High Risk Pregnancy

Citation

Deshmukh, Shilpa. 2019. High Risk Pregnancy. Master's thesis, Harvard Medical School.

Permanent link

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PAPER 1

PREDICTORS OF ANTEPARTUM ADMISSION IN DIABETES

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PAPER 2

KNOWLEDGE AND ATTITUDES TOWARD YOGA AMONG WOMEN WITH HIGH RISK PREGNANCIES

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Dissertation Submitted to the Faculty of Harvard Medical School in Partial Fulfillment of

the Requirements for the Degree of Master of Medical Sciences in Clinical Investigation (MMSCI), Harvard University, Boston, Massachusetts

May 6th 2019.

I have reviewed this thesis. It represents work done by the author under my guidance/supervision.

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ACKNOWLEDGEMENTS

Overview:

In its 2016 report entitled "Advancing the health of mothers in the 21st century", the Center for Disease Control and Prevention stated that an increasing number of pregnant women in the United States have chronic conditions such as high blood pressure, diabetes, or heart disease that may put them at risk of pregnancy complications or death. These preexisting medical conditions which have the potential to cause harm to the mother or the baby or both during pregnancy constitute an important cause of "high risk pregnancies" along with gestational causes such as gestational diabetes, hypertensive disorders of pregnancy or multiple gestation. Though, it is estimated that high risk pregnancies constitute less than 10 percent of all pregnancies, they are associated with significant healthcare costs. Pre-gestational diabetes is a leading cause of high-risk pregnancy. Women with pre-gestational diabetes have poor maternal and fetal outcomes and higher rates of hospitalizations. These high rates of health care utilization consequently lead to increased health care cost. However, data regarding risk factors associated with these trends is limited.

Further, as an adjunct to conventional care, there is growing public and scientific interest in the potential role of complementary practices such as yoga in improving outcomes in high risk pregnant women. This is evident by the growing number of medical centers around the country offering prenatal yoga programs. However, the attitudes and knowledge of yoga therapy in high risk pregnant women is not well understood. We propose two individual studies in high risk pregnant women with the following aims: -

Aim 1: To identify predictors of increased antepartum hospitalization in pregnant women with diabetes through a single center, six-year retrospective cohort study.

Aim 2: To study the attitudes and knowledge of prenatal yoga including barriers and facilitators of practicing prenatal yoga in high risk pregnant women.

Paper 1: Predictors of antepartum admission in diabetes

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Word count: 2214

Number of tables: 4

Number of figures: 2

Abstract

Objective: Diabetes is associated with increased healthcare utilization and cost in pregnant women. We sought to investigate the predictors of antepartum hospitalization in pregnant women with diabetes.

Methods: We performed a retrospective review of women with pre-gestational diabetes who received care in a multidisciplinary program for diabetes in pregnancy at Brigham and women's hospital from 2006-2011. Our primary outcome was antepartum hospitalization, with a secondary measure of length of stay. We modeled the multivariate odds of hospitalization prior to delivery using logistic regression.

Results: We identified 244 women of whom 103 (42.2%) were hospitalized antepartum. The median (IQR) length of stay was 2 days ($\pm$2 days). There was no difference in age, race or pre-pregnancy body mass index (BMI) between women who were admitted and those who were not. Women who were admitted had a higher first Hemoglobin A1c in pregnancy (median of 7.85 $\pm$ 2.75% vs 6.55 $\pm$ 1.48%). In a multivariate model, markers of preconception health including first hemoglobin A1c in pregnancy (adjusted odds ratio[aOR] 1.5, 95% CI 1.24-1.81, p<0.001), smoking (aOR 4.02, CI 1.25- 12.90, p=0.019) and chronic hypertension (aOR 2.05, 95% CI 1.03-4.05, p= 0.03) were associated with increased odds of antepartum admission. First hemoglobin A1c in pregnancy was also associated with increased length of stay prior to delivery (beta=0.32, 95% CI 1.15- 5.87, p=0.004)

Conclusion: In our study, glycemic control, smoking and chronic hypertension prior to pregnancy were associated with antepartum hospitalization, highlighting the importance of preconception health for reproductive-aged women with diabetes.

Introduction:

Diabetes is associated with adverse maternal and fetal outcomes in pregnancy, resulting in antenatal hospital admissions, complex delivery hospitalizations and high utilization of healthcare resources relative to women without chronic medical conditions during pregnancy (1,2,3). Among women with pre-pregnancy diabetes, at least 20% develop hypertensive complications (4). These women are at risk of delivering preterm with a high percentage of infants at term also requiring Neonatal intensive care unit (NICU) admission. Possible reasons for poor outcomes in this population include poor glycemic control prior to pregnancy, poor glucose control during pregnancy or pre-existing medical conditions such as hypertension (2).

In 2008, total costs of hospitalization for all diabetes in pregnancy were estimated to be over $1.4 billion, accounting for approximately 8% of all costs associated with maternal hospitalization. While diabetes is known to be associated with maternal and fetal complications there are few studies looking at predictors of antenatal admission in diabetes. Knorr and colleagues found that in mothers with type 1 diabetes, the overall incidence of hospital admissions was more than double that of control mothers (5). They also found that higher Hemoglobin A1c levels were associated with increased mortality. While increased risk is well documented, there is lack of knowledge about specific predictors for admission in women with pre-existing diabetes.

The aim of this study was therefore to evaluate predictors of antepartum hospital admission among pregnant women with diabetes. We hypothesized that there may be modifiable risk factors that can be addressed to reduce hospitalizations.

Methods:

We performed a retrospective chart review of women with pre-gestational and gestational diabetes who received ambulatory care in a multidisciplinary program for diabetes in pregnancy from 2006-2011 at Brigham and Women's Hospital (BWH), an urban academic tertiary care center. Patients were identified using RPDR, Partners Healthcare research query tool. 635 women were identified of which 244 had a diagnosis of pregestational diabetes (figure 1). Additional methods for collection of this data have been previously described in studies investigating the disparities in care for public insured women with pregestational diabetes and effect of postpartum contraception use on follow up of diabetes screening in patients with gestational diabetes (6,7).

Diabetes in pregnancy is a multidisciplinary program for women with gestational and pregestational diabetes at BWH. This clinic is staffed with co-located maternal- fetal medicine physicians, endocrinologists, diabetes nurse educator, nutritionists and social workers to provide comprehensive care to these patients. Women receiving care as part of this program and delivering beyond 24 weeks of gestation were included in the study. We did not include women who received either prenatal care or pregnancy-associated endocrinology care outside of this multidisciplinary clinic. We also excluded women with incomplete admission data (figure 1). Variables that were missing more than 10% of data were also excluded.

Study variables are described in table 1. Data was collected on demographic and socioeconomic factors including age, race, pre- pregnancy body mass index (BMI), level of education (graduate level), insurance (public or private health insurance) and parity.

Data on medical and reproductive comorbidities included chronic hypertension, type of diabetes (1 or 2), hyperlipidemia, smoking, need for assisted reproduction, glycemic control (hemoglobin

A1c), pregestational insulin use and preconception counselling. Smoking was defined as any smoking during pregnancy. Chronic hypertension was defined per American College of Obstetric (ACOG) guidelines as Systolic BP > 140 or diastolic BP > 90 on two separate occasions prior to 20 weeks or a known diagnosis of chronic hypertension prior to onset of pregnancy. For purposes of this study, a visit with a primary care provider, endocrinologist, obstetrician gynecologist, or maternal–fetal medicine specialist who provided counseling about glycemic targets in pregnancy or made medication changes to prepare for pregnancy was deemed a preconception care consult (18). Additionally, data on maternal and fetal outcomes was also collected.

Our primary outcome was antepartum hospitalization, defined as at least one hospitalization during pregnancy prior to delivery. Secondary outcomes included length of stay, maternal and fetal outcomes. Patient level data was used to measure all primary and secondary outcomes. Maternal outcomes included hypertensive disorder of pregnancy (HDOP), Cesarean section, post-partum hemorrhage, endometritis and wound cellulitis. Fetal outcomes included birth weight, gestational age, Neonatal intensive care unit (NICU) admission, neonatal hypoglycemia, prematurity and fetal anomaly. To further understand the indications for admissions, we also looked at admission level data.

