) (CIs)
BMI (kg/m ²)	Age-adjusted mean	22.42	25.56	22.87	26.01	23.41	25.23	25.43	22.87	23.09
	Model 1	0	2.88 (1.48–4.64)	0	5.58 (3.97–7.42)	0	1.38 (1.03–1.44)	1.28 (1.12–1.37)	0	1.09 (1.05–1.22)
WC (cm)	Model 2	0	2.02 (2.45–4.63)	0	5.34 (3.23–5.43)	0	1.65 (1.34–2.01)	1.12 (1.04–1.87)	0	–
	Age-adjusted mean	81.02	83.01	80.43	82.81	79.88	82.88	81.96	81.32	82.41
WHR	Model 1	0	3.25 (2.89–4.60)	0	6.73 (5.35–8.1)	0	1.82 (0.42–2.43)	1.31 (0.84–2.04)	0	1.99 (0.92–1.06)
	Model 2	0	3.98 (2.04–4.12)	0	4.98 (3.78–5.87)	0	2.01 (1.78–2.67)	–	0	–
WHIR	Age-adjusted mean	0.84	0.87	0.85	0.86	0.84	0.86	0.86	0.84	0.86
	Model 1	0	3.34 (1.99–5.70)	0	5.67 (3.87–5.88)	0	2.21 (1.87–2.76)	1.31 (0.84–2.04)	0	1.10 (1.04–1.15)
WHIR	Model 2	0	4.01 (3.41–6.12)	0	5.56 (3.98–6.56)	0	–	1.46 (1.09–2.65)	0	1.14 (1.04–2.01)
	Age-adjusted mean	0.50	0.51	0.49	0.52	0.50	0.50	0.51	0.51	0.51
SBP (mmHg)	Model 1	0	2.76 (2.01–3.13)	0	4.65 (2.87–5.14)	0	2.15 (1.01–2.23)	1.41 (0.90, 2.22)	0	1.23 (1.19–2.12)
	Model 2	0	3.01 (2.34–4.12)	0	4.77 (2.43–5.36)	0	–	–	0	1.42 (1.32–1.45)
DBP (mmHg)	Age-adjusted mean	125.56	131.60	126.79	131.34	125.87	0	130.34	125.56	130.23
	Model 1	0	2.67 (1.89–2.78)	0	5.65 (4.56–7.87)	0	2.65 (1.98–2.76)	1.58 (1.23–2.41)	0	1.32 (1.11–2.02)
Glucose (mmHg)	Model 2	0	2.89 (1.59–3.85)	0	6.01 (4.57–7.82)	0	–	–	0	–
	Age-adjusted mean	83.43	87.16	84.14	87.79	83.32	86.98	86.12	82.87	85.98
Glucose (mmHg)	Model 1	0	3.54 (2.65–5.02)	0	6.16 (4. 61–7.13)	0	2.23 (2.09–3.12)	2.03 (1.54–3.02)	0	1.54 (1.11–3.21)
	Model 2	0	3.67 (3.01–5.62)	0	6.31 (4.17–7.22)	0	2.42 (1.92–3.45)	2.12 (1.62–3.09)	0	–
Glucose (mmHg)	Age-adjusted mean	96.89	104.32	97.82	102.21	97.94	101.67	100.65	97.98	100.48
	Model 1	0	6.64 (5.16–6.86)	0	5.16 (4.54–5.28)	0	–	2.58 (1.23–2.61)	0	1.62 (1.40–2.12)
Glucose (mmHg)	Model 2	0	6.24 (4.25–6.88)	0	5.21 (3.89–5.71)	0	2.65 (1.98–2.76)	–	0	1.64 (1.43–2.11)

– nonsignificant

TABLE 3 ORs for an increase in risk of predicted CVD event of >10 % through Framingham score with pregnancy complications

