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Severe Preeclampsia and Maternal Self-Report of Oral Health, Hygiene, and Dental Care

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Abstract

Background—Maternal periodontal disease diagnosed by a detailed oral health examination is associated with preeclampsia. Our objective was to measure the association between maternal self-report of oral symptoms/problems, oral hygiene practices, and/or dental service utilization prior to or during pregnancy and severe preeclampsia.

Methods—A written questionnaire was administered to pregnant women at the time of prenatal ultrasound, and outcomes ascertained by chart abstraction. Chi square test compared maternal oral symptoms/problems, hygiene practices, and dental service utilization between women with severe preeclampsia versus normotensive women. Multivariable logistic regression was used to calculate adjusted odds ratios (aOR) and 95% confidence intervals (CI) for severe preeclampsia. Results: 48 (10%) of 470 women reported 2 oral symptoms/problems in the 6 months prior to pregnancy and 77 (16%) since pregnancy. 51(11%) reported prior periodontal treatment. 28 (6%) of 470 developed severe preeclampsia. Women with a history of periodontal treatment were more likely to develop severe preeclampsia (aOR, 95%CI: 3.71, 1.40-9.83) than women without a prior history of periodontal treatment. Self-reported oral health symptoms/problems, oral hygiene practices, or dental service utilization prior to or during pregnancy were not associated with severe preeclampsia when considered in the context of other maternal risk factors. Conclusion: Maternal self report of previous periodontal treatment prior to pregnancy is associated with severe preeclampsia.

Keywords

Pregnancy complications; periodontitis; epidemiology

Introduction

Improving oral health and reducing the impact of oral disease on overall health and well-being are major health priorities.^{1, 2} Oral diseases such as dental caries (cavities), gingivitis, and periodontal disease are prevalent conditions that impact oral health and lead to tooth loss. In addition, periodontal disease has been associated with cardiovascular disease, diabetes, and adverse pregnancy outcomes.³ Some investigators⁴⁻⁸ but not others⁹⁻¹¹ have reported an association between maternal periodontal disease and preeclampsia, a

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hypertensive disorder unique to pregnancy. Preeclampsia is a significant cause of perinatal morbidity.¹² Identification of women at risk for preeclampsia allows opportunity for increased surveillance and potential prevention. However, identifying women at risk for preeclampsia because of the presence of periodontal disease requires access to providers who can provide a detailed oral health examination, which is not practical for all women.

It has been recognized for decades that pregnant women have a higher incidence of gingival inflammation compared to non-pregnant women.¹³ Periodontal disease is also prevalent during pregnancy, particularly among racial/ethnic minority women and those of low socioeconomic status.^{14, 15} The reasons for this are likely multi-factorial and include inadequate oral hygiene, limited access to oral health care, medical co-morbidities that increase oral disease risk, and limited knowledge of the relationship between oral and general health among prenatal care providers and their patients^{16, 17}

We recently reported on maternal oral health knowledge, beliefs, and dental service utilization.¹⁸ We found that pregnant women possess some oral health knowledge, which varied by maternal race/ethnicity. We also found racial/ethnic and economic disparities in oral hygiene practices and dental service utilization.¹⁸ The relationship between maternal reported oral health symptoms/problems or dental service utilization and pregnancy outcomes is not known.

The purpose of this analysis was to measure the association between maternal self-report of oral symptoms/problems, oral hygiene practices, and/or dental service utilization prior to or during pregnancy and severe preeclampsia.

Materials and Methods

The University of North Carolina at Chapel Hill (UNC) Institutional Review Board approved the conduct of this study, and women gave informed written consent in their native language. Women age 18 and over attending the UNC Women's Clinic Ultrasound Unit for a clinically indicated prenatal ultrasound (e.g. documentation of gestational dating; documentation of viability and number of fetuses; limited or detailed evaluation of fetal anatomy; evaluation for evidence of fetal disease including but not limited to aneuploidy, non immune hydrops, in-utero infection; and/or examination for fetal growth and well-being) were approached for participation and asked to complete a self-administered questionnaire. The indication for the ultrasound was not recorded as part of this study, because almost all women who receive prenatal care in North Carolina receive at least one ultrasound during the course of their pregnancy; the majority of women who attend the UNC Women's Clinic Ultrasound Unit are medically low-risk.

