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Dental Cleaning, Community Water Fluoridation and Preterm Birth, Massachusetts: 2009–2016

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Abstract

Objectives Data on the potential effect of dental cleaning and community water fluoridation (CWF) on pregnancy outcomes are scarce. While numerous studies confirm the cost-effectiveness of fluoride in preventing dental caries, the benefit of CWF during pregnancy has not been well established. *Methods* This cross-sectional study used data from 2009 to 2016 Massachusetts Pregnancy Risk Assessment Monitoring System and restricted to singleton live births (n = 9234, weighted response rate = 64.3%). Our exposures were: (1) dental cleaning alone during pregnancy; (2) CWF alone; and (3) dental cleaning and CWF combined (DC–CWF). Women without dental cleaning during pregnancy and CWF comprised our reference group. The outcome was preterm birth, (birth < 37 weeks gestation). This study used multivariate logistic regression modeling, controlling for maternal sociodemographic characteristics, previous medical risk and behavioral factors, and calculated adjusted risk ratios (aRRs) and 95% confidence intervals (CIs). *Results* During 2009–2016, the prevalence of preterm birth among women with a singleton live birth was 8.5% in Massachusetts. Overall, 58.7% of women had dental cleaning during pregnancy, and 63.6% lived in CWF. After adjusting for potential confounders, the associations between dental cleaning alone and preterm birth (aRR = 0.74 [95% CI 0.55–0.98]), and DC–CWF and preterm birth (aRR = 0.74 [95% CI 0.57–0.95]) were significant, while the association between CWF alone and preterm birth was not significant (aRR = 0.81 [95% CI 0.63–1.05]), compared to women without dental cleaning and CWF. *Conclusions for Practice* This study shows that the prevalence of preterm birth was lower among women with DC only and DC–CWF.

Keywords Preterm birth · Dental cleaning · Community water fluoridation · PRAMS

Significance

Prior research has shown that dental cleaning and community water fluoridation improve oral health, but their benefits for birth outcomes have not been well established. Our population-based study combines individual maternal characteristics with report of perinatal dental cleaning and community water fluoridation data to examine their associations with preterm birth. Findings from this study support perinatal dental cleaning and community water fluoridation in potentially improving birth outcomes.

Introduction

The United States (US) has one of the highest preterm birth rates among the developed countries; in 2016, preterm birth affected about 1 in 10 infants born in the US (CDC 2017). The estimated societal cost of prematurity in the US was at least $26 billion in 2005 (Institute of Medicine 2007). Well-established risk factors for preterm birth include a history of prior preterm birth, young or advanced maternal age, low or high body mass index (BMI), smoking, multi-fetal pregnancy, genitourinary tract infection, incompetent cervix and placental abruption, and inflammation (Denney et al. 2008).

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The association between periodontitis, an inflammatory oral health condition, and adverse pregnancy outcomes including preterm birth, has been examined. A systematic review conducted in 2007 including 26 case–control studies, 13 cohort studies, and 5 controlled trials, examined the existing evidence on the relationship between periodontal disease and adverse pregnancy outcomes, including preterm birth, low birth weight, birth weight by gestational age, pregnancy loss, preeclampsia, and gestational diabetes mellitus (Xiong et al. 2007). While 15 of the 44 studies in the review found no evidence of an association, 29 studies suggested an association between periodontal disease and increased risk of adverse pregnancy outcomes. The authors concluded that periodontal disease may be associated with increased risk of adverse pregnancy outcomes (odds ratios ranging from 1.10 to 20.0) (Xiong et al. 2007). A more recent systematic review of nine observational studies evaluated the association between dental caries and preterm birth and concluded that pregnant women with dental caries are not at increased risk for preterm birth (Wagle et al. 2018). However, the findings from this systematic review should be interpreted with caution given the small number of cases in some of the studies and the retrospective non-randomized design of the studies.

The pathophysiological mechanisms through which dental caries/periodontitis lead to preterm birth could be explained by caries-causing bacteria from the mouth entering the bloodstream or colonizing the vagina, subsequently leading to preterm birth (Agueda et al. 2008; Heimonen et al. 2008). The production of inflammatory mediators in the inflamed periodontal tissues could enter the bloodstream and trigger an inflammatory cascade in the uterus, leading to preterm birth (Pihlstrom et al. 2005).