ORs for an increase in risk of predicted CVD event of >10 %	Diabetes mellitus		Hypertension		Size for gestational age		Gestation period		Birth weight	
	No. of pregnancy complication (reference)	Pregnancy diabetes mellitus (CIs)	No. of HDP (reference)	HDP or pre-eclampsia (CIs)	AGA (reference)	SGA or LGA (CIs)	>37 weeks (reference)	<37 weeks (preterm) (CIs)	Normal (reference)	BW (≤2,500 g or 4,000 g (CIs)
Model 1	0 ^a	3.10 (2.15–3.88)	0 ^a	4.69 (3.03–5.11)	0 ^a	1.66 (1.27–2.72)	0 ^a	2.31 (1.82–2.87)	0 ^a	2.42 (2.11–4.17)
Score <10 %	0 ^a	0 ^a	0 ^a	0 ^a	0 ^a	0 ^a	0 ^a	0 ^a	0 ^a	0 ^a
Model 2	0 ^a	3.01 (2.11–3.72)	0 ^a	4.52 (3.68–4.93)	0 ^a	2.16 (2.01–2.79)	0 ^a	2.25 (1.91–2.85)	0 ^a	2.48 (2.08–3.98)
Score <10 %	0 ^a	0 ^a	0 ^a	0 ^a	0 ^a	0 ^a	0 ^a	0 ^a	0 ^a	0 ^a

^aSignifies reference categories

intervention for future risk. Garovic and Hayman have also mentioned that compared with women who have had normotensive pregnancies, those who are hypertensive during pregnancy are at greater risk of cardiovascular and cerebrovascular events and have a less favorable overall risk profile for CVD years after the affected pregnancies.^{37,38} Regional adiposity markers (WC, WHR, and WHtR) tend to estimate the risks better than the general adiposity marker (BMI) making the seriousness of the condition more lucid, especially in the Punjabi Khatri women.

A great number of obesity markers are seen to be associated with HDP and pregnancy diabetes mellitus, and they are also shown to be a stronger marker of future CVD risk (3.01 and 4.52, respectively). This tends to elucidate the specific pathway a complicated pregnancy might follow to predict or cause a cardiovascular disease. Women with a history of preeclampsia have higher circulating concentrations of fasting insulin, lipid, and coagulation factors postpartum. Also, this condition is associated with acute “atherosis” in the placental bed which is identical to atherosclerosis. They tend to reveal a pattern of metabolic and vascular changes which are similar to diagnosis of chronic illness like exaggerated lipid and insulin levels, disturbed hemostatic factors, and endothelial dysfunction. Thus, vascular diseases might be sharing their underlying mechanisms with these pregnancy complications.^{39,40} Recent studies have identified leptin, an adipocyte-derived hormone as a marker of increased risk for CVD. Elevated levels of leptin are suggestive of resistance to its metabolic effects and levels of biologically active leptin are increased significantly in pre-eclamptic mothers.^{41,42} Hypercoagulability and oxidative stress during complex pregnancy might put women at a higher risk of hypertension in later life.³⁸ Further, intricacies associated with these mechanisms opens avenues for future research.

Intriguingly, adverse pregnancy outcomes are seen to increase odds of women falling in categories ≥ 10 % higher risk for future CVD event (through Framingham score) by nearly three times. Another retrospective study noted that women who give birth to LBW infants have seven to 11 times higher chances of occurrence of a cardiovascular event than with babies $>3,500$ g.^{10,43} while a preterm delivery poses twice the risk of coronary disease to the mother.⁸ Low neonatal birth weight usually results from intrauterine growth restriction or from preterm birth, resulting in a neonate appropriate for gestational age but smaller than term. Because these reasons for low birth weight differ in their pathogenesis, their links to cardiovascular risk prediction may differ as well.⁴

The utility of clinical history of a mother is very evident from these results. This might also provide us with an opportunity to alter chronic disease trajectories before their exposure is maximal. What needs to be done is to understand associations of complicated pregnancies and cardiovascular events for women of various ethnicities. Also, each of these pregnancy complications tends to pile on the damage to the vascular system and so poses a greater damage to multiparous women. We also need to identify whether these conditions work independently or in unison by defining the particular definitions and combinations of pregnancy complications that are the most sensitive and specific for predicting cardiovascular disease. These pregnancy complications work in perfect sync with Framingham predictive score and, hence, can be further correlated to other scores for better predictive values. A perfect screening and collaboration of clinicians, public health analysts, researchers, and primary care givers is required to form an information link that a mother has direct access to and, therefore, knows the risk she might be predisposed to in future. The complete analysis is an important landmark presenting the applicability of life course approach and how this knowledge about obstetric history can be applied to reduce the global chronic burden.

CONCLUSION

The relationship between cardiometabolic health and pregnancy history is clear. HDP, pregnancy diabetes mellitus, and pregnancy outcomes are all associated with an increased risk of CVD 10 years later. Each component of the obstetric data predicts the CVD risk independently in varying proportions and in unity with other complications. Hence, pregnancy may provide an insight into the future risk associated with cardiometabolic health, relatively early in life and can serve as a crucial time for clinical identification and intervention for future risk. This gives optimum opportunity to induce timely interventions and alter lifestyles to reduce the impending risk, very early in the course of life. It is time to incorporate obstetric history into cardiovascular risk assessment.