Statistical analysis:

We compared differences between those who were admitted antepartum and those who were not admitted prior to delivery using appropriate non-parametric testing. Fisher exact test was used for categorical variables and Wilcoxon rank-sum test for continuous variables as appropriate with statistical significance defined as a two-sided P value <0.05. Variables which had two-sided p value of 0.10 or less on univariate analysis were the included in the multivariate model to identify predictors of antepartum admission (model 1). We modeled odds of antepartum admission using

logistic regression controlling for race, insurance, smoking, chronic hypertension, 1st hemoglobin A1c (HbA1c) in pregnancy and preconception consult. Additional multivariate modelling was performed to support our results. Clinically relevant variables were chosen, and forward logistic regression was performed (model 2). Another multivariate regression modelling for odds of antepartum admission which included all clinically relevant variables was performed (model 3).

We then modeled length of hospital stay prior to delivery controlling for the same covariates as in model 1 using a multivariate linear regression model. Study data was stored and managed with REDCap electronic data capture tools hosted by Harvard University. Statistical analysis was performed using SPSS (IBM SPSS for Windows, Version 24.0, Armonk NY. IBM Corp.) The study was approved by the Partners Institutional Review Board.

Results

We identified 244 women during the study period, 9 were excluded as they were missing admission data. 103 (42.2%) required antepartum hospitalization for a total of 218 admissions. The median (IQR) length of stay was 2 days (2 days). Of the women hospitalized 46 had a single admission, 26 women had 2 admissions each and 31 women were admitted 3 or more times (figure 2). Sixty-nine (32%) admissions resulted in delivery. Looking at admission level data, among the indications for admissions, glycemic control was the most common (46%) followed by hypertensive disorder of pregnancy (32%) with other obstetric and fetal indications accounting for the remainder.

The distribution of age, race and pre-pregnancy BMI was similar among both women who were admitted and those who were not and a similar proportion of women in both groups had type

2 diabetes (table 1). Women who were admitted were more likely to have public insurance (59.2% vs 44.6, p=0.048) and had a higher first HbA1c (median of 7.85 + 2.75 vs 6.55 + 1.48) (table 1).

There was no significant difference in the maternal outcomes of requiring C-section, induced labor, endometritis, post-partum hemorrhage and wound cellulitis among the two groups (table 2). Gestational age at delivery (35.83 weeks + 3.7 vs 37.48 weeks + 4.5, p < 0.005) and birth weight (2920 grams + 894 vs 3609 +594, p < 0.005) were lower among the women who were admitted antepartum. Neonates born to women with prior antepartum hospitalization were more likely to be admitted to the NICU (37% vs 21%, p=0.01.)

In a univariate logistic regression model, first Hb A1c in pregnancy, chronic hypertension, insurance type, pre-conception consult, smoking and race were independently associated with increased odds of antepartum admission (two-sided p value less than or equal to 0.1) (table 3). We modeled the odds of hospitalization prior to delivery using the above-mentioned variables. In a multivariate model, first HbA1c in pregnancy, smoking and chronic hypertension were associated with increased odds of antepartum admission (table 4). For each unit increase in initial HbA1C the odds of admission increased by 50% (odds ratio 1.5, 95% CI 1.24-1.81, p<0.001). Women who smoked were 4 times more likely to get admitted as compared to nonsmokers (odds ratio 4.02, CI- 1.25- 12.90, p=0.019). The odds of antepartum hospitalization in women with chronic hypertension was twice as compared to those without chronic hypertension (odds ratio 2.05, 95% CI 1.03-4.05, p= 0.03). Models 2 and 3 supported the results of model 1 (table 4).

Type of insurance, race and pre-conception counselling were not significantly predictive of antepartum admission. In a multivariate model including chronic hypertension, insurance type, pre-conception consult, smoking and race, 1st HbA1c in pregnancy was associated with increased length of stay prior to delivery (beta=0.32, 95% CI 1.15- 5.87, p=0.004).

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Discussion

Among the 218 antepartum admissions in our cohort, uncontrolled diabetes was the most common primary reason for hospitalization (N=101, 46%) followed by hypertensive disorder of pregnancy (N= 71, 33%). There was no significant difference in the rates of maternal complications like induced labor, endometritis, post-partum hemorrhage and wound cellulitis among the two groups. Reflecting the earlier gestational age at delivery, the fetal outcomes were worse in the group that required antepartum admissions with higher rates of low birth weight and NICU admission. These poor fetal outcomes are similar to those reported in prior studies done in women with pregestational and gestational diabetes (11).

Smoking, chronic hypertension and increased 1st HbA1c in pregnancy were associated increased odds of antepartum admission. In a multivariate model, higher initial HbA1c in pregnancy was also associated with increased length of stay.

Our study demonstrates that antenatal hyperglycemic control is a predictor of antepartum hospitalization. The American Diabetes Association (ADA) recommends the target HbA1c be as close to normal as possible without significant hypoglycemia prior to pregnancy to prevent miscarriage and major congenital anomalies (2). The ADA also recommends that women should be given contraception until stable and acceptable glycemic control has been achieved (2). In our cohort, the women who required admission has significantly higher initial HbA1c levels (median 7.85 ± 2.75) which reinforces these recommendations. Studies have shown that maternal smoking is associated with several maternal and fetal complications like hypertensive disorder of pregnancy, intra-uterine growth retardation, low birth weight, congenital malformations and

increased perinatal mortality (11,12). Our study adds to this existing literature by showing that maternal smoking is also associated with increased antepartum hospitalizations. Smoking and glycemic control are modifiable risk factors which can be addressed prior to pregnancy. Improving preconception care could potentially decrease antepartum admissions thereby decreasing healthcare costs and also improve outcomes in high risk pregnant women. Preconception care to optimize glycemic control and encourage smoking cessation are important health strategies and potentially cost effective. Our study also showed that women with chronic hypertension had increased odds of hospitalization prior to delivery. Few studies have looked at predictors of hospitalization among pregnant women with diabetes (10). Our study is unique in this aspect as it could help us identify women who would be at risk of admissions during pregnancy. Several interventions can be proposed to optimize care in these women once they are identified to be at high risk of admissions. For example- they may be offered more frequent follow up visits either with their endocrinologist or diabetes educator. They may also benefit from appointment and medication refill reminders. Further studies are needed to identify which of these interventions would be most effective and feasible.

Our study findings must be interpreted in the context of the design and its limitations. Given the observational nature of the study it is susceptible to confounding. We have tried to address confounding by adjusting our analysis for race, insurance, smoking, chronic hypertension and preconception consult. We realize that there may be other unknown confounders. Health insurance was used as a surrogate for socioeconomic status. We did not collect data on patient occupation and income which are other indicators of socioeconomic status. We did not have sufficient behavioral health data to speculate on the role of maternal mental health conditions which prior studies have established are associated with increased rates of hospital admission (15).

Finally, as a single center study at a tertiary referral center, the findings may not be generalizable to all populations, and may reflect local practice patterns regarding threshold for admission, particularly for glycemic control. We did not include women who received endocrine care outside of our practice which may lead to selection bias.

Nonetheless, our study extends the limited literature on systems of care for women with diabetes, and potential targets for quality improvement initiatives prior to pregnancy. Based on available local estimates, approximate cost of a brief inpatient hospitalization is $7000. Antenatal hyperglycemia and smoking cessation are modifiable risk factors which if optimized could lead to decreased antenatal admissions, thus decreasing heath care costs.

Conclusion

In our study, first hemoglobin A1c in pregnancy, chronic hypertension and smoking were associated with increased odds of antepartum admission. First hemoglobin A1c in pregnancy was also associated with increased length of stay. These findings emphasize the importance of optimizing preconception health for reproductive-aged women with diabetes to improve clinical outcomes and reduce healthcare costs.