To prevent oral diseases and improve oral health, the American Dental Association (ADA) recommends regular professional dental cleanings. Dental cleaning removes plaque, an acidic substance which, if not removed, will eventually cause tooth decay by corroding dental enamel when it builds up on teeth (ADA 2013). In addition, a national consensus statement was developed for health professionals, program administrators, and policymakers to improve oral health services for women during pregnancy (Oral Health Care During Pregnancy Expert Workgroup 2012). Furthermore, the American College of Obstetricians and Gynecologists (ACOG) committee opinion (ACOG 2013) on oral health care for pregnancy was released in 2013, reinforcing the safety of dental care during pregnancy. Despite these recommendations, only 57.5% of women in the US visited a dentist during pregnancy in 2015 (ADA 2016).

Another well-established intervention for improving oral health is the addition of fluoride to community water supplies [US Department of Health and Human Services Federal Panel on Community Water Fluoridation 2015]. Community water fluoridation (CWF) is one of the most cost-effective preventive measures for tooth decay for all ages including pregnant women (Allukian and Horowitz 2002; Heimonen et al. 2008). The Centers for Disease Control and Prevention (CDC) has recognized CWF as one of the greatest public health achievements of the twentieth century (CDC 1999). While systematic reviews of the literature have established the safety and efficacy of water fluoridation, dental fluorosis remains the only adverse outcome reported (McDonagh et al. 2000). A comprehensive review of fluoridation indicates that the benefit of fluoridation was highest for baby teeth (ages 3–5), with 30–60 percent fewer caries, followed by 15–35 percent fewer caries for adolescents, and about the same for adults (Newbrun 1989).

To our knowledge, there is no population-based study on the association between dental cleaning during pregnancy and the known protective effect of CWF in reducing the prevalence of preterm birth. Our objective was to examine the association of maternal dental cleaning during pregnancy and exposure to CWF on preterm birth using a population-based survey of women who recently gave birth.

Methods

Study Population

This study used the Massachusetts Pregnancy Risk Assessment Monitoring System (PRAMS) data from 2009 to 2016. PRAMS is a collaborative surveillance project of the Centers for Disease Control and Prevention (CDC) and state health departments. PRAMS provides population-based state-level data on maternal attitudes and experiences before, during, and shortly after pregnancy. PRAMS survey participants were sampled from a frame of eligible birth certificates which included all in-state live births to resident women. Consistent with CDC's protocol, adoptions, surrogates, and multiple-births greater than triplets were excluded from the sampling frame (Shulman et al. 2006). Informed consent was obtained from all participants. To ensure adequate representation of all race/ethnic groups in the study sample, all live births to Black, non-Hispanics, Hispanics, and other, non-Hispanics were oversampled and the data were weighted to provide state population-based estimates. Non-response adjustment factors were incorporated to address the increased likelihood of non-response from certain groups of women, such as those who had < 12 years of education. Additional details about the MA PRAMS protocol has been described elsewhere (MDPH 2010).

The study sample included Massachusetts resident women with a live birth during 2009 through 2016 who responded to the PRAMS survey (N = 11,704) with a weighted response rate of 64.3%. After excluding

multiples (n = 232), missing data for dental cleaning during pregnancy, CWF, and/or gestational age (n = 426), and missing data on selected maternal characteristics relevant to the study (n = 1812), the final study sample was 9234 women with a singleton live birth (Fig. 1).

Measures

The outcome variable was preterm birth, defined as birth prior to 37 weeks completed gestation. This variable was derived from the infant's birth certificate.

The exposure variables were (1) Dental cleaning during pregnancy, which was obtained from the PRAMS survey (Online Appendix 1 lists the PRAMS oral health questions) and was categorized as Yes/No; (2) CWF, which was provided by the Massachusetts Department of Public Health, Office of Oral Health, and was defined as living in a town where fluoride was added to community water supplies, and was categorized as Yes/No. These were then categorized as follows:

- The absence of both dental cleaning during pregnancy and living in CWF (None);
- Dental cleaning during pregnancy only (DC Only);
- CWF only (CWF Only);
- Having received dental cleaning during pregnancy and living in CWF (DC–CWF).

