

**ORAL HEALTH BELIEF, BEHAVIOR, AND
BARRIERS TO DENTAL CARE DURING PREGNANCY:
AN ANALYSIS OF THE PREGNANCY RISK ASSESSMENT
MONITORING SYSTEM, FROM 2012 TO 2015**

by

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ABSTRACT

Demographic, socioeconomic, and behavioral factors were shown to be associated with oral health status and dental service utilization during pregnancy. Perceived oral health beliefs can be important factors that affect dental service utilization based on Health Belief Model. This study was a retrospective cross-sectional study on the Pregnancy Risk Assessment Monitoring System (PRAMS) datasets on 75,029 women with a recent single live birth, who represented more than 4.5 million women ages 20 and older between 2012 to 2015. About half of the women (51.8%) reported that they had at least one dental visit for cleaning during their most recent pregnancy. More than nine out of ten women responded that they perceived the importance of oral health during pregnancy (90.6%). When adjusted for mother's age, marital status, medical insurance type, mother's education, previous live birth, and prenatal visit scores, non-Hispanic black women had 15% lower odds in visiting a dentist for cleaning during pregnancy compared to non-Hispanic white women. Interaction analysis showed that the black-white disparity gap in dental visits during pregnancy became wider when women perceived barriers in accessing dental care during pregnancy with a lack of self-reported dental coverage. Non-Hispanic black women had 70% higher odds in perceiving difficulty in finding dental providers than other racial/ethnic groups. Women enrolled in Medicaid had more than 2.5 times greater odds in difficulty in finding dentists who accepted pregnant patients compared to women covered by private health insurance. Women without state Medicaid dental coverage for cleaning were significantly less likely to visit a dentist during pregnancy compared to women with limited dental coverage, and women with comprehensive dental coverage. Women with perceived oral health benefits had 21% lower odds of preterm birth compared to women who responded that they did not perceive the importance of oral health during pregnancy. Disparities in dental service utilization were evident in minorities,

especially in non-Hispanic black women and women enrolled in Medicaid. With mounting evidence of disparities in dental care during pregnancy, oral health programs that address specific barriers that pregnant women may perceive are necessary.

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Dedication

This thesis is dedicated to my 5-year-old son, *Gungjung*, for graciously sharing his mother with her study since when he was one.

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CHAPTER 1

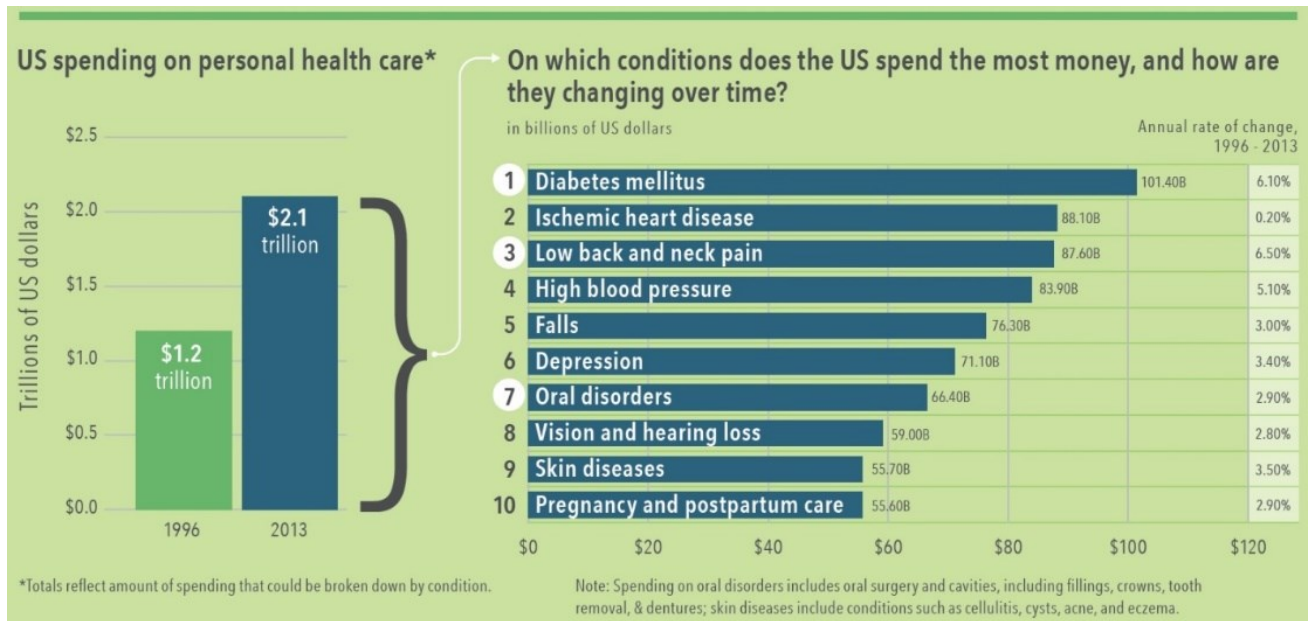
INTRODUCTION

Oral health affects overall health throughout the lifespan. Dental caries (tooth decay) may affect speech, nutrition, growth and function, and social development (1, 2) as the most common chronic diseases of children and adolescents, and it is four times more common than asthma (3). Another common oral health condition that is more prevalent in the older population is periodontitis. Periodontitis is an oral infection caused by pathogenic bacteria that trigger chronic inflammation and destruct connective tissue (gum) and bones that support the teeth (4). A number of studies showed the association between periodontal disease and multiple chronic conditions such as cardiovascular disease, respiratory disease, and diabetes (4-7).

While these oral-systemic links are evident, oral health is often omitted in primary care discussion due to historical separations between dentistry and medicine from training to care level. Disease in the mouth may not be fatal in most cases, but it is one of the most costly and neglected conditions in the U.S. Oral disorder is listed as one of the top ten conditions that the U.S. spends the most money on. A recent study on U.S. spending on personal health care showed that oral disorder was ranked higher than the total personal health care spending for pregnancy and postpartum care (Fig 1) (8). The Medical Expenditure Panel Survey (MEPS) also showed that after chronic conditions (47%), acute illness (25%), and trauma (8%), dental-related expenditure (7%) was greater than routine preventive health care (6%) and pregnancy/birth-related expenditure (4%) (9). On another note, more than half of (52.5%) of the U.S. Army recruits were not deployable due to urgent dental conditions (10, 11). The oral disorder also affects underserved populations disproportionately. Adults ages 20 to 64 with a family income

below 100 % of the federal poverty level were three times more likely to have untreated dental caries than adults with incomes above 400 % federal poverty level (11).