The questionnaire was developed by the primary investigators as previously described¹⁸ and consisted of 39 questions designed to assess maternal knowledge, beliefs, and health practices regarding oral health for herself and her child(ren). The questionnaire was available in both English and Spanish. Bilingual study staff were available to read the questionnaire to women who were illiterate. Women were compensated with a \$10 incentive for completion of the questionnaire. Exclusion for participation included currently not pregnant, age < 18 years, or language other than English or Spanish.

Maternal characteristics including age, race/ethnicity, level of education, annual household income, and insurance coverage were collected. Women self-characterized race/ethnicity by choosing one or more of the following categories to describe themselves: Asian; American Indian or Alaska Native; Black or African-American; Hispanic/Latina; Native Hawaiian or other Pacific Islander; White; or Other, please specify. Maternal oral health symptoms and problems (bleeding around teeth; swollen/red gums; teeth seem longer; sore gums for 2 or

more weeks; gum infection for 2 or more weeks; one or more teeth felt loose; one more teeth pulled or fell out not including wisdom teeth or extractions for orthodontic procedures) and frequency of oral hygiene practices (tooth brushing; use of dental floss; use of mouthwash) in the 6 months before pregnancy and since becoming pregnant were ascertained by self report using forced choice questions. Data regarding dental service utilization prior to and during pregnancy were collected. Questionnaire results for the study cohort have been previously published.¹⁸

Medical history and pregnancy outcomes were ascertained by medical record abstraction. The primary outcome for this analysis was development of severe preeclampsia (proteinuric hypertension and at least one of the following: symptoms of central nervous system dysfunction or liver capsule distention; hepatocellular injury; systolic blood pressure ≥ 160 mm Hg or diastolic blood pressure ≥ 110 mm Hg on two occasions at least six hours apart; platelet count $< 100,000$ per cubic mm; 5 or more grams of proteinuria in 24 hours; < 500 milliliters urine in 24 hours; fetal growth restriction; pulmonary edema; or cerebrovascular accident) or the syndrome of hemolysis, elevated liver enzymes, low platelets (HELLP).^{12, 19}

Bivariate analyses (t test for parametric ordinal measures; chi square for comparing proportions) were performed to test the association between maternal demographic and medical data, oral health symptoms/problems, oral hygiene practices, dental service utilization, and severe preeclampsia/HELLP syndrome. Variables associated with severe preeclampsia/HELLP syndrome at $p \leq .20$ level in bivariate analysis were considered in the initial predictive model. Variables found not to be significantly associated with severe preeclampsia/HELLP syndrome ($p > .05$) in the full multivariable logistic regression analysis were sequentially removed to calculate the final adjusted odds ratios (aORs) and 95% confidence intervals (CIs) for each variable associated with severe preeclampsia/HELLP syndrome. Tobacco use was forced into the final multivariable logistic regression model. Statistical analyses were performed using Stata 10 (StataCorp, College Station, TX).

Results

During the study period, 1292 women attended the UNC Women's Clinic for the purpose of an antenatal ultrasound. Study personnel were available to recruit women into the study two to three days per week of the study period; thus 701 (54%) of 1292 women who attended the clinic were invited to participate. Eighty-six women declined participation and 615 enrolled and gave informed written consent. Sixteen enrolled women were excluded because they no longer met eligibility criteria, had duplicate participation, or were unable to complete the questionnaire; thus a total of 599 completed surveys were evaluated for this analysis. Five hundred eighty two (97%) were self-administered and 17 (3%) were read to the study woman. 442 (74%) of 599 were completed in English and 157 (26%) in Spanish.

Maternal oral hygiene practices and dental service utilization of the original cohort of 599 women who completed questionnaires has been previously reported.¹⁸ For the current analysis, 470 (78%) of 599 delivered at the UNC Women's Hospital and had delivery information available; 129 (22%) delivered elsewhere, thus pregnancy outcome data were unavailable. Demographics of the original 599 women who completed the questionnaire are shown in Table 1. Women who delivered at UNC were similar to those delivered elsewhere with regard to demographic characteristics, with the exception of trimester of ultrasound. Of the 470 women included in this analysis, 35 (7%) reported smoking during pregnancy, 42 (9%) had a history of chronic hypertension, and 20 (4%) reported pre-gestational diabetes. Two hundred and seventy eight (59%) of 470 women had a prior pregnancy that was

delivered at > 20 weeks gestation, and 22 (8%) of those women had a history of preeclampsia.