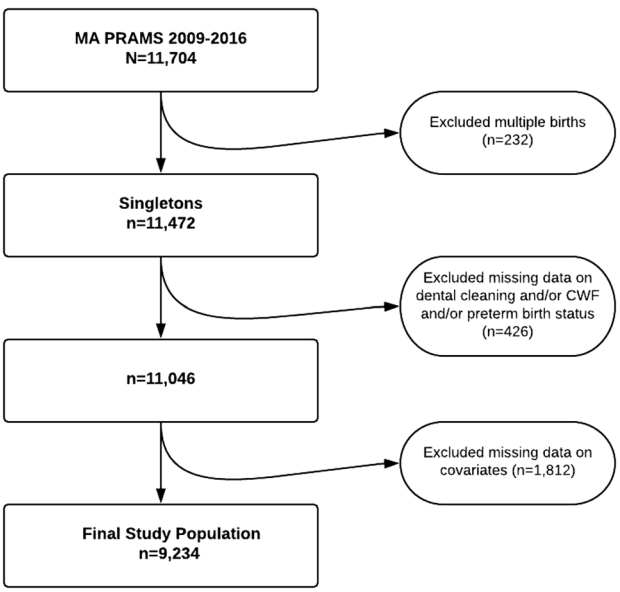

Fig. 1 Flowchart of PRAMS participants and final study population

Covariates

Based on the literature, three categories of covariates were considered: maternal sociodemographic characteristics, previous medical risk factors, and behavioral risk factors. Maternal age (< 20, 20–29, 30–39, or 40+ years), race/ethnicity (White non-Hispanic, Black non-Hispanic, Hispanic, or other non-Hispanic), education (< high school, high school diploma/GED, some college, or completed college), pre-pregnancy diabetes (Yes/No), history of a previous preterm birth (Yes/No), and maternity nativity (US-born/not US-born) were obtained from the birth certificate. Family income based on the annual federal poverty level (FPL) and household size (≤ 100%, 101–200%, or 201% or greater), pre-pregnancy BMI [underweight (< 18.5), normal (18.5–24.9), overweight (25.0–29.9), or obese (30.0 or greater)], and health insurance during pregnancy (pubic, private, other, or none) were all derived from PRAMS.

Analytic Approach

To account for complex survey design, sampling and weighting of PRAMS, this study used SAS 9.4 and SUDAAN 11.0. Chi square statistics were used to compare the prevalence of DC and CWF by maternal race/ethnicity, age, education, FPL, insurance status, pre-pregnancy diabetes, prior preterm birth, nativity and pre-pregnancy BMI, with the outcome of preterm birth. Adjusted risk ratios (aRRs) and 95% confidence intervals (CIs) were calculated for the association of DC, CWF, DC–CWF and preterm birth, controlling for maternal race/ethnicity, age, education, FPL, insurance status, pre-pregnancy diabetes, prior preterm birth, nativity and pre-pregnancy BMI. These covariates were chosen based on either their significant association with both our exposure and outcome (p-value < 0.05), or based on the literature.

Institutional Review Board approval was obtained from Massachusetts Department of Public Health.

Results

The majority of the study population were white, non-Hispanic (66.2%), 30–39 years old (53.6%), had at least a college degree (50.6%), had a household income above 200% FPL (58.6%), were born in the US (72.9%), and had a normal BMI prior to becoming pregnant (54.9%). Overall, 33.3% of women reported having a dental cleaning during pregnancy and living in a community with water fluoridation (DC–CWF); 19.1% reported having a dental cleaning during pregnancy, but living in a community without water fluoridation (DC Only); 30.1% reported living in a community with water fluoridation, but did not have their teeth cleaned during pregnancy (CWF Only); and 17.5% reported

neither having a dental cleaning during pregnancy nor living in a community with water fluoridation (None) (Table 1). Among those who lived in CWF, 58.8% had dental cleaning during pregnancy and among those who did not live in CWF, 58.5% had dental cleaning during pregnancy (data not shown). PRAMS data indicated that one in 12 (8.5%) women who delivered an infant during 2009 through 2016 had a preterm birth (Fig. 2).