Table 1: Demographics

Characteristic	no antepartum admission n= 132 (54%)	antepartum admission n= 103 (42.2%)	p value
diabetes type 1	48 (36.4%)	38 (36.9%)	1
diabetes type 2	84 (63.6%)	65 (63.1%)	1
median age in years (25,75 percentiles)	32.39 (29,37)	31.84(26,36)	0.556
white non-Hispanic N (%)	65 (49.2%)	39 (37.9%)	0.062
public health insurance	59 (44.7%)	61 (59.2%)	0.048
nulliparous	55 (41.7%)	49 (47.6%)	0.427
median pre-pregnancy BMI (25,75 percentiles)	30.38 (26.3,36.7)	31.17 (27,38.3)	0.575
chronic hypertension	24 (18.2%)	30 (29.1%)	0.060
assisted reproduction	8 (6.1%)	11 (10.7%)	0.232
hyperlipidemia	11 (8.3%)	12 (11.6%)	0.508
smoking	7 (5.3%)	13 (12.6%)	0.059
Median 1st HbA1c in pregnancy (25,75 percentiles)	6.55 (5.9,7.3)	7.85 (6.5,9.3)	<0.001
on insulin before pregnancy	70 (53%)	56 (54.4%)	0.895
preconception counselling	30 (22.7%)	14 (13.5%)	0.092

Table 2: Maternal and fetal outcomes

Outcome	no antepartum admission N=132	antepartum admission N=103	p value
hypertensive disorder of pregnancy	46(34.8%)	67 (65%)	< 0.001
induced/augmented labor	100 (75.7%)	82(79.6%)	0.500
c-section	81 (61.4%)	67 (65%)	0.568
post-partum hemorrhage	15 (11.4%)	13 (12.6%)	0.841
endometritis	8 (6.1%)	4 (3.9%)	0.558
wound cellulitis	8 (6.1%)	7 (6.8%)	1
birth weight in grams	3609 $\pm$594	2920 $\pm$ 894	< 0.005
gestational age in weeks	37.48 $\pm$ 4.5	35.83 $\pm$ 3.7	< 0.005
NICU admission	28 (21.2%)	38 (36.9%)	0.010
neonatal hypoglycemia	16 (12.1%)	9 (8.7%)	0.523
prematurity	8 (6.1%)	23 (22.3%)	< 0.005
fetal anomaly	8 (6.1%)	7 (6.8%)	0.795

Table 3. Univariate analysis of predictors of antepartum admission

Variable	Odds ratio	P value	95% confidence interval
diabetes type	0.97	0.933	(0.57-1.66)
Maternal age	0.98	0.491	(0.94-1.02)
Race, white vs non-white	0.59	0.051	(0.34-1.00)
Public Health insurance	1.74	0.036	(1.03-2.94)
parity	0.78	0.366	(0.46-1.32)
pre-pregnancy BMI	1.00	0.633	(0.97-1.04)
chronic HTN	1.87	0.045	(1.01-3.46)
assisted reproduction	1.85	0.203	(0.71-4.7)
hyperlipidemia	1.45	0.398	(0.61-3.43)
smoking	2.57	0.053	(0.99-6.72)
1st HbA1c in pregnancy	1.54	<0.001	(1.29-1.84)
on insulin before pregnancy	1.05	0.838	(0.62-1.77)
preconception counselling	0.53	0.073	(0.26-1.06)

Table 4: Multivariate analysis of predictors of antepartum admission

Variables	Model 1 aOR (95% CI)	Model 2 aOR (95% CI)	Model 3 aOR (95% CI)
Race, white vs non-white	0.65 (0.34-1.21)	--	0.58 (0.30-1.13)
Health insurance	1.00 (0.52-1.94)	--	0.83 (0.40-1.73)
Chronic HTN	2.05 (1.03-4.05)*	2.05 (1.04-4.05)*	1.87 (0.88-3.98)
Smoking	4.02 (1.25-12.90)*	5.11 (1.53-17.08)*	6.31 (1.79-22.29)*
1st HbA1c in pregnancy	1.50 (1.24-1.81)*	1.49 (1.23-1.80)*	1.52 (1.24-1.86)*
Preconception counselling	1.03 (0.46-2.29)	--	0.94 (0.41-2.15)
Pre-pregnancy BMI	--	--	0.98 (0.94-1.02)
Parity	--	--	0.54 (0.27-1.08)
Maternal age	--	--	1.05 (0.98-1.11)

Model 1- included all variables with p<0.1 on univariate analysis

Model 2- forward section of all clinically relevant predictors

Model 3- inclusion of all clinically relevant predictors

**aOR- adjusted odds ratio, *p<0.05

95% CI – 95% confidence interval.
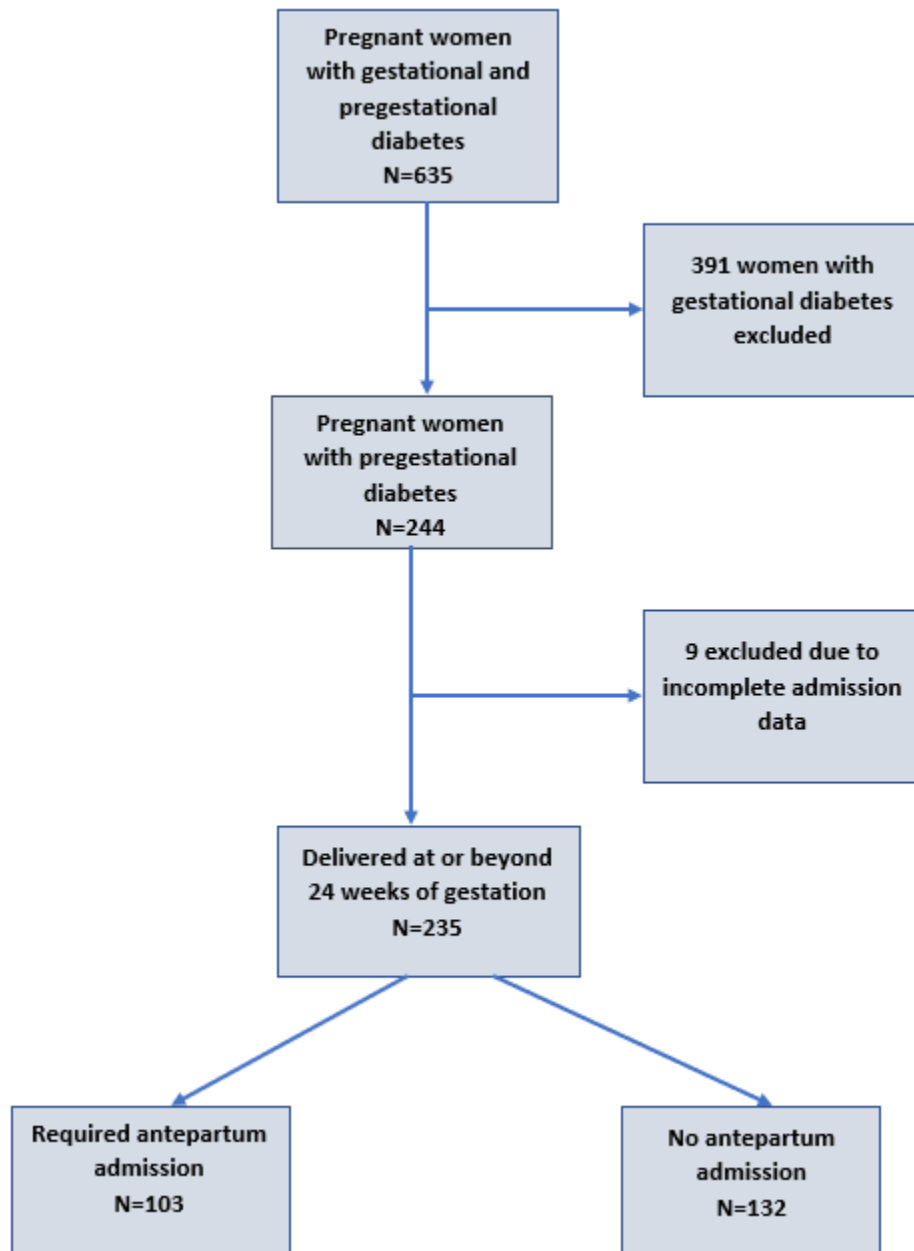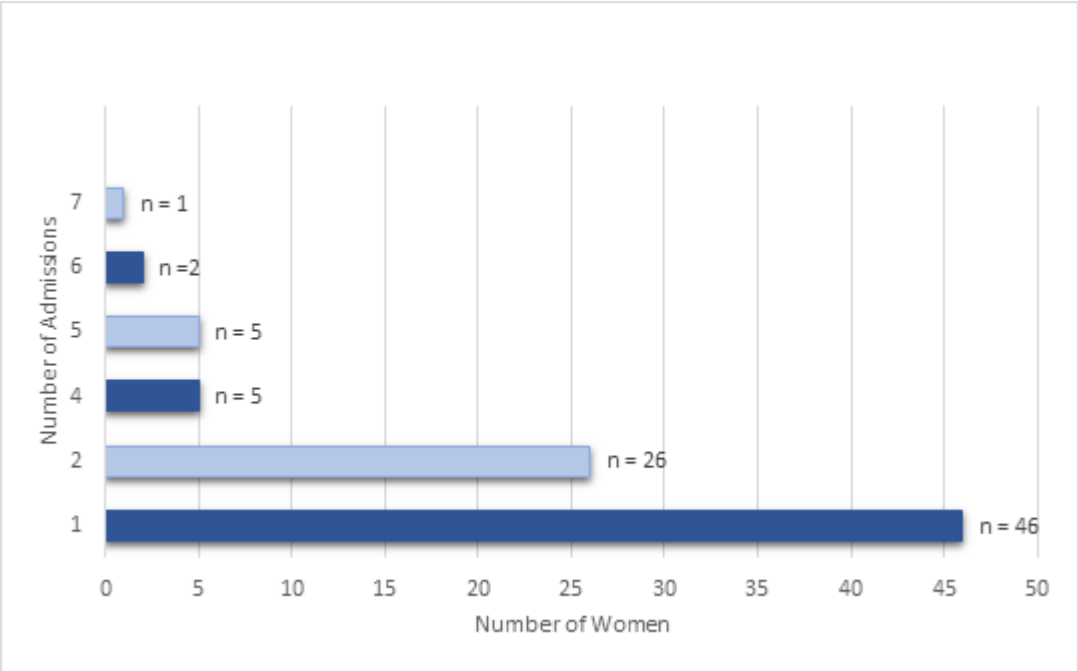
Figure 1: Flow chart for inclusion and exclusion criteria