32 (7%) of 470 reported ever being told they have ‘gum disease’; 51 (11%) reported prior treatment for ‘gum disease’. 123 (24%) of 470 reported ever having a tooth fall out or pulled (excluding wisdom teeth and for orthodontic procedures) in the past. 121 (26%) of 470 women reported bleeding around the teeth/gums in the 6 months prior to pregnancy; this increased significantly to 203 (43%) of 470 women when asked about oral health symptoms or problems since becoming pregnant ($p < .001$). 48 (10%) of 470 reported 2 symptoms/problems in the six months prior to pregnancy, and 77 (16%) of 470 reported 2 symptoms/problems since becoming pregnant ($p = .005$). 126 (27%) of 470 reported tooth brushing once per day or less; 362 (77%) of 470 reported flossing less frequently than once per day; only 146 (31%) of 470 reported daily mouthwash/rinse use. 72 (15%) of 470 reported never receiving routine dental care, and 167 (36%) of 470 reported having one or fewer preventive professional dental care visits per year.

46 (10%) of 470 women developed a hypertensive complication of pregnancy (gestational hypertension, mild preeclampsia, or severe preeclampsia including HELLP syndrome) in the study pregnancy. 18 (4%) of 470 developed gestational hypertension or mild preeclampsia and 28 (6%) of 470 developed severe preeclampsia/HELLP syndrome. The 424 normotensive women were compared to the 28 women who developed severe preeclampsia/HELLP syndrome as shown in Table 2. Women with severe preeclampsia/HELLP syndrome differed from healthy women using our pre-specified threshold ($p < .2$) with regard to age, annual household income, medical insurance, tobacco use, pregestational diabetes, and presence of chronic hypertension. As shown in Table 3, in bivariate analyses, maternal report of frequency of use of mouthwash/rinse, frequency of routine dental care, treatment ever for ‘gum disease’, presence of swollen/red gums, gum soreness or infection for 2 weeks, and 2 or more oral health symptoms/problems in the 6 months prior to pregnancy, were associated with severe preeclampsia/HELLP syndrome. Women who reported gum soreness or infection for 2 weeks, one or more teeth missing, and 2 oral health symptoms/problems since becoming pregnant were also more likely to develop severe preeclampsia/HELLP syndrome (Table 3) than women without these symptoms/problems. Table 4 shows the unadjusted OR (95% CI) for severe preeclampsia/HELLP, the initial model that includes variables associated with severe preeclampsia/HELLP syndrome using our pre-specified $p = .20$ level in bivariate analysis (initial model), and the adjusted OR (95% CI) for the reduced model, which includes variables associated with severe preeclampsia/HELLP syndrome at our pre-specified $p < .20$ level in the initial model. In the final reduced model only history of prior gum disease treatment remained significantly associated with severe preeclampsia/HELLP syndrome (Table 4). Of the 28 women with severe preeclampsia/HELLP syndrome, 5 (18%) reported a history of prior gum disease treatment but no history of chronic hypertension or previous preeclampsia, and therefore would not have otherwise been identified as at risk for preeclampsia.

Discussion

Our data show that oral health symptoms/problems, reported oral hygiene practices, or dental service utilization prior to or during pregnancy were not associated with severe preeclampsia/HELLP syndrome when considered in the context of other potential risk factors. However, a past history of periodontal treatment was associated with severe preeclampsia/HELLP syndrome, and this association was comparable to the association between chronic hypertension and severe preeclampsia/HELLP syndrome. We⁴ and others^{6, 7} have previously reported a significant relationship between maternal periodontal disease detected during pregnancy and preeclampsia. In a meta-analysis of infectious risk

factors for preeclampsia, maternal periodontal disease was associated with a 1.76-fold pooled odds ratio for preeclampsia.²⁰ Some have suggested that inflammation plays a key role in causing preeclampsia and its manifestations^{21, 22}, thus raising the possibility of infection as a trigger for preeclampsia.²³ The presence of periodontal pathogens is thought to incite local and systemic inflammatory responses that predisposes to preeclampsia²⁴, although the exact mechanism of the association is unknown. The current analysis was limited to include only severe preeclampsia/HELLP syndrome because of the impact of this disease on maternal and fetal outcomes.¹² Severe preeclampsia/HELLP syndrome can result in maternal organ failure, and often precipitates a preterm birth¹² and is more likely to be associated with maternal inflammation and vascular disease.¹²