Bivariate analyses show significant differences in dental cleaning during pregnancy and CWF by maternal race/

Table 1 Selected characteristics of women with live births by dental cleaning and CWF status in Massachusetts, Pregnancy Risk Assessment Monitoring System, 2009–2016 (N = 9234)

	All (%)	Dental cleaning during pregnancy & community water fluoridation				*P* value
		None n = 1283 (%)	Dental cleaning only n = 1614 (%)	Community water fluoridation only n = 2908 (%)	Dental cleaning and community water fluoridation n = 3429 (%)	
Overall		17.5	19.1	30.1	33.3	
Maternal race/ethnicity						< 0.0001
White, non-Hispanic	66.2	68.7	77.3	53.7	67.6	
Black, non-Hispanic	9.0	11.2	7.1	12.6	6.6	
Hispanic	14.9	14.1	11.6	17.8	15.0	
Other, non-Hispanic	9.9	6.0	4.0	15.8	10.8	
Maternal age (years)						< 0.0001
< 20	3.2	4.8	4.2	3.2	2.0	
20–29	39.1	50.2	39.7	44.9	30.2	
30–39	53.6	41.2	52.6	48.4	62.9	
≥ 40	4.1	3.8	3.5	3.5	5.0	
Maternal education						< 0.0001
< High school	7.3	8.0	5.8	9.4	6.3	
High school diploma	18.9	29.2	17.0	22.3	13.5	
Some college	23.2	30.3	26.7	26.7	16.0	
≥ College graduate	50.6	32.6	50.4	41.5	64.2	
Federal poverty level						< 0.0001
≤ 100%	24.2	34.6	20.1	29.5	18.5	
101–200%	17.2	24.4	17.0	21.5	11.5	
≥ 201%	58.6	41.1	62.9	48.9	70.0	
Health insurance during pregnancy						< 0.0001
Public	36.8	52.4	31.4	46.8	26.5	
Private	60.8	44.7	66.6	50.1	71.4	
Other	2.1	2.5	1.6	2.8	1.6	
None	0.4	0.5	0.4	0.4	0.4	
Medical risk factors						
Pre-pregnancy diabetes						0.2691
Yes	0.9	0.8	1.0	1.3	0.7	
Previous preterm birth						0.0583
Yes	1.2	2.4	1.3	0.8	1.0	
Maternal nativity						< 0.0001
U.S. born	72.9	77.7	82.9	62.6	72.6	
Pre-pregnancy BMI						< 0.0001
Underweight (< 18.5)	3.3	3.3	3.3	3.5	3.1	
Normal (18.5–24.9)	54.9	45.1	54.0	53.8	60.0	
Overweight (25.0–29.9)	23.7	24.7	25.8	23.9	22.0	
Obese (≥ 30)	18.2	27.0	16.9	18.8	14.9	
Preterm birth (< 37 weeks)						0.0078
Yes	8.5	11.5	7.7	9.0	7.4	