Figure 1. U.S. spending on personal health care (8, 12)



As a pediatric dentist as well as a mother of a young child, I am puzzled and often feel I have not done my job when I see otherwise healthy three- and four-year-old boys and girls ending up in extensive dental treatments under general anesthesia. Early childhood caries is defined as the presence of one or more decayed, missing (due to caries), or filled tooth surfaces in any primary tooth in a child under the age of six (13). In children younger than three years of age, any sign of smooth-surface caries is indicative of severe early childhood caries (13). If young children cannot cooperate with necessary dental procedures in the office setting, dental rehabilitation under general anesthesia can be the only option for these children to be disease-free. While I wait to see these children wake up from the general anesthesia next to their worried mothers, I ask myself, “How did the healthcare system fail to educate these loving and caring

mothers to stop this from happening?” With this question, it was natural for me to be drawn to an upstream approach in promoting oral health among pregnant women.

Improving oral health and maintaining good oral health during pregnancy are essential for the oral and overall health of expecting mothers and their young children. Untreated dental caries in pregnant women can lead to a higher risk for dental caries in young children by vertically transferring cariogenic bacteria from their mouth to the mouth of their baby (14, 15). Early childhood caries, in turn, may require extensive dental treatment under sedation or even general anesthesia if a young child cannot cooperate with necessary dental procedures at the chair-side. Previous research on the maternal population also showed a positive association between the periodontal disease of expecting mothers and adverse birth outcomes, such as pre-eclampsia, low birth weight, and preterm birth. Since the first study in this topic was published in 1996 (16), numerous cross-sectional, case-control, longitudinal studies, and systematic reviews confirmed such positive associations (7, 16-32). Mother’s oral health knowledge and belief may also influence children’s oral health and daily diet and oral hygiene (33). Taken together, pregnancy should be considered as a window of opportunity to secure the oral health of women at the childbearing age as well as the oral health of their young children.

In 2012, I was serving at the U.S. Department of Health and Human Services (HHS) as a public health officer and participated in the publication of the National Consensus: Oral Health During Pregnancy (34). This national guideline, published by federal public health agencies and national professional organizations in dentistry and medicine, clearly indicates that preventive, diagnostic, and restorative dental treatments are safe throughout pregnancy and effective in improving and maintaining oral health (34-36). However, the chasm between scientific evidence and practice remains significant. A study on the Centers for Disease Control and Prevention

(CDC)'s Pregnancy Risk Assessment Monitoring System (PRAMS) databases between 2004 and 2006 showed that only 40% of women responded that they had at least one dental visit for teeth cleaning during pregnancy (30). This low dental service utilization is heightened among women from marginalized backgrounds. The same study showed that non-Hispanic black women (24%) and Hispanic women (25%) were significantly less likely to have their teeth cleaned by dental providers during pregnancy than non-Hispanic white women (44%) (37). The National Health and Nutrition Examination Survey (NHANES) data between 1999 and 2004 also found that 58.3% of pregnant women had a dental visit in the previous year, and less than two-thirds of the women (61.4%) said it was for the preventive dental visit, such as dental cleaning (38). Although the most recent data showed a moderately improved utilization of dental service (33% to 59%), almost half of the women still did not, or could not, access dental care during pregnancy with evident disparities by race/ethnicity and income levels (39-42).

Demographic, socioeconomic, psychological, and behavioral factors were shown to be associated with oral health status and dental service utilization during pregnancy (43). Pregnant women who were less educated, from low-income families on public health insurance, or from a racial or ethnic minority group were less likely to report good oral health and were more likely to have a higher prevalence of untreated dental caries and periodontitis (37, 38, 44-47). These marginalized women were also less likely to access oral health care during pregnancy as compared to women who had higher income, private health insurance, or identified as non-Hispanic White women (37-42, 44-47). Perceived of oral health benefits and perceived barriers in accessing oral health care during pregnancy may also be important factors that affect dental service utilization. A lack of knowledge regarding the value of oral health during pregnancy, fear and safety concerns on oral health care during pregnancy, inconvenient access to dental

service during pregnancy, and availability of prenatal oral health counseling may affect care-seeking behaviors (43, 48).

In this study, I examined the relationship between race/ethnicity of pregnant women and prenatal dental service utilization based on a nationally represented database, CDC's PRAMS survey and its responses from 36 states and New York City (NYC) between 2012 to 2015. I aimed to understand the effects of socio-demographic factors as well as women's perceived oral health beliefs on dental utilization during pregnancy. In addition, I examined the associations of preterm birth outcomes with dental variables based on the biological link between poor oral health during pregnancy and preterm birth (7, 16-31). Preterm birth, defined by delivery of an infant prior to 37 weeks gestation, has complex associations with demographic, socioeconomic, psychological, and behavioral factors. In previous studies, the association between dental service utilization during pregnancy and preterm birth was studied when the model was controlled for other socioeconomic variables. In the current study, I examined how oral health beliefs and dental service utilization were associated with preterm birth outcomes. Lastly, I performed a separate analysis on a subset of women enrolled in Medicaid and analyzed the relationship between state Medicaid dental coverage policy and dental service utilization and oral health beliefs during pregnancy. Previous research focused on dental service utilization during pregnancy and how it was associated with health outcomes based on claim and clinical data. My dissertation proposes a broader study model, which includes oral health perception and behavior reported by pregnant women through a nationally representative patient-reported outcome dataset, PRAMS. I expect that the outcome of my thesis study provides a perspective for the low dental service utilization among pregnant women and calls for future prenatal programs and policy development to address specific barriers perceived by women at childbearing age.

CHAPTER 2

LITERATURE REVIEW

The following Medical Subject Headings (MeSH) terms were used to create the search scheme on PubMed and Embase: “pregnancy/pregnant,” “oral health,” “dental,” and “periodontal.” 1,507 articles published in English between Jan 2009 and October 2019 were identified and reviewed for relevance to the proposed study (Fig 2).