In this study maternal self-report of a prior history of periodontal treatment was found to be comparable to a history of chronic hypertension as a risk factor for severe preeclampsia/HELLP syndrome. We suspect that a prior history of periodontal treatment suggests the presence of oral pathogens; while treatment may ameliorate the clinical changes within the gingiva and the effects of this microbial burden, it may not eliminate it entirely. Periodontal disease is often asymptomatic, and symptoms suggestive of periodontal disease such as swollen, red or bleeding gums can also be symptoms of physiologic changes of pregnancy. In this cohort, oral health symptoms/problems leading up to or during pregnancy did not identify women at risk for preeclampsia. Because of the potential overlap with normal physiologic changes of pregnancy, as well as gingivitis, maternal self-report of symptoms may be a poor surrogate to assess periodontal disease status or more importantly, the oral microbial burden and subsequent systemic inflammatory response. The diagnosis and classification of periodontal disease is based entirely on traditional clinical measurements²⁵, which requires a specialized examination of the teeth and gingiva. The most recent oral health surveillance data²⁶ reports that 14-90% of adults have some form of dental disease. Since we did not perform oral health exams as part of this study, we cannot determine if our population is comparable to the population survey as part of the U.S surveillance report.

We¹⁸ and others²⁷⁻²⁹ have reported on maternal self report of oral health, oral symptoms, and dental service utilization during pregnancy. To our knowledge, this is the largest study to examine the association between pregnancy outcomes and maternal report of oral health symptoms/problems, oral hygiene practices, and dental service utilization. In a case-control study of 111 women, Shub and colleagues³⁰ found that women with an unexplained perinatal death at > 20 weeks were more likely to have clinical periodontal disease compared to healthy controls (43 vs. 24%). In this study, women completed a questionnaire regarding ten oral health symptoms and practices; none were associated with perinatal mortality. They did not examine the relationship between symptoms and other outcomes such as preeclampsia, or multiple symptoms and perinatal death.³⁰

The strengths of this study include our large sample size, diversity in race/ethnicity, and prevalence of low-income women, which makes our findings relevant to women at risk for oral diseases.¹ Another strength is the prospective design. In addition, while survey data has potential sources of bias as outlined below, asking women about their history of prior treatment for gum disease represents information that would be available to a prenatal care provider, as opposed to a detailed periodontal exam.

Despite these strengths, limitations of this study exist. We did not ascertain the timing of the previous periodontal treatment. Given the age of the study cohort, it is unlikely that treatment occurred more than 10 years previous to this study (the median age of the subjects was 29 years). However, it is possible that very distant treatment of periodontal disease is only a marker for another underlying medical condition and thus not truly a risk factor for preeclampsia. In contrast to another study³¹ this study revealed that maternal report of

smoking was associated with severe preeclampsia/HELLP on bivariate analysis. It is unclear why this is the case, however, smoking did not remain significantly associated with severe preeclampsia/HELLP syndrome in the multivariable model. Women did not undergo oral health examinations, thus relying solely on maternal self-report has the potential for bias due to under- or over-reporting. Women may under report symptoms and/or over report positive health practices. However, if this were the case it would bias our findings to the null. In addition, asking women to rate their oral health and describe their symptoms requires subjective assessment, which may vary from woman to woman (or vary among women). Another possible limitation is that we have pregnancy outcome data on only 470 (79%) of the overall cohort; delivery information was not available for women who did not deliver at UNC Women's Hospital. The 129 women who delivered elsewhere were more likely to be in the first trimester, but were otherwise comparable with regard to maternal demographic and oral health and hygiene data. If there were a higher rate of severe preeclampsia among women who delivered at UNC our findings would not be generalizable to all pregnant women. This is a concern because the rate of severe preeclampsia reported in the cohort of women delivered at UNC (6%) is higher than is reported in general populations of pregnant women.³² However, we believe that our data are relevant for counseling a low-income group of pregnant women who receive care at a tertiary care center.

Despite these limitations, the current study demonstrates the potential relationship between periodontal disease treatment prior to pregnancy and severe preeclampsia/HELLP syndrome. These findings are relevant in the context of the recent data demonstrating that treatment of periodontal disease during early pregnancy does not reduce preeclampsia.³³ Whether other preeclampsia prevention strategies (e.g. anti-platelet agents) should be offered to women with a history of periodontal disease treatment has not been addressed. Further research should be directed at the use of maternal self-report of periodontal disease treatment and use of reported preeclampsia prevention strategies.