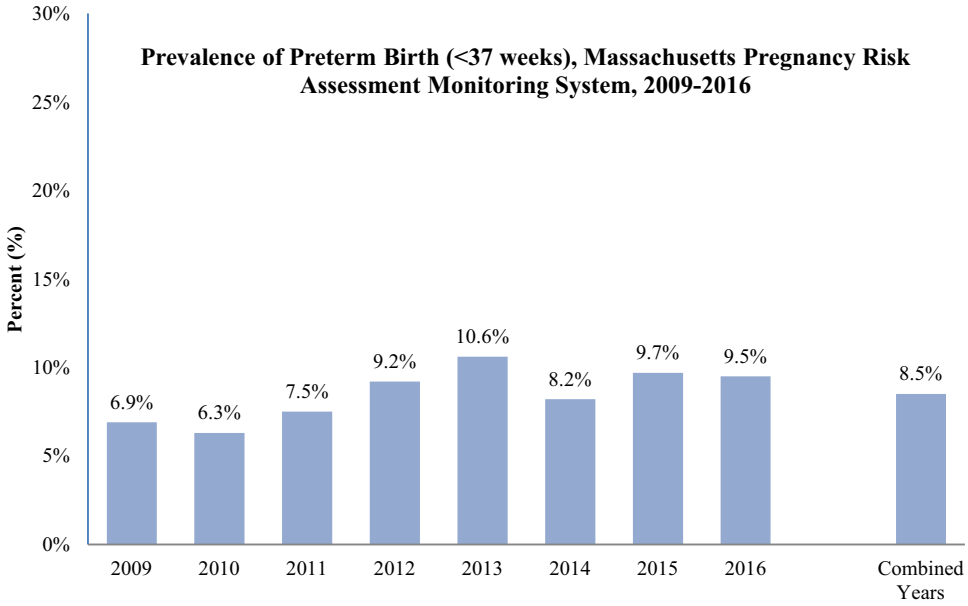

Fig. 2 Prevalence of preterm birth (< 37 weeks), Massachusetts Pregnancy Risk Assessment Monitoring System, 2009–2016

ethnicity, age, education, FPL, insurance status, nativity and pre-pregnancy BMI (Table 1). Black, non-Hispanic women were less likely to have the combination of DC–CWF compared with other race/ethnic groups. Women under 30, without a college degree, or below 201% FPL were less likely to have DC–CWF compared with women in other age/education/FPL groups. Women with private insurance were more likely to have both dental cleaning during pregnancy and/or live in a town with CWF compared with women who had public insurance. Preterm birth was also associated with maternal race/ethnicity, age, education, FPL, insurance status, pre-pregnancy diabetes, prior preterm birth, nativity and pre-pregnancy BMI (Table 2).

Among the 9234 women in our analytic model, after adjusting for maternal race/ethnicity, age, education, FPL, insurance status, pre-pregnancy diabetes, prior preterm birth, nativity, and pre-pregnancy BMI, women in the DC group alone and women in the DC-CWF group were 26% less likely to have a preterm birth than women in the reference group (none) [aRR 0.74, 95% CI (0.55–0.98), aRR 0.74, 95% CI (0.57–0.95), respectively]. Women aged 30–39, and 40 and above, were more likely to have a preterm birth [aRR 1.45, 95% CI (1.17–1.80), aRR 2.43, 95% CI (1.71–3.45), respectively]. Compared with those who had a college degree, women with less than a high school education [aRR 1.65, 95% CI (1.13–2.42)], high school diploma [aRR 1.58, 95% CI (1.14–2.19)], or some college [aRR 1.70, 95% CI (1.32–2.20)] were more likely to have a preterm birth. Women with a previous preterm birth [aRR 2.88, 95% CI (1.91–4.34)], those with pre-pregnancy diabetes [aRR 2.13, 95% CI (1.25–3.62)], and women who were overweight [aRR 1.47, 95% CI (1.19–1.81)], were more likely to have a preterm birth (Table 3).

Discussion

In this population-based study, we found that women with DC alone and DC–CWF have significantly lower prevalence of preterm birth compared with women who had neither DC nor CWF after controlling for confounders. While previous studies found (1) optimal levels of naturally-occurring fluoride in water supplies improved dental health (Pollick 2004); and (2) CWF also protected women from adverse birth outcomes in the US (Allukian and Horowitz 2002), our findings suggest that the combination of DC and CWF was associated with a lower prevalence of preterm birth, not CWF only. The protective effects of DC and DC–CWF on preterm birth are also supported by other studies, which examine the association between periodontal disease and preterm birth. Consistent with the findings that CWF has been shown to lessen the burden of oral health disease (Silk et al. 2008; McDonagh et al. 2000), and the findings that dental cleaning reduces periodontal disease, which has been shown to be associated with preterm birth, our study provides evidence that DC and DC–CWF are protective against preterm birth by reducing periodontal disease.