Figure 2. Boolean Logic

```
((("pregnancy"[MeSH Terms] OR ("pregnancy"[Title/Abstract] OR "pregnant"[Title/Abstract])) AND ("oral health"[MeSH Terms] OR ("dental"[Title/Abstract] OR "periodontal"[Title/Abstract]))) AND ("2009/01/01"[PDAT] : "3000"[PDAT]) AND English[lang]
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Dental caries during pregnancy

Foods and beverages high in carbohydrates can cause cariogenic bacteria to produce acidic by-products (49). The acidic by-product can breakdown the outer layer of the tooth, which is called demineralization (49). About 82.1% of adults age between 20 and 34 and 93.6% of adults age 35 and 49 had caries experience, which included both untreated dental caries and any treated caries (50). One in three adults (27%) age between 20 and 49 had untreated caries, and the rate of untreated caries was greater for adults from racial/ethnic minorities, highest in non-Hispanic black adults (42%) (50).

Reducing the number of cariogenic bacteria in pregnant mothers through good oral health

could delay or prevent the onset of colonization of these bacteria in their infants, which reduce the early childhood caries risk (51). Cariogenic bacteria, mainly *mutans streptococci* (MS), was found to be vertically transmitted from a mother's mouth to the mouth of her baby during common parenting behavior, such as sharing spoons and licking pacifier (14, 15, 52). Pregnancy may increase the risk for dental caries due to increased acidity in the mouth from morning sickness or gastroesophageal reflux and higher intake of sugary snacks from craving (15, 33). While dental caries was found not to increase the risk of adverse birth outcomes (53), dental caries in pregnant women can negatively affect baby's oral health.

The risk of caries in young children increased when mothers of young children have untreated dental caries and a greater number of cariogenic bacteria (14, 15, 33, 54-56). NHANES and a related birth certificate-linked data for 1,184 mother-child dyads showed that children (age 2 to 6) of mothers who had high levels of untreated caries were more than three times as likely to have higher levels of caries experience (treated or untreated dental caries) compared with children whose mothers had no untreated caries (odds ratio [OR]=3.5, 95 % CI [2.0-6.2]) (54). In another study, untreated maternal caries itself doubled the odds of child's untreated caries and significantly increased child's caries severity by about three surfaces when controlled for other demographic factors (56). Higher maternal salivary content of MS also doubled the child caries compared to mother with a low level of MS, adjusting for socio-demographics, feeding and care practices, and maternal dental status (cumulative incidence ratio=1.9, 95% CI [1.1, 3.8]) (55).

This vertical transmission of cariogenic bacteria occurred as early as when the baby had no teeth yet (14, 57). The earlier transmission of these cariogenic bacteria increased the caries risk among young children (58-60). A longitudinal study found that children who showed caries

by 30 months were more likely to be MS colonized by 18 months ($p < 0.001$) compared to those who developed caries at 36 months (58). In another study, the mean decayed, missing, and filled primary tooth surface (dmfs) scores at age 4 in the children who acquired MS during the first two years of life was 10.6, whereas in children in whom colonization occurred later had the mean dmfs score of 3.4 at age 4 ($p < .005$) (60).

Mother's oral health knowledge and belief can also significantly affect diet and home oral hygiene practice for young children (61-69). Data from 1,021 low-income African-American families in Detroit with at least one child who was five or younger showed that maternal oral health-related self-efficacy was a strong and significant predictor of children's brushing frequency (69). Children of mothers who received oral health education, dental referral, and dental evaluation had significant clinical outcomes, such as less dental caries ($p = 0.019$), fewer extractions ($p < 0.021$), and number of teeth with caries at 2–3 years of age ($p < 0.001$) compared with children of mothers who did not participate in such interventions (61). Another study in rural Oregon also showed a significant reduction in the mean number of teeth with dental caries when the mother was given face-to-face oral health education along with dental referral (62). A community-based public health program in Oregon provided low-income pregnant women home visits or counseling sessions through the Women, Infant, and Children (WIC) program and assigned them a dental home under a dental managed care program. Through the program, more than half of the eligible pregnant women received dental care during pregnancy, which was far exceeding the dental service utilization rate among poor women in other counties. This intervention reduced child dental caries and resulted in children being up to 1.5 times more likely to be caries-free (62).

A systemic review of oral health educational studies showed a positive impact of oral

health education during pregnancy in preventing early childhood caries (65). While oral health education during pregnancy was critical to empower expecting mothers to bring their baby to his/her first dental visit and create a dental home, mother's parenting practice change, including low-cariogenic dietary practice for her baby, could significantly improve oral health outcomes of children (66). In addition, children with mothers who had a regular source of dental care were more likely to receive dental care (70). However, this educational effect was not sustainable in multiple studies (61, 63, 64, 71). Reinforcement through referral or follow up visit reminders after delivery were suggested to sustain improved oral health outcomes (66). A longitudinal study which followed from pregnancy to teen children showed that early oral health care promotion starting during pregnancy with periodic follow-up visit and oral health education could achieve a sustained and long-term improvement of the oral health of children (67, 68).

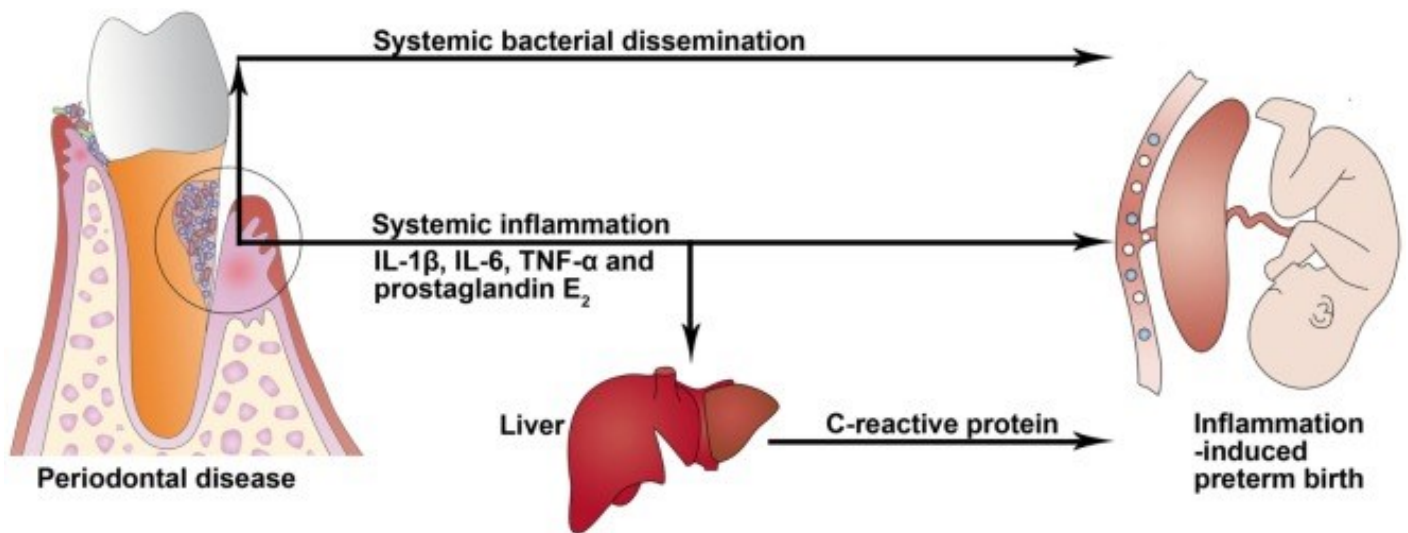
Periodontitis during Pregnancy

Pregnant women often experience periodontal symptoms due to increased sex hormones, which may lead to increased vascular permeability and gingival fluid (15, 33, 72, 73). The recent systematic review confirmed that gingival inflammation was significantly increased throughout pregnancy when comparing pregnant versus post-partum or non-pregnant women, without a concomitant increase in plaque levels (72). Plaque score, gingival inflammation, and probing depth were found to be increased during pregnancy but reduced after delivery (73). With all these changes during pregnancy, the oral health-related quality of life of pregnant women was lower than that of non-pregnant women (74, 75).