LIMITATIONS AND STRENGTHS

These women are too young, and hence, the CVD events are not common. The sample size and cross-sectional epidemiological approach as against a longitudinal study is another drawback of the present research work. The analysis did not involve pregnancy conditions for those other than the indexed pregnancy. The prospective design, linking cardiometabolic data to pregnancy history 3–8 years later, complete records on lifestyle factors and socioeconomic status with assessment to different regional and general adiposity markers is the strength of the present study.

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REFERENCES

1. Mishra GD, Cooper R, Kuh D. A life course approach to reproductive health: theory and methods. *Maturitas*. 2010; 65(2): 92–97.
2. Lawlor DA, Morton S, Batty GD, Macintyre S, Clark H, et al. Obstetrician-assessed maternal health at pregnancy predicts offspring future health. *PLoS ONE*. 2007; 2(8): e666. doi:10.1371/journal.pone.0000666.
3. Marco LJ, McCloskey K, Vuillermine PJ, Burgner D, Said J, Ponson A. Cardiovascular disease risk in the offspring of diabetic women: the impact of the intrauterine environment. *Exp Diabetes Res*. 2012; 565160: 10. doi:10.1155/2012/565160. Epub 2012 Oct 22.
4. Rich-Edwards JW, McElrath TF, Karumanchi SA, Seely EW. Breathing life into the lifecourse approach pregnancy history and cardiovascular disease in women. *Hypertension*. 2010 Sep; 56(3): 331–4. Epub August 2, 2010.
5. Bellamy L, Casas JP, Hingorani AD, Williams DJ. Pre-eclampsia and risk of cardiovascular disease and cancer in later life: systematic review and meta-analysis. *BMJ*. 2007; 335: 974.
6. Bellamy L, Casas JP, Hingorani AD, Williams D. Type 2 diabetes mellitus after gestational diabetes: a systematic review and meta-analysis. *Lancet*. 2009; 373: 1773–1779.
7. Shah BR, Retnakaran R, Booth GL. Increased risk of cardiovascular disease in young women following gestational diabetes mellitus. *Diabetes Care*. 2008; 31: 1668–1669.

8. DaveySmith G, Whitley E, Gissler M, Hemminki E. Birth dimensions of offspring, premature birth, and the mortality of mother. *Lancet*. 2000; 356: 20667.
9. Davey Smith G, Sterne J, Tynelius P, Lawlor DA, Rasmussen F. Birth weight of offspring and subsequent cardiovascular mortality of the parents. *Epidemiology*. 2005; 16: 563–569.
10. Smith GCS, Pell JP, Walsh D. Pregnancy complications and maternal risk of ischemic heart disease: a retrospective cohort study of 129 290 births. *Lancet*. 2001; 357: 20026.
11. Sattar N, Greer IA. Pregnancy complications and maternal cardiovascular risk: opportunities for intervention and screening? *BMJ*. 2002; 325: 157.
12. Fraser A, Nelson SM, Macdonald-Wallis C, Cherry L, Butler E, Sattar N, Lawlor DA. Associations of pregnancy complications with calculated cardiovascular disease risk and cardiovascular risk factors in middle age: the Avon Longitudinal Study of Parents and Children. *Circulation*. 2012; 125: 1367–1380.
13. Gelson E, Johnson M. Effect of maternal heart disease on pregnancy outcomes. *Expert Rev Obstet Gynecol*. 2010; 5(5): 605–617.
14. Yusuf S, Hawken S, Ounpuu S, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case–control study. *Lancet*. 2004; 364: 937–952.
15. World Health Organization (WHO) India [Accessed April 29, 2010]; National cardiovascular disease database. Available at: http://www.whoindia.org/LinkFiles/NMH_Resources_National_CVD_database-Final_Report.pdf.
16. Kapoor SS. Blood pressure, waist to hip ratio and body mass index among affluent Punjabi girls of Delhi. *Acta Medica Auxologica*. 2000; 32(3): 153–157.
17. Sinha R, Kapoor S. Parent–child correlations for indices of adiposity. *Coll Antropol*. 2006; 30(2): 291–296.
18. Sinha R, Kapoor S, Mungreiphy NK, Kapoor AK. Environmental and genetical differences in linear and adiposity dimensions among adolescents boys. *Open Anthropol J*. 2012; 5: 1–5.
19. Tandon K. Obesity, its distribution pattern and health implications among Khatri population, Ph.D. thesis, Department of Anthropology, University of Delhi, Delhi, India, 2006.
20. Aggarwal OP, Bhasin SK, Sharma AK, Chhabra P, Aggarwal K, Rajoura OP. A new instrument (scale) for measuring the socioeconomic status of a family: preliminary study. *Indian J Community Med*. 2005; 30(4): 111–114.
21. Weiner JS, Lourie JA. *Practical Human Biology*. New York: Academic; 1981.
22. Glucose Hexokinase Reagent Set. Available at: <http://www.biopacific.net/pointepackage-inserts/Glucose-Hex.pdf>
23. van Dijk SB, Takken T, Prinsen EC, Wittink H. Different anthropometric adiposity measures and their association with cardiovascular disease risk factors: a meta-analysis. *Neth Heart J*. 2012; 20(5): 208–218.
24. World Health Organization. Obesity—preventing and managing the global epidemic: report of a WHO consultation on obesity. World Health Organization, Geneva. 1998.
25. Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) [special communication]. *JAMA* 2001; 285: 2486–2947.
26. Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report [special communication]. *Circulation*. 2002; 106: 3143–3421.
27. American Diabetes Association. Diagnosis and classification of diabetes mellitus. *Diabetes Care*. 2006; 29(suppl 1): S43–S48.
28. Chobanian AV, Bakris GL, Black HR. The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure: the JNC 7 report. *JAMA* 2003; 289: 2560–2572.
29. Willett WC, Dietz WH, Colditz GA. Guidelines for healthy weight. *New Engl J Med*. 1999; 341: 427–434.