Our study has several strengths. PRAMS is a population-based survey, with an averaged Massachusetts response rate > 64%, strengthening the generalizability of our findings to all women delivering a live birth in Massachusetts. We were able to account for relevant confounders of preterm birth and DC–CWF, strengthening the internal validity of this study. While the reference group (without DC and without CWF) group had a slightly higher prevalence of prior preterm birth (2.4%) compared to the DC only group (1.3%) and DC–CWF group (1.0%), our multivariate analysis showed that the protective effect of DC and DC–CWF

Table 2 Selected characteristics of women with live births by preterm birth status in Massachusetts, Pregnancy Risk Assessment Monitoring System, 2009–2016 (N = 9234)

	Outcome: preterm birth (< 37 weeks)		
	No n = 8358 (%)	Yes n = 876 (%)	*P* value
Dental cleaning and community water fluoridation			
None	14.6	20.5	0.0078
Dental cleaning only	21.5	19.3	
Community water fluoridation only	26.1	27.7	
Dental cleaning and community water fluoridation	37.9	32.6	
Maternal race/ethnicity			< 0.0001
White, non-Hispanic	66.8	59.3	
Black, non-Hispanic	8.7	12.1	
Hispanic	14.5	18.7	
Other, non-Hispanic	10.0	9.8	
Maternal age (years)			0.0139
< 20	3.1	4.1	
20–29	39.4	35.4	
30–39	53.6	53.3	
≥ 40	3.8	7.2	
Maternal education			< 0.0001
< High school	7.0	9.7	
High school diploma	18.6	22.8	
Some college	22.6	29.8	
≥ College graduate	51.8	37.6	
Federal poverty level			0.0002
≤ 100%	23.5	31.2	
101–200%	17.1	18.8	
≥ 201%	59.4	50.1	
Health insurance during pregnancy			0.0010
Public	36.0	45.1	
Private	61.5	52.7	
Other	2.1	1.6	
None	0.4	0.6	
Medical risk factors			
Pre-pregnancy diabetes			0.0140
Yes	0.8	2.4	
Previous preterm births			0.0005
Yes	1.0	4.1	
Maternal nativity			0.0442
U.S. born	73.3	69.5	
Pre-pregnancy BMI			< 0.0001
Underweight (< 18.5)	3.2	3.7	
Normal (18.5–24.9)	55.9	44.0	
Overweight (25.0–29.9)	23.1	30.3	
Obese (≥ 30)	17.8	22.0	

remained statistically significant after controlling for prior preterm birth. This study also provides a replicable framework for other PRAMS states to examine associations between DC–CWF and birth outcomes to improve maternal and child health.

Our study also has some limitations. While previous meta-analysis has shown a possible association between periodontal infection and preterm birth (Xiong et al. 2007), to our knowledge there is little evidence to show improvement in birth outcomes after perinatal treatment for periodontal disease (ACOG 2013). Among women who reported that they had a dental cleaning during pregnancy, it is unknown if additional dental services were provided, or for what reason(s). Additionally, as PRAMS surveys women 2–4 months postpartum, recall bias could lead to reporting of inaccurate information on dental cleanings. However, previous studies have shown that self-reported oral health measures show good agreement with clinical reports, suggesting that recall bias for dental cleanings may not significantly affect our study (Genco et al. 2007; Taylor and Borgnakke 2007). Sensitive analysis indicated bias of missing data for DC would yield a slightly wider 95% CI for DC–CWF [aRR 0.77, 95% CI (0.61–0.97)]; however, the protective effect of DC would be attenuated [aRR 0.79, 95% CI (0.61–1.03)].

While we adjusted for maternal sociodemographic characteristics, previous medical risk factors, and behavioral risk factors related to the exposure and the outcome of this study, it is still plausible that there remain underlying, unknown differences in women who received dental cleaning and/or resided in CWF. Low prevalence of pre-pregnancy diabetes did not permit us to examine the interaction between maternal race/ethnicity and pre-pregnancy diabetes. Additionally, information on urban versus rural residency, and information on women's length of residency in CWF were unavailable. Comprehensive oral health care which includes dental cleaning prior to pregnancy may further improve infant outcomes by reducing periodontal inflammation before conception. However, data on dental cleaning prior to pregnancy were not available.