Previous research on the maternal population has shown a positive association between the periodontal disease of expecting mothers and adverse birth outcomes, such as pre-eclampsia,

low birth weight, and preterm birth (7, 16-32). When uncontrolled and untreated, periodontitis can induce systematic inflammation responses that may lead to premature rupture of membranes and myometrial contraction (7, 32, 76) (Fig 3). Another biological pathway suggested that periodontal bacteria may cross the placental barrier and directly increase intra-amniotic inflammation and vascular damage that lead to adverse birth outcomes, including preterm birth (7, 24, 30, 32).

Figure 3. Potential biological mechanisms linking periodontal disease to preterm birth (77)



The preterm birth is defined as the delivery of an infant prior to 37 weeks gestation. The preterm birth rate rose from 2017 (9.9%) to 2018 (10.0%) (78), and about one in ten infants are born prematurely in the U.S. In most cases, prematurely born babies grow up healthy without major health issues. However, it is possible that preterm birth can lead to a severe medical condition with life-long disabilities and psychological distress to families. The associated cost for preterm birth is estimated to be as high as \$26 billion annually, including \$5.7 billion in lost household and labor market productivity associated with those disabilities

(79, 80). Maternal age (both young and advanced at conception), low-socioeconomic status, a history of smoking, substance abuse, obstetrical history, diabetes, and hypertension are common risk factors for preterm birth (80-84). Race and ethnicity are also strongly associated with preterm birth; African-American women have a higher risk of preterm birth than other racial groups (78, 85, 86). Nationally, the proportion of women who had preterm birth among African-American women was 13.2% in 2014, while 8.9% of non-Hispanic white women experienced preterm birth in the same year (85). In the most recent data for 2018, preterm rates increased across racial/ethnic groups (78). The proportion of non-Hispanic black women who had preterm birth increased to 14.1%, but the increase in preterm births to non-Hispanic white mothers (9.1%) was not significant (78).

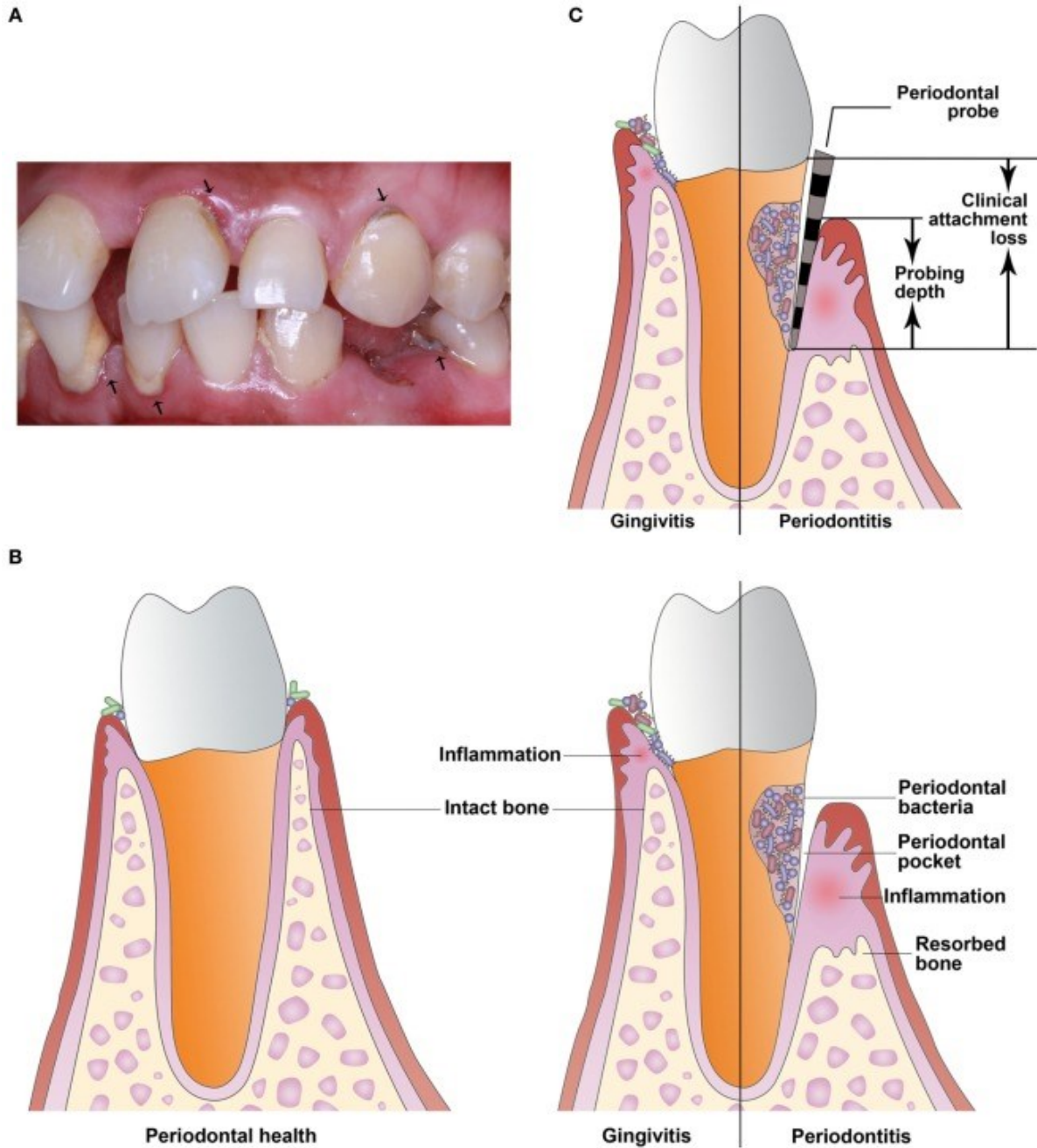
Enrollment in Medicaid, which covers nearly half of all births in the U.S., is itself an independent predictor of preterm delivery (87-92). Medicaid beneficiaries share common characteristics, such as low family income and inadequate health literacy, among other risk factors. These factors, in turn, impact their access to and utilization of primary and prenatal health services as well as birth outcomes (87-92). The proportion of Medicaid-enrolled pregnant women who received more than 80 percent of the expected number of prenatal visits ranged from 1 to 85 percent with considerable geographic variation across states (93, 94). Most mothers whose births were covered by Medicaid were between ages 20 and 34 (79.3%), and more than half of Medicaid-covered births were among non-Hispanic white women (95). The majority of Medicaid-financed births occurred in urban areas (84.3%) (95). While mothers enrolled in Medicaid in rural areas were mostly non-Hispanic white and young (under 20), a greater proportion of women enrolled in Medicaid were Hispanic and non-Hispanic black in urban areas (95).

The majority of epidemiological studies, including cross-sectional, case-control, and longitudinal studies, have revealed positive associations between poor periodontal status and adverse birth outcomes, and these associations were confirmed in systematic review studies (7, 19, 20, 24, 25, 28, 31). The first study on periodontitis and preterm birth identified maternal periodontitis as a significant risk factor for preterm birth among 124 pregnant women (16). Periodontitis progression during pregnancy and severe periodontal disease at delivery were found to be associated with pre-eclampsia and preterm birth in longitudinal studies (18, 27). In a systematic review for the selected studies included a total of 10,215 women, pregnant mothers with periodontitis doubled the risk of preterm birth (OR=2.01, 95% CI [1.71-2.36]) (31). A systematic overview of 23 systematic reviews studying the association between periodontal disease and adverse pregnancy outcomes also indicated a positive association between periodontitis and adverse birth outcomes (28). Consistent evidence from systematic reviews with low risk of bias showed that pregnant women with periodontal disease were at increased risk of pre-eclampsia and preterm birth (RR=1.6, 95% CI [1.3-2.0]; 17 studies, 6,741 participants) (28). This systemic overview of systemic reviews and meta-analysis studies estimated population-attributable fractions for periodontal disease ranged between 5% to 38% for preterm birth (28). The study had limitations, however, as several primary studies did not adjust for confounding factors. Other systemic review and meta-analysis on 22 studies found a low but existing association between periodontitis and preterm birth (RR= 1.71, $p < 0.001$) (20). A meta-analysis on 17 case-control studies, which accounted for a total of 10,148 pregnant women, also found a positive association between periodontitis and preterm birth (OR = 1.78, 95% CI [1.58, 2.01]) (19).

On the other hand, a number of studies showed no association between periodontitis and

adverse birth outcomes. After controlling for confounding factors, periodontitis was not shown as a risk factor for preterm low birth weight infants (96). In another case-control study, periodontitis did not show an association with low birth weight (OR = 1.00; 95% CI = 0.61-1.68), after adjustment for confounders, including age, pre-gestational body mass index, number of prenatal consultations, number of pregnancies, maternal schooling level, smoking habit during pregnancy, and hypertension (97). An umbrella review study, which included 19 systematic reviews and meta-analyses showed that the magnitude and statistical significance of the relationship between periodontitis and adverse birth outcomes were influenced by the context in which the studies have been conducted. The definition of periodontal disease and disease improvement (Fig 4), criteria of gestational age for study purposes, and potential confounders could influence the association between periodontitis and adverse outcomes (98). In addition, preterm birth and other adverse birth outcomes had complex associations with socio-demographic characteristics, behavioral factors, and the presence of important confounders, whose effect cannot be addressed. This complexity may prevent validation of the meta-analysis outcomes (19, 25).