Figure 2: Number of admissions

References:

1. Wier, L.M., Witt, E., Burgess, J. and Elixhauser, A., 2006. Hospitalizations related to diabetes in pregnancy, 2008: statistical brief# 102.

2. Lin, S.F., Kuo, C.F., Chiou, M.J. and Chang, S.H., 2017. Maternal and fetal outcomes of pregnant women with type 1 diabetes, a national population study. *Oncotarget*, *8*(46), p.80679.

3. Phillippe, M., Frigoletto, F.D., von Oeyen, P., Acker, D. and Kitzmiller, J.L., 1982. High risk antenatal hospitalization. *International Journal of Gynecology & Obstetrics*, *20*(6), pp.475-480.

4. Sullivan, S.D., Umans, J.G. and Ratner, R., 2011. Hypertension complicating diabetic pregnancies: pathophysiology, management, and controversies. *The Journal of Clinical Hypertension*, *13*(4), pp.275-284.

5. Knorr, S., Juul, S., Bytoft, B., Lohse, Z., Clausen, T.D., Jensen, R.B., Damm, P., Beck-Nielsen, H., Mathiesen, E.R., Jensen, D.M. and Gravholt, C.H., 2018. Impact of type 1 diabetes on maternal long-term risk of hospitalisation and mortality: a nationwide combined clinical and register-based cohort study (The EPICOM study). *Diabetologia*, pp.1-10.

6. Easter, S.R., Rosenthal, E.W., Morton-Eggleston, E., Nour, N., Tuomala, R. and Zera, C.A., 2017. Disparities in care for publicly insured women with pregestational diabetes. *Obstetrics & Gynecology*, *130*(5), pp.946-952.

7. Rosenthal, E.W., Easter, S.R., Morton-Eggleston, E., Dutton, C. and Zera, C., 2017. Contraception and postpartum follow-up in patients with gestational diabetes. *Contraception*, *95*(4), pp.431-433.

8. Kitzmiller, J.L., Block, J.M., Brown, F.M., Catalano, P.M., Conway, D.L., Coustan, D.R., Gunderson, E.P., Herman, W.H., Hoffman, L.D., Inturrisi, M. and Jovanovic, L.B., 2008. Managing preexisting diabetes for pregnancy: summary of evidence and consensus recommendations for care. *Diabetes care*, *31*(5), pp.1060-1079.

9. HAPO Study Cooperative Research Group, 2008. Hyperglycemia and adverse pregnancy outcomes. *New England Journal of Medicine*, *358*(19), pp.1991-2002.

10. Schei, B.R.B., 1998. Factors predicting antenatal hospital admission in pregnancy. *Scandinavian journal of primary health care*, *16*(2), pp.85-89.

11. Svare, J.A., Hansen, B.B. and Mølsted-Pedersen, L., 2001. Perinatal complications in women with gestational diabetes mellitus. *Acta obstetricia et gynecologica Scandinavica*, *80*(10), pp.899-904.

12. Carter, E.B., Tuuli, M.G., Odibo, A.O., Macones, G.A. and Cahill, A.G., 2017. Prenatal visit utilization and outcomes in pregnant women with type II and gestational diabetes. *Journal of Perinatology*, *37*(2), p.122.

13. Cnattingius, S., 2004. The epidemiology of smoking during pregnancy: smoking prevalence, maternal characteristics, and pregnancy outcomes. *Nicotine & tobacco research*, *6*(Suppl_2), pp.S125-S140.

14. Berlin, I. and Oncken, C., 2018. Maternal smoking during pregnancy and negative health outcomes in the offspring.

15. Mercer, R.T. and Ferketich, S.L., 1988. Stress and social support as predictors of anxiety and depression during pregnancy. *ANS. Advances in nursing science*, *10*(2), pp.26-39.

16. Leichtentritt, R.D., Blumenthal, N., Elyassi, A. and Rotmensch, S., 2005. High-risk pregnancy and hospitalization: the women's voices. *Health & Social Work*, *30*(1), pp.39-47.

17. Raven, M.C., Billings, J.C., Goldfrank, L.R., Manheimer, E.D. and Gourevitch, M.N., 2009. Medicaid patients at high risk for frequent hospital admission: real-time identification and remediable risks. *Journal of Urban Health*, *86*(2), pp.230-241.

18. Robbins, C.L., Zapata, L.B., Farr, S.L., Kroelinger, C.D., Morrow, B., Ahluwalia, I., D'Angelo, D.V., Barradas, D., Cox, S., Goodman, D. and Williams, L., 2014. Core state preconception health indicators—pregnancy risk assessment monitoring system and behavioral risk factor surveillance system, 2009. *Morbidity and Mortality Weekly Report: Surveillance Summaries*, *63*(3), pp.1-62.

Paper 2: Knowledge and attitudes toward prenatal yoga among women with high risk pregnancies

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Word count: 2311

Number of tables: 4

Abstract

Objective: To evaluate the attitudes and knowledge of prenatal yoga and investigate barriers and facilitators to yoga participation in high risk pregnant women receiving prenatal care in an academic tertiary care center.