In 2014, 70.4% of Massachusetts residents lived in CWF (CDC 2014) and our study showed a lower prevalence of Massachusetts women with a live birth resided in CWF (63.6%), thus pregnant women were less likely to reside in CWF compared to the general Massachusetts population during this study period. Policy makers, healthcare providers and public health advocates can help to raise the awareness of the health benefits of fluoridation in community water supplies and encourage all women to receive dental cleaning during pregnancy. For those women living in non-CWF areas, dental cleaning during pregnancy is especially important since our study showed the DC alone group also had lower risk of preterm birth than women without DC. This finding was consistent with ADA's suggestion of dental

Table 3 Association of dental cleaning during pregnancy, CWF and preterm birth in Massachusetts, Pregnancy Risk Assessment Monitoring System, 2009–2016 (N = 9234)

	Preterm birth (< 37 weeks)	
	Crude RR (95% CI)	Adjusted RR (95% CI)
Dental cleaning during pregnancy and community water fluoridation		
None	Ref.	Ref.
Dental cleaning only	0.67 (0.50–0.89)**	0.74 (0.55–0.98)*
Community water fluoridation only	0.78 (0.61–1.00)	0.81 (0.63–1.05)
Dental cleaning and community water fluoridation	0.64 (0.50–0.82)**	0.74 (0.57–0.95)*
Maternal race/ethnicity		
White, non-Hispanic	Ref.	Ref.
Black, non-Hispanic	1.51 (1.25–1.81)**	1.16 (0.92–1.48)
Hispanic	1.40 (1.17–1.69)**	1.14 (0.88–1.47)
Other, non-Hispanic	1.10 (0.89–1.36)	1.13 (0.88–1.46)
Maternal age (years)		
< 20	1.42 (0.91–2.20)	1.30 (0.81–2.07)
20–29	Ref.	Ref.
30–39	1.10 (0.91–1.33)	1.45 (1.17–1.80)**
≥ 40	1.95 (1.39–2.72)**	2.43 (1.71–3.45)**
Maternal education		
< High school	1.80 (1.36–2.37)**	1.65 (1.13–2.42)*
High school diploma	1.62 (1.28–2.05)**	1.58 (1.14–2.19)**
Some college	1.73 (1.40–2.12)**	1.70 (1.32–2.20)**
≥ College graduate	Ref.	Ref.
Federal poverty level		
≤ 100%	1.51 (1.25–1.83)**	1.10 (0.78–1.54)
101–200%	1.27 (1.01–1.60)*	0.94 (0.69–1.28)
≥ 201%	Ref.	Ref.
Health insurance during pregnancy		
Public	1.41 (1.19–1.68)**	1.00 (0.75–1.32)
Private	Ref.	Ref.
Other	0.92 (0.47–1.83)	0.79 (0.40–1.56)
None	1.72 (0.85–3.51)	1.19 (0.57–2.50)
Medical risk factors		
Pre-pregnancy diabetes		
No	Ref.	Ref.
Yes	2.63 (1.62–4.27)**	2.13 (1.25–3.62)**
Previous preterm births		
No	Ref.	Ref.
Yes	3.41 (2.32–5.00)**	2.88 (1.91–4.34)**
Maternal nativity		
Non-U.S. born	1.18 (1.01–1.39)*	1.02 (0.82–1.25)
U.S. born	Ref.	Ref.
Pre-pregnancy BMI		
Underweight (< 18.5)	1.41 (0.92–2.17)	1.35 (0.87–2.08)
Normal (18.5–24.9)	Ref.	Ref.
Overweight (25.0–29.9)	1.60 (1.30–1.96)**	1.47 (1.19–1.81)**
Obese (≥ 30)	1.51 (1.22–1.88)**	1.24 (0.99–1.56)

CI confidence interval, *RR* risk ratio, *Ref* reference

*$p < 0.05$; **$p < 0.01$

cleaning during pregnancy (ADA 2013), and could be used as an evidence for policy makers to take actions on improving the awareness of the importance of dental cleaning during pregnancy.

In conclusion, this study found that women who had dental cleaning during pregnancy and lived in a community with water fluoridation had lower prevalence of preterm birth. The findings of this study support the promotion of dental cleanings during pregnancy and CWF for improved birth outcomes and improved women's health.

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