Figure 4. Periodontal disease is a highly prevalent infectious and inflammatory disease of tooth-supporting tissues (77)



(A) The arrowheads indicate periodontal disease. (B) Periodontal disease includes gingivitis and periodontitis. Gingivitis is the presence of gingival inflammation without loss of connective tissue attachment. Periodontitis is the presence of gingival inflammation at sites where there has been apical migration of the epithelial attachment onto the root surfaces accompanied by the loss of connective tissue and alveolar bone. (C) Clinical attachment loss is measured with a periodontal probe and is the distance from the base of the probable crevice to the cemento-enamel junction. Probing depth is defined as the distance between the bottom of the periodontal pocket and the gingival margin (77)

A comprehensive meta-analysis on periodontal disease and adverse outcomes, which included both English and non-English publication, discussed the methodology and the overall quality of the studies, all of which could affect the study outcomes (24, 25). The meta-analysis of case-control studies, which used categorical definitions of periodontal status, showed a strong association between periodontal disease during pregnancy and preterm birth (24). However, pooled data from case-control studies, which used continuous periodontal measures of probing depth and gingival bleeding, showed no association between gingival attachment loss and preterm birth. A meta-analysis of data from prospective studies had mixed results (24). The type of the periodontal examination, the timing of the examination concerning gestational age, the involvement of examiners who were blinded to the outcome, and other confounders could affect the quality of study and the strength of association (24, 25). In fact, this systemic review found more than 50 continuous parameters, and 14 different definitions of periodontal cases have been used in these studies included in the review (24). A clinical study on 932 women showed that the definitions of periodontitis with different levels of clinical attachment and probing depth impacted the frequency of periodontitis, ranged from 12.1% to 37.7%. This variability also produced different odd ratios for the associations with risk factors for periodontitis (99).

Despite this inconsistency in the literature findings, the majority of multiple systematic reviews and meta-analysis concluded that periodontitis is an independent factor for adverse birth outcomes, consistent with proposed biological pathways (7, 24). There is a clear need for future research in this field with an agreed and standardized definition of disease, treatment, and health outcome definitions.

Periodontal treatment during pregnancy

Most studies have shown periodontitis as an independent risk factor for preterm birth, but outcomes from randomized controlled trials on a treatment for periodontitis and improved birth outcomes were mixed and inconsistent. Small-scale, single-center studies reported improvement of birth outcomes in association with periodontal treatment during pregnancy, whereas large-scale multi-center studies failed to show such association (7, 32). An early randomized controlled study showed that periodontal treatment during pregnancy reduced the risk of preterm low birth weight (100). Other trials involving a single study site with defined sub-population showed a positive effect of periodontal treatment in preventing adverse birth outcomes, such as preterm birth and low birth weight (101-104). In these studies, periodontal treatment was more effective among pregnant women with less severe periodontal disease (102-105). It could be easier for a mild periodontal condition to improve with non-surgical therapy during pregnancy and possibly led to an improved birth outcome (32). Systemic reviews and meta-analysis of randomized controlled trials also indicated a significant effect of non-surgical periodontal treatment during pregnancy in reducing preterm birth outcomes (106-108). A meta-analysis on 20 randomized controlled studies found periodontal treatment during pregnancy was associated with significantly decreased risk of perinatal mortality and preterm birth when the preterm birth was defined as birth prior to 37 gestational weeks (107). However, periodontal treatment had no significant impact on preterm birth earlier than 35 gestational weeks (107).

A study based on patient-reported PRAMS survey data on 35,367 women with recent birth history examined the association between dental service utilization during pregnancy and preterm birth outcomes (44). When compared to women who delivered full-term infants, women who delivered prematurely (< 37 weeks) were less likely to receive dental care during pregnancy

and were less likely to receive teeth cleaning before and during pregnancy. However, there was no difference between the two groups of mothers in terms of having a tooth problem during pregnancy, receiving dental counseling, or teeth cleaning prior to pregnancy (44). When adjusted for age, income, education, insurance status before pregnancy, adequacy of prenatal care, smoking, multiple gestations, maternal morbidities, including diabetes, hypertension, placental problems, and kidney/bladder infection, there was a significantly higher risk for delivering a preterm infant among mothers who did not receive dental cleaning during pregnancy compared to mothers who received dental cleaning during pregnancy (OR=1.23, 95% CI [1.08,1.41]) (44). In addition to a multivariate analysis model, the study examined the relative contributions of each variable to preterm birth (44). The most significant contributors to the risk of preterm birth were multiple gestations and adequacy of prenatal care visits. Teeth cleaning during pregnancy contributed 8.3% of the risk to preterm birth, which was greater than placental problems or high blood pressure. In contrast, the contribution from any dental care (including both preventive or and non-preventive dental care) during pregnancy was minimal (44).