30. Ashwell M. Waist to height ratio and the Ashwell chart could predict the health risk of obesity in adults and children in all ethnic groups. *Nutr Food Sci.* 2005; 35(3): 359–363.
31. Dobbelsteyn CJ, Joffres MR, MacLean DR, Flowerdew G. A comparative evaluation of waist circumference, waist-to-hip ratio and body mass index as indicators of cardiovascular risk factors. The Canadian Heart Health Surveys. *Int J Obes Relat Metab Disord.* 2001; 25(5): 652–661.
32. Davey DA, MacGillivray I. The classification and definition of the hypertensive disorders of pregnancy. *Am J Obstet Gynecol.* 1988; 158: 892–898.
33. WHO. The incidence of low birth weight. A critical review of available information. *World Health Stat Q.* 1980; 33: 197–224.
34. Lucas A, Fewtrell MS, Cole TJ. Fetal origins of adult disease—the hypothesis revisited. *BMJ.* 1999; 319: 245–249.
35. Wilson PW, D'Agostino RB, Levy D, Belanger AM, Silbershatz H, Kannel WB. Prediction of coronary heart disease using risk factor categories. *Circulation.* 1998; 97(18): 1837–1847.
36. The Framingham Heart Study. General cardiovascular disease (10 year risk). <http://www.framinghamheartstudy.org/risk/genecardio.html>.
37. Parthasarathy S, Santanam N. Mechanisms of oxidation, antioxidants, and atherosclerosis. *Curr Opin Lipidol.* 1994; 5: 371–375.
38. Garovic VD, Hayman SR. Hypertension in pregnancy: an emerging risk factor for cardiovascular disease. *Nat Clin Pract Nephrol.* 2007; 3(11): 613–622.
39. Chambers JC, Fusi L, Malik IS, Haskard DO, De Swiet M, Kooner JS. Association of maternal endothelial dysfunction with preeclampsia. *JAMA.* 2001; 285: 1607–1612.
40. Sattar N, Gaw A, Packard CJ, Greer IA. Potential pathogenic roles of aberrant lipoprotein and fatty acid metabolism in pre-eclampsia. *Br J Obstet Gynaecol.* 1996; 103: 614–620.
41. Davi G, et al. Platelet activation in obese women: role of inflammation and oxidant stress. *JAMA.* 2000; 288: 2008–2014.
42. Teppa RJ et al. Free leptin is increased in normal pregnancy and further increased in preeclampsia. *Metabolism* 49: 1043–1048.
43. Davey-Smith G, Harding S, Rosato M. Relation between infants' birth weight and mothers' mortality: prospective observational study. *BMJ.* 2000; 320: 83940.