Methods: We surveyed a convenience sample of women receiving prenatal care through the Maternal-Fetal Medicine practice at Brigham and Women's Hospital. We classified participants as yoga experienced or yoga naïve depending on self-report. We compared differences between the two groups using the appropriate nonparametric tests and compared bivariate odds ratios for survey results using logistic regression.

Results: Of the 100 respondents, 53% had practiced yoga previously. Women with yoga experience were older (age 34.9 $\pm$5.6 vs 31 $\pm$6 years, p=0.004), more likely to be college graduates (94% vs 68%, p=0.002), and more likely to be white (77% vs 47%, p=0.002) than women without previous yoga experience. Previous yoga experience was associated with agreement that yoga was safe during their current pregnancy (OR 5.9, 95% CI 1.9-17.7). Of the women surveyed, 56% agreed that they would like to attend a prenatal yoga class. In a multivariate model including age, race and education, previous yoga experience was the only significant predictor associated with willingness to participate in prenatal yoga classes during current pregnancy. (OR 3.1, 95% CI 1.1-8.6)

Conclusion: Prior yoga experience was the strongest predictor of willingness to attend a prenatal yoga class in our population. Our results suggest that women with high risk pregnancies who may benefit from prenatal yoga interventions but lack prior yoga experience may need additional education to facilitate participation.

Introduction:

Yoga is an ancient discipline grouping physical, mental and spiritual practices which originated in the Indian subcontinent and is now becoming increasingly popular in many parts of the world. The 2016 Yoga and America Study conducted by Yoga journal and Yoga alliance reported that there are 36.7 million people in USA practicing yoga, up from 20.4 million in 2012 (1). There is tremendous interest both in the general population and health care community about the potential health benefits of yoga.

Current literature suggests yoga as adjunctive treatment for chronic conditions such as chronic pain, depression and diabetes (2,3,4,5) in non- pregnant adults and yoga is a promising intervention for common concerns in normal pregnancies including low back pain (6) and depressive symptoms (7). Studies focused on women with high-risk pregnancy suggest yoga may also reduce risks for hypertensive complications of pregnancy (8,9) and improve measures of glycemic control in women with gestational diabetes (10).

While several groups are investigating the potential benefits of yoga during pregnancy, current data are limited in applicability to a high-risk population. Furthermore, previous clinical trials of yoga as an intervention have been limited by difficulties recruiting and retaining subjects (11). Few have investigated the current practices and attitudes of pregnant women, particularly in those with high-risk pregnancies (12).

We therefore sought to evaluate the attitudes and knowledge of prenatal yoga in women receiving high-risk prenatal care at Brigham and Women's Hospital, an academic tertiary care center. We also studied potential barriers and facilitators to practicing prenatal yoga in this population to inform recruitment efforts for future studies. We hypothesize that women with prior

yoga experience would be more willing to attend prenatal yoga program as compared to women who have never tried yoga before.

Methods:

An anonymous, voluntary, self-administered paper questionnaire was offered to all English-speaking women at the time of checking in at our institution's Maternal-Fetal medicine practice in 2016. The Maternal-Fetal Medicine practice at the Brigham and Women's Hospital exclusively provides care to high risk pregnant women. Brigham and Women's Hospital is an urban academic tertiary care center with the largest delivery volume in Massachusetts. Pregnant women with any high-risk condition, irrespective of their age were included in the study. A collection box was made available in the waiting room for patients to deposit the questionnaires, once filled in. A convenience sample of a hundred completed surveys was selected for analysis. This sample size was estimated based on expert consensus, given the lack of comparable reference studies in this population available to guide sample size calculations. All hundred surveys were included in the descriptive analysis (Table 1), however those with any missing answers were excluded from the statistical analysis. The questionnaire was formulated by the authors. Questions were selected based on both, expert consensus through consultation with authorities in the fields of yoga, diabetes and high-risk pregnancy and a review of current literature. There were total 28 questions which included 6 questions on demographics, 5 questions pertaining to obstetric history and 17 questions on attitudes and knowledge about yoga (questionnaire included in appendix I). Data was collected on demographics, pregnancy information, attitudes and knowledge of yoga, barriers and facilitators to practicing yoga. Demographic questions included age, race, ethnicity, education, primary language, parity and gestational age. Obstetric information included a self-report of high-risk conditions such as pregestational diabetes mellitus, gestational diabetes mellitus,

hypertension, cardiac disease and pregnancy complications like multiple gestation, history of preterm birth, pregnancy loss, cardiac condition or other poor obstetric history. Participants were asked to identify potential benefits of yoga and potential barriers (e.g. lack of previous yoga experience and logistical difficulties including preferences for different locations). Participants were classified as yoga experienced if they had attended any yoga class in the past and those who denied prior yoga experience were classified as yoga naïve.

Statistical analysis:

We compared differences between the two groups using the appropriate nonparametric tests. Fisher exact test was used for categorical variables and Wilcoxon rank-sum test for continuous variables as appropriate with statistical significance defined as a two-sided P value <0.05. We calculated bivariate odds ratios for survey results using logistic regression. Univariate logistic regression to model the odds of willingness to participate in a yoga was performed followed by multivariate logistic regression to model the odds of willingness to participate in a yoga program controlling for age, race, education and previous yoga experience. These covariates were selected based on known associations with yoga use as described in studies with populations other than high risk pregnant women (13,14,15). We also modeled the odds for perceived safety of yoga using the same covariates. Study data was stored and managed with REDCap electronic data capture tools hosted by Harvard University. Statistical analyses were performed using SPSS (IBM SPSS for Windows, Version 24.0, Armonk NY: IBM Corp). The protocol was submitted to the Partners IRB which deemed the study to be exempt from review as only deidentified data was collected.

Results:

We obtained surveys from 100 women. Of the respondents, 53% had practiced yoga previously. Women with yoga experience were older (mean age 34.9 ($\pm$5.6) vs 31 ($\pm$6) years, p=0.004), more likely to be college graduates (94% vs 68%, p=0.002), and more likely to be white (77% vs 47%, p=0.002) than women without previous yoga experience. The distribution of gestational age was similar in the two groups. Women reported a variety of pre-pregnancy conditions and pregnancy complications (Table 1); 20% of the sample reported a pregnancy complicated by gestational or pregestational diabetes. Random missing data was less than ten percent.

The response by women to a series of reasons that might make them interested in prenatal yoga is shown in table 2. Compared to yoga naïve women, those with prior yoga experience were more likely to believe that prenatal yoga may reduce stress (81.8% vs 48.9%, p=0.001) and anxiety (62.2% vs 34%, p=0.006). Significantly higher number of women with yoga experience believed that prenatal yoga may improve flexibility (77.3% vs 46.8%, p=0.002), improve childbirth (75.4% vs 38.2%, p<0.001), improve pain during pregnancy (73.5% vs 34%, p<0.001) and decrease weight gain during pregnancy (52.8% vs 31.9%, p=0.04). Similar number of women in both groups believed that prenatal yoga is safe for most women (37.7% in yoga experienced women vs 23.4% in yoga naïve women).

Potential barriers to attending a hospital based prenatal yoga class are described in table 3. The most common reason for not attending a prenatal yoga class at the hospital in yoga naïve women was lack of prior yoga experience (57.44%). Women with previous yoga experience were most likely to cite not wanting to come to the hospital for a yoga class if they did not have an appointment that day (47.1%) as a barrier. Lack of time was a barrier mentioned by respondents

in both groups; 22.6% in the yoga experienced group and 36% in the yoga naïve group. Overall 35% of women surveyed said they would not want to come to the hospital and 32% of women surveyed said that they would not want to pay for parking if they did not have an appointment that day. Only 2 women cited safety as a barrier to hospital-based yoga participation. Of the alternative sites identified by women, 47% responded that they would prefer to attend a yoga class at a studio, only 26% of women preferred the hospital.