The landmark Maternal Oral Therapy to Reduce Obstetric Risk Study was a randomized, treatment-masked, controlled clinical trial implemented in three sites (Alabama, North Carolina, and Texas) with 1,760 pregnant women to examine the association between periodontal treatment and birth outcomes (109). These women presented periodontal disease and were receiving standard obstetric care. Pregnant women received periodontal treatment either during the second trimester or after delivery. The study found no statistically significant differences when comparing women in the treatment group (13.5%) with those in the control group (11.5%) concerning the adverse birth outcomes (109). There was also a significant interaction effect between study sites. When probing-depth measures were used, periodontal status was

significantly improved in the treatment group only in the Texas study site ($p < 0.001$). When the gingiva attachment level and bleeding on probing measures were considered outcome measures, there was no center interaction effect. Both measures showed significantly improved periodontal outcomes in the treatment group compared with the control group ($p = 0.005$ and $p < 0.001$, respectively). However, the study concluded that the study failed to arrest disease progression between baseline and delivery. The periodontal disease progressed among patients in both the treatment (30.5%) and control groups (40.7%), and only a proportion of the treatment group achieved what would be considered periodontal health (109).

A lack of significant difference between the incidence of preterm birth in the control group and the periodontal treatment group of pregnant women was found in another randomized controlled trial (110). This study, however, showed a significant relationship between successful periodontal treatment and full-term birth (OR = 6.02, 95% CI [2.57-14.03]) when controlled for ethnicity, maternal age, smoking, and alcohol consumption (110). The success of periodontal treatment was determined by a blinded clinical exam, 20 weeks after initial therapy. The resolution of gingival inflammation and the lack of progression of attachment loss or periodontal probing pocket depth were definitions of successful periodontal treatment. On the other hand, unsuccessful treatment was defined with increased gingival inflammation or increased probing pocket depth or attachment loss in at least five sites. Another major randomized controlled trial showed no effect of periodontal treatment on adverse birth outcomes (111). However, this study showed a positive treatment effect when the study was re-analyzed later to correct potential bias for fetal survival between intervention and control groups (29).

Through systematic and narrative reviews, the synthesis of randomized controlled trials concluded that non-surgical treatment of periodontitis during pregnancy did not result in

decreased rates of adverse birth outcomes (25). A meta-analysis on 13 randomized controlled trials also showed no association between periodontal treatment during pregnancy and preterm birth outcomes (112). Other systematic reviews and meta-analysis supported that treatment of periodontal disease could not be considered to be an efficient way of reducing the incidence of preterm birth (105, 113-116).

In summary, findings from randomized controlled trials testing the effects of periodontal therapy on systemic health outcomes were conflicting and inconsistent (7). These could be due to heterogeneity of case definitions of periodontal disease and successful outcomes of periodontal treatment across studies, other confounding factors, selection of study participants, and timing, frequency, and success of the periodontal intervention (7, 25, 33, 116). The recent Cochrane review also concluded that there was a lack of evidence that periodontal treatment improves preterm birth outcomes (117). This conclusion should not be interpreted that periodontitis is unrelated to preterm birth (25, 117). The level of access and utilization of periodontal treatment may not directly impact health outcomes, possibly due to ineffective intervention, inappropriate timing of intervention, or irreversible damage from existing periodontitis (25). Also, it is not only treatment delivered at a dental facility but also daily oral hygiene practice, which improves periodontal status.

While the association between periodontal treatment and the improved birth outcome has been inconclusive, the value of oral health education and non-surgical periodontal therapy during pregnancy was proven with improved oral health. This was demonstrated by decreased gingival inflammation and generalized improvement of periodontal health (33, 110, 111, 118). Intensive oral hygiene regimen during pregnancy, which included multiple dental cleaning and oral hygiene instruction, could decrease gingivitis effectively in pregnant women measured by

plaque and gingival index scores (118). Decreased level of inflammatory factors, such as TNF-alpha and Interleukin-1-Beta, was also observed in gingival crevicular fluid among pregnant women who received non-surgical periodontal treatment during pregnancy (119). Recognizing the value of oral health during pregnancy, the American College of Obstetricians and Gynecologists states that ‘women should routinely be counseled about the maintenance of good oral health habits throughout their lives as well as the safety and importance of oral health care during pregnancy, and should refer for dental care as would be the practice with referrals to any medical specialists’ (15).

Dental service utilization needs and disparities during pregnancy

The need for dental care during pregnancy is evident (120). A study on pregnant women living in the state of Oklahoma showed that dental care was the most commonly self-reported needs (50.1%), followed by nutrition assistance (48.0%) and breastfeeding (30.0%). However, only 38.2% of pregnant women who cited dental needs actually received dental service during pregnancy (121). A survey of mothers with infants ages 6 to 12 months-old on unmet needs showed that dental needs (11 %) were close to the need for housing (13 %) and childcare (11%) (122). A lack of dental service utilization was found to be related to poorer oral health, measured by greater bleeding on probing, higher plaque index score, and greater untreated dental caries during pregnancy, as mentioned earlier (123).

While there was a clear need for dental care during pregnancy, a nationally representative sample of PRAMS data from 2004 and 2006 found that more than half of women with recent birth history (56%) did not or could not seek dental care during pregnancy (37). Only 39.7% of women in the same study reported they had a dental cleaning, the most basic form of non-emergency