The data reported here demonstrate that maternal self-report of previous periodontal disease that required treatment is a significant risk factor for preeclampsia. The strength of this association is comparable to the strength of the association between a history of chronic hypertension and preeclampsia. We speculate that previous periodontal disease is a marker for systemic inflammatory effects that may lead to hypertensive disorders. These data will lead to future research on the mechanisms of the association of periodontal disease and preeclampsia, and potential intervention strategies to reduce this association.

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Summary

In this study group, maternal report of previous periodontal disease treatment was associated with preeclampsia.

Table 1Maternal demographic characteristics of original study cohort that completed questionnaire (n=599)^{*}

Demographic characteristic	Women who delivered at UNC (n=470)	Women who delivered elsewhere (n=129)
Maternal age at enrollment (years)	29 [25-33]	29 [24-33]
Race/ethnicity		
White	191 (41)	57 (44)
African-American	97 (21)	24 (19)
Hispanic	147 (31)	37 (29)
All others	35 (7)	11 (9)
Marital status		
Married/living with partner	391 (83)	103 (80)
Single/not living with partner	62 (13)	19 (15)
Data missing	17 (4)	7 (5)
Educational attainment		
Less than high school	120 (26)	32 (25)
High school graduate or higher	343 (73)	93 (72)
Data missing	7 (1)	4 (3)
Annual household income		
Less than \$30K	202 (43)	51 (40)
\$30 – \$60K	64 (14)	27 (21)
> \$60K	120 (26)	31 (24)
Data missing	84 (18)	20 (16)
Has dental insurance (private or Medicaid)	259 (55)	70 (54)
Trimester at study enrollment		
First	53 (11)	23 (18)
Second/third	413 (88)	97 (75)
Missing	4 (1)	9 (7)

Data presented as number (%) except age, which is presented as median [interquartile range]

^{*} All comparisons non significant ($p > .05$) except for trimester at enrollment ($p = .02$)

Table 2

Maternal demographic and medical data by severe preeclampsia (n=452) *

Demographic and medical data	Severe preeclampsia/HELLP (n=28)	Normotensive women (n=424)	P value
Maternal age (years) [†]	30.8 ± 7.4	29.6 ± 6.0	.82
Race/ethnicity			.79
White	13 (46)	169 (40)	
African-American	6 (21)	87 (21)	
Hispanic	8 (29)	134 (32)	
Other	1 (4)	34 (8)	
Marital status			.86
Married/living with partner	23 (82)	353 (83)	
Single/not living with partner	4 (14)	56 (13)	
Data missing	1 (4)	15 (4)	
Education level			.71
< High School diploma	8 (29)	110 (26)	
High School or greater	19 (68)	308 (73)	
Data missing	1 (4)	6 (1)	
Annual household income			.15
< \$30K	15 (54)	179 (42)	
\$30-60K	1 (4)	59 (14)	
>\$60K	5 (18)	111 (26)	
Data missing	7 (25)	75 (18)	
Has dental insurance (private or Medicaid)	18 (64)	232 (55)	.32
Medical insurance			.10
Uninsured/self-pay	1 (4)	23 (5)	
Medicaid/Medicare	20 (71)	211 (50)	
Private	7 (25)	182 (43)	
Data missing	0 (0)	8 (2)	
Tobacco use during pregnancy	5 (18)	27 (6)	.02
Nulliparous	13 (46)	161 (38)	.51
Multiparous, prior preeclampsia	2 (7)	20 (5)	
Multiparous, no prior preeclampsia	13 (46)	243 (57)	
Pre-gestational diabetes	5 (18)	13 (3)	<.001
Gestational diabetes	1 (4)	15 (4)	.99
Chronic hypertension	8 (29)	30 (7)	<.001

Data presented as number (%)

* Total number excludes 18 (4%) of 470 women with gestational hypertension or mild preeclampsia

Table 3

Oral hygiene practices, symptoms and problems by presence of severe preeclampsia (n=452)*