While 88% of the women surveyed agreed that yoga was safe during pregnancy, previous yoga experience was associated with increased odds of agreement that yoga was safe during their own pregnancy (OR 5.9, 95% CI 1.9-17.7). More than half (56%) of the women surveyed agreed that they would like to attend a yoga class during pregnancy. In a multivariate model including age, race and education, yoga experience was the only predictor significantly associated with willingness to attend yoga class during current pregnancy (OR 3.1, 95% CI 1.1-8.6) (table 4). Yoga experience was also associated with increased odds of perceived safety of yoga (OR 3.9, 95% CI 1.0-15.5). However, after adjusting for age, race and education, yoga experience was no longer a significant predictor of perceived safety of yoga.

Discussion:

A majority of the participants (56%) were interested in attending prenatal yoga classes. Our study showed that women who practiced yoga were mainly older, white and college educated. These demographic differences are similar to those reported in other studies (13,14). Lack of prior yoga experience was the most common reason cited by yoga naive women for not attending a yoga class despite controlling for known demographic confounders (13,14,15). This finding is unique

to our study and has not been previously investigated. The study illustrates a key role of exposure to yoga in influencing willingness to engage in future yoga practice.

To our knowledge, there are no previous studies surveying attitudes and knowledge of yoga among high-risk pregnant women. A survey of 500 pregnant women by Babbar and Colleagues in Virginia showed 65% women believed prenatal yoga is beneficial and 40% had attempted yoga before pregnancy (12). While their sample was larger, it was not exclusive to high risk pregnant women, who may be less receptive to interventions that include physical activity during pregnancy (16). Importantly, our study shows a high rate of perceived safety with antenatal yoga (88%), and few of the high-risk pregnant women cited safety specifically as barrier. Though the safety of yoga has not been specifically studied in high risk pregnant women, a randomized controlled trial done in 68 patients to evaluate the role of yoga in high-risk pregnancy did not report any adverse events (8). A previous single blinded, randomized controlled trial with 56 patients recommending yoga in non high-risk pregnant women showed no significant change in fetal blood flow acutely after performing yoga for the first time (17). Additionally, another study of 25 healthy pregnant women examined 26 yoga postures and found that yoga was well tolerated with no acute adverse maternal physiologic or fetal heart rate changes (18).

There has been a recent interest in evaluation of the benefits of yoga as a non-pharmacological therapy to improve outcomes in several diseases like diabetes, gestational diabetes, hypertension, eclampsia, depression and chronic pain (2,3,6,8,10). Current literature supports potential benefits and minimal harm from yoga therapy (8,9,17,18). Despite these potential benefits, yoga remains underutilized and is not widely accepted as standard of care due to lack of evidence (19). Most studies on the potential benefits of yoga in high-risk pregnancy are constrained by small sample sizes or lack of randomization (19). This may be in part, due to difficulties in recruitment and

retention in this population (11). A review study done by Paula Frew and colleagues in 2014 highlights logistical challenges among other barriers to patient participation. In this study, demographics (age, income and education), transportation and access to the study site, time to participate, pregnancy related health problems and social factors like spouse/partner preferences were found to influence patient recruitment and retention in pregnant women (11). Our study also identifies important logistical barriers such as not wanting to attend yoga class if no concurrent antenatal appointment (35%), parking fees (32%) and time constraints (28%). Twice as many women wanted to have a yoga class outside the hospital, not at the hospital.

Our study findings must be interpreted in the context of the design and its limitations. The questionnaire was administered at a tertiary care center and was not validated. Only English-speaking women were offered the survey. These factors may limit the generalizability of our findings to other populations. According to RPDR, the Partners Healthcare research query tool, approximately 61% of women seen in the Maternal-Fetal Medicine clinic at Brigham and women's Hospital during the study period were white and 9.5% of women were Hispanic (Appendix II). In our study, 63% of women who filled the survey were white and 8% were Hispanic. Although, only English-speaking women were offered the survey, our study population was demographically comparable to the clinic population. We were unable to collect data on women who opted not complete the survey and we did not measure the response rate for filling the survey. However, based on the clinic census during the study period, we estimate that approximately 10 patients were offered the survey each day and it took us around six months to collect 100 complete surveys. The study also relied on participant self-report of high-risk conditions. Nonetheless, we think our results suggest an opportunity to engage women who might previously have not considered yoga as a possible intervention during pregnancy. While our study showed that prior yoga experience

was associated with willingness to practice prenatal yoga, we did not quantify the number of yoga classes it would take to influence patient behavior. Although 56 % of women surveyed said they would like to attend a prenatal yoga class, willingness to attend may be different than actual attendance at yoga class. Despite these limitations, our study provides a unique insight into the perceptions of prenatal yoga in high-risk pregnant women, which has not been previously investigated.

Our study highlights the lack of prior yoga experience as an important and potentially modifiable barrier to yoga participation among women with high risk pregnancies. Future steps to address this challenge may include focus groups discussions. This would include administering the questionnaire in a targeted population, in a controlled setting which will allow focus-group atmosphere where several aspects of the questionnaire can be discussed with the those filling the survey (20). This would help formulate a survey which should be validated and tested for reliability. Additionally, the potential role of a brief introductory yoga session which may be offered to yoga naïve patients, with the aim of familiarizing yoga and therefore influencing participation in prenatal yoga programs can be investigated. Our study also provides a valuable understanding about logistical barriers towards participation in prenatal yoga programs. We hope this knowledge will help inform future recruitment and retention efforts in antenatal yoga programs and clinical studies involving high risk pregnant women.

Conclusion:

Prior yoga experience was the strongest predictor of willingness to attend a prenatal yoga class in our population. Our results suggest that women with high risk pregnancies who may benefit from prenatal yoga interventions but lack prior yoga experience may need additional education to facilitate participation.

TABLE 1: Demographics

Category	Yoga experienced	Yoga naïve	P value
N (%)	53 (53%)	47 (47%)	
Mean age	35 ($\pm$ 6)	31 ($\pm$ 6)	0.004
White race	41 (77.3%)	22 (46.8%)	0.002
Hispanic	0	8 (17%)	0.001
College educated	50 (94.3%)	32 (68%)	0.002
English speaking	49 (92.4%)	36 (76.5%)	0.047
Nulliparous	22 (41.5%)	17 (36.1%)	0.407
GESTATIONAL AGE			
Less than 12 weeks	5 (9.4%)	3 (6.3%)	NS
12-20 weeks	13 (24.5%)	8 (17%)	0.464
20-30weeks	13 (24.5%)	8 (17%)	0.464
More than 30 weeks	22 (41.5%)	22 (46.8%)	0.550
Postpartum	0	5	0.019
COMPLICATIONS			
Pregestational diabetes	3 (5.66%)	4 (8.51%)	0.703
Gestational Diabetes	5 (9.43%)	8 (17.02%)	0.373

Cardiac condition	4 (7.5%)	4 (8.5%)	1
Hypertension	3 (5.6%)	7 (14.8%)	0.183
History of pregnancy loss	16 (30.1%)	12 (25.5%)	0.660

TABLE 2: Facilitators of participation in prenatal yoga program

Which if any of the following reasons made you or would make you interested in prenatal yoga?	Yoga experienced N= 53 (53%)	Yoga naïve N=47 (47%)	P value
Prenatal yoga may reduce stress	43 (81.1%)	23 (48.9%)	0.001
It may provide benefits of mild to moderate exercise	34 (64.1%)	19 (40.4%)	0.027
It's safe for most women	20 (37.7%)	11 (23.4%)	0.136
It may reduce anxiety	33 (62.2%)	16 (34%)	0.006
It may improve childbirth	40 (75.4%)	18 (38.2%)	<0.001
It may reduce depression	26 (49%)	14 (29.7%)	0.066
It may improve flexibility	41 (77.3%)	22 (46.8%)	0.002
It may improve pain during pregnancy	39 (73.5%)	16 (34%)	<0.001
It may reduce weight gain during pregnancy	28 (52.8%)	15 (31.9%)	0.044