routine dental care, during the most recent pregnancy (37). This remarkably low dental service utilization rate has improved over the years, but still, about half of the pregnant women across the nation did not receive dental care during pregnancy. On the other hand, the Behavioral Risk Factor Surveillance System (BRFSS) during a similar time period showed that 70% of pregnant women received dental care in the previous 12 months (124). In a study based on the NHANES (1999-2004), 58.3% of pregnant women age 15-44 had a dental visit in the previous year (38). Different survey methods and study designs may account for these differences. For example, dental service utilization in the NHANES study was higher than the PRAMS study because NHANES asked about 'dental visit in the past year' for pregnant women while PRAMS asked for 'dental visit during pregnancy.' Responders for the NHANES survey may not have been pregnant when they visited the dentist in the previous year (38). BRFSS collected responses via a home telephone survey, which may not have reached people without a home or home phone (125). Other studies reported a range of 56% to 74% of pregnant women who did not have dental visits during pregnancy (43, 46, 126).

Demographic, socioeconomic, psychological, and behavioral factors were shown to be associated with dental service utilization during pregnancy (43). Pregnant women who were from low-income families, on public health insurance (e.g., Medicaid), less educated, or from a racial or ethnic minority were less likely to report good oral health and more likely to have a higher prevalence of untreated dental caries and periodontitis (37, 38, 44-47). These marginalized women were also less likely to access oral health care during pregnancy than women from higher-income families, privately insured, or non-Hispanic white women (37-42, 44-47).

NHANES data from 1999 to 2004 showed that non-Hispanic black and Mexican

American women, women with low incomes, and women with less than a high school education were less likely to report having very good or good mouth and teeth condition (38). Significantly higher percentages of non-Hispanic white pregnant women (77.1%), pregnant women with family income at or more than 200% of the FPL (77.0%), and pregnant women with more than high school education (81.1%) reported having very good or good mouth and teeth condition than did those in other racial/ethnic groups, those with incomes less than 100% of the FPL (51.7%), and with low education levels (51.7%) (all with $p < 0.001$) (38). The percentage of women who reported having very good or good mouth and teeth condition was significantly higher among older pregnant women (ages 35–44 years, 85.8%) than among younger pregnant women (15–24 years, 57.2%) (38). However, the pattern of this self-reported oral health condition was the opposite for non-pregnant women, where non-pregnant women age 15 to 24 had a higher percentage of women (75.3%) who reported good oral condition compared to an older group of non-pregnant women age 35-44 (67.0%).

Among pregnant women, significantly higher percentages of non-Hispanic whites (71.1%) and those with more than high school education (68.6%) reported having a dental visit in the previous year compared with other racial/ethnic groups of women and women with fewer years in education (all with $p < 0.001$) (38). A higher percentage of pregnant women with family income greater than 200% of the federal poverty level reported having a dental visit in the previous year (66.2%) compared with those with family income less than 100% federal poverty level (40.6%, $p < 0.001$). Also, a higher percentage of pregnant women with family income greater than 200% of the federal poverty level reported having preventive care as the main reason for their last dental visit (70.1%) than did those with family income less than 100% of the federal poverty level (41.4%, $p < 0.001$).

The same researcher group analyzed the study cohort to examine the prevalence of dental caries and periodontal disease among pregnant and non-pregnant women of reproductive age from 15 to 44 (120). There were no statistically significant differences between pregnant women and non-pregnant women in the prevalence of untreated dental caries and periodontal disease when the study sample was from all levels of income and education level. However, the significant differences in dental caries and periodontal disease were found when stratified by socio-demographic characteristics. Younger pregnant women (age 15 to 24) had a greater prevalence of untreated dental caries (41%) compared to non-pregnant women in the same age group (24 %) (120). Racial/ethnic minorities and women with a lower level of education and family income had a higher prevalence of untreated dental caries and periodontal disease when compared to non-Hispanic whites or women with a higher level of education and family income level (120). The prevalence of untreated dental caries was significantly higher among non-Hispanic black women (45%) and Mexican American (42%) pregnant women than among non-Hispanic white pregnant women (18%). The prevalence of untreated dental caries was also higher among pregnant women with less than high school education (46%) when compared to pregnant women with more than a high school education (17%). Lastly, the prevalence of untreated dental caries was significantly higher among pregnant women with family income <100 percent of the federal poverty level (53%) than pregnant women with family income \geq 200 percent of the federal poverty level (16%).

There was a clear racial/ethnic disparity for periodontal disease among pregnant women as well. Mexican American pregnant women had a higher prevalence of periodontal disease (9.3%) than non-Hispanic white pregnant women (2.0%). Notably, the prevalence of the periodontal disease among non-pregnant non-Hispanic black women was significantly higher

(10.9%) than among pregnant non-Hispanic black women (2.2 %), which was the opposite of the general understanding periodontal health, which worsened during pregnancy (120), but the study did not discuss in depth for potential causes of this reversed relationship.