Oral hygiene practices, symptoms and problems	Severe preeclampsia/HELLP (n=28)	Normotensive women (n=424)	P value
Self-reported oral health status			.48
Excellent/good	18 (64)	254 (57)	
Fair/poor/very poor	10 (36)	188 (43)	
Tooth brushing			.27
Once per day or less	10 (36)	116 (26)	
More than once per day	18 (64)	326 (74)	
Flossing			.36
Less than once per day	19 (68)	334 (76)	
At least once per day	9 (32)	108 (24)	
Use of mouthwash/dental rinse			.07
Less than once per day	15 (54)	309 (70)	
At least once per day	13 (46)	133 (30)	
Frequency of routine dental care			.18
Less than one visit per year	15 (54)	178 (40)	
At least one visit per year	13 (46)	261 (59)	
Data missing	0 (0)	3 (1)	
Dental visit since pregnant	8 (29)	113 (26)	.67
Been told had gum disease	3 (11)	29 (7)	.37
Data missing	1 (4)	4 (1)	
Treatment ever for gum disease	8 (29)	43 (10)	.001
Data missing	1 (4)	3 (1)	
One or more teeth pulled/fell out (excluding wisdom teeth and those for orthodontics)	8 (29)	105 (24)	.51
Data missing	1 (4)	4 (1)	
In the 6 months before pregnancy:			
Bleeding around teeth/gums	8 (29)	113 (26)	.72
Swollen/red gums	6 (21)	42 (10)	.01
Teeth seem longer	0 (0)	6 (1)	.54
Gum soreness for 2 weeks	4 (14)	21 (5)	.03
Gum infection for 2 weeks	2 (7)	7 (2)	.04
One or more teeth felt loose	2 (7)	16 (4)	.34
One or more teeth pulled/fell out (excluding wisdom teeth and those for orthodontics)	1 (4)	21 (5)	.79
2 or more symptoms	5 (18)	43 (10)	.08

Oral hygiene practices, symptoms and problems	Severe preeclampsia/HELLP (n=28)	Normotensive women (n=424)	P value
Since becoming pregnant:			
Bleeding around teeth/gums	13 (46)	190 (43)	.66
Swollen/red gums	6 (21)	70 (16)	.33
Teeth seem longer	0 (0)	8 (2)	.46
Gum soreness for 2 weeks	5 (18)	26 (6)	.01
Gum infection for 2 weeks	2 (7)	12 (3)	.18
One or more teeth felt loose	0 (0)	23 (5)	.22
One or more teeth pulled/fell out (excluding wisdom teeth and those for orthodontics)	2 (7)	12 (3)	.18
2 or more symptoms	7 (25)	70 (16)	.18

Data presented as number (%)

* Total number excludes 18 (4%) of 470 women with gestational hypertension or mild preeclampsia

Table 4

Multivariable logistic regression model for severe preeclampsia/HELLP (n=452)

Maternal characteristic	Unadjusted OR (95%CI)	Initial* adjusted OR (95% CI)	Reduced [§] adjusted OR (95%CI)
Maternal age (years)	1.01 (1.00-1.02)	1.02 (1.00-1.03)	1.01 (1.00-1.02)
Annual household income			
< \$30K	1.86 (.66-5.26)	1.60 (.26-9.78)	--
\$30-60K	.38 (.04-3.30)	0.23 (.02-2.31)	--
>\$60K	Reference	Reference	--
Medical insurance			
Self-pay/uninsured	1.13 (.13-9.61)	2.47 (.16-37.36)	1.32 (.13-13.57)
Medicaid	2.46 (1.02-5.96)	2.97 (.54-16.25)	3.33 (1.06-10.43)
Private	Reference	Reference	Reference
Tobacco use in pregnancy	3.20 (1.13-9.07)	3.18 (.81-12.55)	1.63 (.49-5.42)
Chronic hypertension	5.25 (2.14-12.92)	2.38 (.62-9.13)	3.13 (1.11-8.82)
Pregestational diabetes	6.87 (2.26-20.93)	6.67 (1.20-37.02)	6.04 (1.61-22.67)
Frequency of dental visit			
Less than once per year	1.70 (.79-3.67)	2.33 (.74-7.34)	-
Use of mouthwash/ dental rinse			
Less than once per day	.50 (.23-1.09)	0.50 (.17-1.44)	-
In the 6 months before pregnancy:			
2 or more dental health symptoms reported	2.03 (.73-5.63)	1.53 (.36-6.50)	--
Treatment ever for gum disease	3.80 (1.57-9.21)	2.74 (.83-9.00)	3.22 (1.20-8.62)

†Reduced model created by sequentially removing variables found not to be associated with severe preeclampsia/HELLP syndrome ($p < .05$) in the initial model

* Initial model includes all variables associated with severe preeclampsia/HELLP syndrome at $p < .20$ level in bivariate analysis

§ Maternal age represented by quadratic relationship between maternal age as a continuous variable and severe preeclampsia