TABLE 3: Barriers to participation in a prenatal yoga program

Barriers to attending a prenatal yoga class	Yoga experienced N=53 (53%)	Yoga naïve N=47 (47%)	P value
I have never done yoga	0	27 (57.4%)	<0.001
I don't like yoga	0	6 (12.7%)	0.009
I don't think yoga is safe for me	1 (1.8%)	1 (2.1%)	1
I don't think I can do yoga	0	2 (4.2%)	0.218
I haven't had time	12 (22.6%)	16 (34%)	0.369
I'm not interested in yoga	0	8 (17%)	0.002
I don't have childcare	3 (5.6%)	1 (2.1%)	0.620
I don't want to come to BWH if I don't have appointment that day	25 (47.1%)	10 (21.2%)	0.011
I don't want to pay for parking if I don't have appointment that day	19 (35.8%)	13 (27.6%)	0.400
I would like to but haven't gone yet	9 (16.9%)	6 (12.7%)	0.589

Table 4: Multivariate analysis for odds of willingness to attend a yoga class during current pregnancy

Variable	P value	Odds ratio	95% confidence interval
Yoga experience	0.025	3.16	(1.15-8.68)
Age	0.371	0.96	(0.88-1.04)
Race (white)	0.731	1.18	(0.44-3.18)
College education	0.152	3.19	(0.65-15.70)

References:

1. Yoga in America study conducted by yoga journal and yoga alliance. 2016

2. Chauhan, A., Semwal, D. K., Mishra, S. P., & Semwal, R. B. (2017). Yoga practice improves the body mass index and blood pressure: A randomized controlled trial. *International journal of yoga*, *10*(2), 103.

3. Hartfiel, N., Clarke, G., Havenhand, J., Phillips, C., & Edwards, R. T. (2017). Cost-effectiveness of yoga for managing musculoskeletal conditions in the workplace. *Occupational Medicine*, *67*(9), 687-695.

4. Cox, H., Tilbrook, H., Aplin, J., Chuang, L. H., Hewitt, C., Jayakody, S., ... & Watt, I. (2010). A pragmatic multi-centred randomised controlled trial of yoga for chronic low back pain: trial protocol. *Complementary therapies in clinical practice*, *16*(2), 76-80.

5. Skoro-Kondza, L., Tai, S. S., Gadelrab, R., Drincevic, D., & Greenhalgh, T. (2009). Community based yoga classes for type 2 diabetes: an exploratory randomised controlled trial. *BMC health services research*, *9*(1), 33.

6. Sun, Y. C., Hung, Y. C., Chang, Y., & Kuo, S. C. (2010). Effects of a prenatal yoga programme on the discomforts of pregnancy and maternal childbirth self-efficacy in Taiwan. *Midwifery*, *26*(6), e31-e36.

7. Field, T., Diego, M., Delgado, J., & Medina, L. (2013). Yoga and social support reduce prenatal depression, anxiety and cortisol. *Journal of bodywork and movement therapies*, *17*(4), 397-403.

8. Deshpande, C. S., Rakshani, A., Nagarathna, R., Ganpat, T. S., Kurpad, A., Maskar, R., ... & Anura, K. (2013). Yoga for High-Risk Pregnancy: A Randomized Controlled Trial. *Annals of medical and health sciences research*, *3*(3), 341-344.

9. Rakhshani, A., Nagarathna, R., Mhaskar, R., Mhaskar, A., Thomas, A., & Gunasheela, S. (2012). The effects of yoga in prevention of pregnancy complications in high-risk pregnancies: a randomized controlled trial. *Preventive medicine*, *55*(4), 333-340.

10. Youngwanichsetha, S., Phumdoung, S., & Ingkathawornwong, T. (2014). The effects of mindfulness eating and yoga exercise on blood sugar levels of pregnant women with gestational diabetes mellitus. *Applied Nursing Research*, *27*(4), 227-230.

11. Frew, P.M., Saint-Victor, D.S., Isaacs, M.B., Kim, S., Swamy, G.K., Sheffield, J.S., Edwards, K.M., Villafana, T., Kamagate, O. and Ault, K., 2014. Recruitment and retention of pregnant women into clinical research trials: an overview of challenges, facilitators, and best practices. *Clinical Infectious Diseases*, *59*(suppl_7), pp.S400-S407.

12. Babbar, S., & Chauhan, S. P. (2015). Exercise and yoga during pregnancy: a survey. *The Journal of Maternal-Fetal & Neonatal Medicine*, *28*(4), 431-435.

13. Desai, K., Bowman, M. A., Galantino, M. L., Hughes-Halbert, C., Vapiwala, N., DeMichele, A., & Mao, J. J. (2010). Predictors of yoga use among patients with breast cancer. *Explore: The Journal of Science and Healing*, *6*(6), 359-363.

14. Cramer, H., Ward, L., Steel, A., Lauche, R., Dobos, G. and Zhang, Y., 2016. Prevalence, patterns, and predictors of yoga use: results of a US nationally representative survey. *American journal of preventive medicine*, *50*(2), pp.230-235.

15. Cramer, H., Lauche, R., Langhorst, J., Paul, A., Michalsen, A. and Dobos, G., 2013. Predictors of yoga use among internal medicine patients. *BMC complementary and alternative medicine*, *13*(1), p.172.

16. Coll, C. V., Domingues, M. R., Goncalves, H., & Bertoldi, A. D. (2017). Perceived barriers to leisure-time physical activity during pregnancy: A literature review of quantitative and qualitative evidence. *Journal of science and medicine in sport*, *20*(1), 17-25.

17. Babbar, S., Hill, J.B., Williams, K.B., Pinon, M., Chauhan, S.P. and Maulik, D., 2016. Acute feTal behavioral Response to prenatal Yoga: a single, blinded, randomized controlled trial (TRY yoga). *American journal of obstetrics and gynecology*, *214*(3), pp.399-e1.

18. Polis, R.L., Gussman, D. and Kuo, Y.H., 2015. Yoga in pregnancy: an examination of maternal and fetal responses to 26 yoga postures. *Obstetrics & Gynecology*, *126*(6), pp.1237-1241.

19. Curtis, K., Weinrib, A. and Katz, J., 2012. Systematic review of yoga for pregnant women: current status and future directions. *Evidence-based complementary and alternative medicine*, *2012*.

20. Jones, T.L., Baxter, M.A.J. and Khanduja, V., 2013. A quick guide to survey research. *The Annals of The Royal College of Surgeons of England*, *95*(1), pp.5-7.

Summary and Conclusion:

High-risk pregnancy is an important cause of poor pregnancy related outcomes and increased health care costs. We performed 2 unique studies in high-risk pregnant women.

In the first study, we aimed at identifying predictors of antepartum admission among women with pregestational diabetes by performing a retrospective cohort study. In our study, first hemoglobin A1c in pregnancy, chronic hypertension and smoking were associated with increased odds of antepartum admission. First hemoglobin A1c in pregnancy was also associated with increased length of stay. These findings emphasize the importance of optimizing preconception health for reproductive-aged women with diabetes to improve clinical outcomes and reduce healthcare costs.

In our second study we aimed to study the attitudes and knowledge of prenatal yoga and barriers and facilitators to practicing it among high-risk pregnant women. A majority of the study participants expressed willingness to attend prenatal yoga classes. Uniquely, our study identifies the lack of yoga experience as an important, modifiable barrier to participation in yoga interventions in pregnant women which has not been previously reported. In our study, after adjusting for demographic confounders, yoga experience was the only predictor significantly associated with willingness to attend yoga class during current pregnancy. It also provides a valuable understanding about logistical barriers towards participation in prenatal yoga programs. We hope this knowledge will help inform recruitment and retention efforts in future antenatal yoga programs and clinical studies involving high-risk pregnant women.

Appendix:

    (I)   Questionnaire for studying attitudes and knowledge of yoga among high risk pregnant

             women.

Prenatal yoga is a structured program of poses, breathing and meditation exercises that are designed for pregnant women. We are conducting this anonymous survey to improve the offerings we provide pregnant women at Brigham and Women's Hospital (BWH). Your participation is voluntary, and if you choose not to participate it will not affect your care in any way. If you choose to complete the survey, please do so only once. If you have any questions, please contact Chloe Zera, MD at 617-732-4287 or czera@partners.org.

1. Have you ever attended a yoga class, either before or during pregnancy?
☐ Yes
☐ No

2. Do you practice yoga at least once per week?
☐ Yes
☐ No

3. Are you aware of the prenatal yoga classes at BWH?
☐ Yes
☐ No

4. Have you attended any prenatal yoga classes at BWH?
☐ Yes
☐ No
(If yes, skip to question 7)

5. If you have not attended any prenatal yoga classes at BWH, have you attended other prenatal yoga classes?
☐ Yes
☐ No

6. If you have not attended any prenatal yoga classes at BWH, why not? (check all that apply):
☐ I have never done yoga
☐ I don't like yoga
☐ I don't think yoga is safe for me
☐ I don't think I can do yoga
☐ I haven't had time
☐ I'm not interested in yoga
☐ I don't have childcare
☐ I don't want to come to BWH if I don't have an appointment that day
☐ I don't want to pay for parking if I don't have an appointment that day
☐ I would like to but haven't gone yet
☐ I didn't know there was a prenatal yoga class
☐ I can't come at the time the class is offered
☐ Other (please explain):

7. Where would you be willing to attend a yoga class? (check all that apply)
- [ ] BWH Main Campus (75 Francis Street)
- [ ] BWH at 850 Boylston
- [ ] Yoga studio
- [ ] Gym
- [ ] School
- [ ] Church
- [ ] I am not willing/able to attend a yoga class right now
- [ ] I am not willing/able to attend a yoga class ever

8. If it were convenient, would you be willing to attend a yoga class at BWH?
- [ ] Yes, I have already attended a yoga class at BWH
- [ ] Yes, I have not yet attended a yoga class at BWH but I would be willing to attend
- [ ] No

(If no, skip to question 13)

9. If you were willing to attend a yoga class at BWH, what time(s) of day would you attend?
- [ ] 6-8 am
- [ ] 8-11 am
- [ ] 11-1 pm
- [ ] 1-4 pm
- [ ] 4-7 pm
- [ ] 7-9 pm

10. If you were willing to attend a yoga class at BWH, what day(s) of the week would you attend?
- [ ] Monday
- [ ] Tuesday
- [ ] Wednesday
- [ ] Thursday
- [ ] Friday
- [ ] Saturday
- [ ] Sunday

11. If a yoga class were offered at BWH, would you be willing to attend on a day other than when you had an appointment?
- [ ] Yes
- [ ] No

12. If no, how close to your appointment would the class need to be for you to be willing to attend?
- [ ] within 1 hour
- [ ] within 2 hours
- [ ] within 3 hours
- [ ] within 4 or more hours
- [ ] I would not attend a class on a day that I did not have a scheduled appointment

Please rate your agreement with the following items by circling your response:

13. I think yoga is safe during pregnancy

Strongly disagree   Disagree   No opinion   Agree   Strongly agree

14. I think yoga is safe for me during pregnancy

Strongly disagree   Disagree   No opinion   Agree   Strongly agree

15. I am interested in learning more about yoga in pregnancy

Strongly disagree   Disagree   No opinion   Agree   Strongly agree

16. I would like to take a yoga class during pregnancy

Strongly disagree   Disagree   No opinion   Agree   Strongly agree

17. Which if any of the following reasons would make you interested in prenatal yoga (check all that apply)?

☐ Prenatal yoga may reduce stress
☐ Prenatal yoga may provide the benefits of mild to moderate exercise
☐ Prenatal yoga is safe for most women
☐ Prenatal yoga may reduce anxiety
☐ Prenatal yoga may improve childbirth
☐ Prenatal yoga may reduce depression
☐ Prenatal yoga may improve flexibility
☐ Prenatal yoga may improve pain during pregnancy
☐ Prenatal yoga may reduce weight gain in pregnancy
☐ Other (please explain):
_____

18. How far along in your pregnancy are you today?
☐ Less than 12 weeks
☐ 12-20 weeks
☐ 20-30 weeks
☐ More than 30 weeks
☐ Postpartum

19. Including your current pregnancy, how many pregnancies have you had? _____

20. How many deliveries have you had? _____

21. Do you have any high risk issues during this pregnancy? (check all that apply):
☐ Diabetes (diagnosed before pregnancy)
☐ Gestational diabetes
☐ Hypertension (high blood pressure)
☐ Multiple gestation (twins, triplets, etc.)
☐ History of preterm delivery
☐ History of preeclampsia

☐ History of pregnancy loss
☐ Thyroid disease or condition
☐ Cardiac (heart) disease or condition
☐ Lupus or rheumatoid arthritis
☐ Seizure disorder
☐ BMI greater than 30 kg/m2
☐ Infertility requiring treatment to conceive
☐ Fetal problem (e.g. heart abnormality, kidney abnormality, brain abnormality, chromosome abnormality, other congenital anomaly)
☐ Intrauterine growth restriction
☐ Placenta previa
☐ Placenta accreta
☐ Other high risk condition: _____

22. Who is your primary obstetric provider?
☐ Doctor
☐ Midwife

DEMOGRAPHIC INFORMATION

1) a) Height (feet/inches): _____   b) Weight (lbs): _____

2) Age: _____

3) Ethnicity (check one):
___ Hispanic or Latino
___ Not Hispanic or Latino

4) Race (check one or more):
___ American Indian or Alaska Native
___ Asian
___ Black or African American
___ Native Hawaiian or other Pacific Islander
___ White
___ Other (please specify): _____

5) What is the highest level of education you have completed? (Check one)
___ Did not complete high school
___ High school/GED
___ Some college
___ Associate degree
___ Bachelor's degree
___ Graduate degree (Master's, PhD, MD, JD, etc.)

6) What is your primary language?
___ English
___ Spanish
___ Mandarin
___ Arabic
___ Somali
___ Portuguese
___ Other: _____

(II)   Demographics of patients seen in Maternal-fetal medicine clinic in the year 2016

PARTNERS
HEALTHCARE SYSTEM

RESEARCH PATIENT DATA REGISTRY (RPDR)

The query entitled "BWH OBGYN MFM (10030010209) on 05/18/2019", submitted on 5/18/2019 11:05:47 AM, was successfully completed on 5/18/2019 11:05:48 AM. This query was performed for Jadeja, Neville of the group of Sarkis, Rani A.,M.D.,M.SC.. The search was completed in 1 seconds.

QUERY DESCRIPTION
# of times an item is recorded is > 0
Independent of Visit

BWH OBGYN MFM (10030010209)
Encounter detail \ Epic Departments \ BWH \ BWH OBGYN MFM
Independent of Visit
Not constrained by importance
From 01/01/2016 to 12/31/2016
# of times an item is recorded is > 0

O R

BWP OBGYN MFM FXB (10030040023)
Encounter detail \ Epic Departments \ BWH \ BWP OBGYN MFM FXB
Independent of Visit
Not constrained by importance
From 01/01/2016 to 12/31/2016
# of times an item is recorded is > 0

print
QUERY RESULTS

Total Number of Cases

Total Patients Matching Query
2300 ±3

Total Unique Patients by Gender

Gender	Counts
Female	2290 ±3
Male	10 ±3
Undefined	<=3

Total Unique Patients by Race

Race	Counts
American Indian	5 ±3
Asian	198 ±3
Black	342 ±3
White	1402 ±3
Hispanic	219 ±3
Other	163 ±3
Not Recorded	44 ±3

Total Unique Patients by Vital Status

Status	Counts
Alive	2297 ±3
Deceased	<=3
Not Recorded	<=3

Total Unique Patients by Age

From	To	Counts	Graph
0	9	<3	-
10	19	5 ±3	▮
20	29	299 ±3	▬▬▬▬
30	39	1378 ±3	▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬
40	49	568 ±3	▬▬▬▬▬▬▬

50	59	33 ±3	■
60	69	9 ±3	■
70	79	3 ±3	■
80	89	3 ±3	■
>=90		<3	--

print