Another nationally representative survey research on PRAMS data (2004-2006) examined the association between dental service utilization and oral health counseling during pregnancy (37). The dataset included survey responses from mothers who have recently delivered a live infant with three oral health-related questions. (Fig 5) (37). Other socio-demographic variables considered in this study were the age of mother at delivery (<20, 20-34, >34), race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic), maternal education measured in completed years of school (0-8, 9-11, 12, 13-15, 16 and more), annual household income (<\$10,000, \$10,000-19,999, \$20,000-34,999, \$35,000-\$49,999, and >\$50,000), health insurance status before pregnancy (private, Medicaid, uninsured), smoking history, and Kotelchuck prenatal service utilization score (37).

Figure 5. PRAMS oral health questions (37).

1. This question is about the care of your teeth during your most recent pregnancy. For each item, circle Y (Yes) if it is true or circle N (no) if it is not true
 - a. I needed to see a dentist for a problem
 - b. I went to dentist or dental clinic
 - c. A dental or other health care worker talked with me about how to care of my teeth and gums
2. Have you ever had your teeth cleaned by a dentist or dental hygienist?
3. When did you have your teeth cleaned by a dentist or dental hygienist? For each of the three time periods, circle Y (Yes) if you had your teeth cleaned then or circle N (No) if you did not have your teeth cleaned then
 - a. Before my most recent pregnancy
 - b. During my most recent pregnancy
 - c. After my most recent pregnancy

Less than half of women reported that they received any dental counseling during pregnancy (41.0%) and received dental cleaning during pregnancy (39.7%) (37). One in four women (26.4 %) responded that they had dental problems during pregnancy. Evident racial/ethnic disparities were observed in this PRAMS analysis. Non-Hispanic black had a greater proportion of women who reported dental problems during pregnancy (34.1%) compared to non-Hispanic white women (25.0%) or Hispanic women (26.6%). About two out of five women responded that they had dental cleaning visit during pregnancy (39.7%), and there was significantly less proportion of women who went to a dentist for cleaning among non-Hispanic black women (24.1%) and Hispanic women (24.5%), compared to non-Hispanic white women (43.7%). Hispanic women were less likely to receive dental counseling during pregnancy (31.9%) compared to non-Hispanic white women (41.9%) and non-Hispanic black women (40.6%). This could be rooted in the language barrier.

When controlled for age, income, education, insurance status before pregnancy adequacy of prenatal care, and smoking, non-Hispanic black women had significantly higher odds of having dental problems compared to non-Hispanic white women (OR = 1.19, 95% CI [1.05-1.35]). Both non-Hispanic black and Hispanic women were significantly less likely to obtain dental care before as well as during pregnancy (37). Compared to the non-Hispanic white women, non-Hispanic black women were less likely to have dental cleaning before pregnancy (OR=0.82, 95% CI [0.72-0.94]), and during pregnancy (OR=0.68, 95% CI [0.59-0.78]) when adjusted for other confounders listed above. For Hispanic women, a similar pattern of dental service utilization for cleaning was observed when compared to non-Hispanic white women before pregnancy (OR=0.60, 95% CI [0.50-0.72]) and during pregnancy (OR=0.74, 95% CI [0.61-0.90]).

This study also assessed unmet dental needs during pregnancy (37). Among women who

reported dental problems during pregnancy, almost half (44%) of women did not or could not seek dental care. When the dental problem was included in the multivariate analysis, there was a slight change, but the direction of association remains. The study concluded that non-Hispanic black and Hispanic women were significantly less likely to obtain dental care during pregnancy than non-Hispanic white women after adjusting for demographic, socioeconomic, and behavior (measured by prenatal service utilization) variables. These findings were consistent with other national studies (125, 127). This PRAMS study discussed multiple social and medical stressors experience by minority women as potential reasons for the persistent racial/ethnic disparities in prenatal dental care (37).

This pattern of racial/ethnic disparities in dental service utilization during pregnancy was observed state-level PRAMS studies (128, 129). A PRAMS study in Maryland found that less than half of women reported they visited a dentist during their pregnancy at least once (48 %), and less than half of women reported that a dentist or other health care worker talked to them about how to take care of their teeth and gums (48 %) (128). One in four women (25.5%) reported a need to see a dentist for a problem during pregnancy, and 33% of them did not receive dental care during pregnancy despite their need, depicting a clear ‘unmet dental need’ (128). The study’s multivariate model showed that racial/ethnic minorities, unmarried status, fewer years in education (12 years or less in school), and low annual income (<\$40,000) were all associated with lower odds in visiting dentist during pregnancy (128). Notably, women enrolled in the WIC program were more likely to visit a dentist than women who were not insured and not enroll in the WIC program (OR=1.62, 95% CI [1.16-2.26]) after adjusting for mother’s race/ethnicity, marital status, annual household income, insurance prior to pregnancy, WIC enrollment, and dental problem during pregnancy. A multivariate logistic regression model

demonstrated that women who were not married (OR=2.46, 95% CI [1.39-4.37]) and women who did not receive prenatal care as early as they desired (OR=1.89, 95% CI [1.23-2.76]) were more likely to have an unmet dental need than the respective reference groups after adjusting for other factors (128). Women with an annual household income lower than \$40,000 were also more likely to have an unmet dental need during pregnancy than women with an annual income of >\$40,000 after adjusting for other factors (128). A PRAMS study conducted in West Virginia examined the factors associated with pre-pregnancy preventive dental care (129). The study found about 47% of participants in the study population visited a dentist for 12 months before pregnancy. Non-Hispanic white women and women with more than a high-school education and women with private insurance were more likely to receive dental cleaning than women less than high school education and racial/ethnic minorities.

In a study with 99 pregnant women enrolled in the CenteringPregnancy® group-based prenatal care model, Hispanic women, compared to non-Hispanic white women, had poorer periodontal and caries status (123). Lower levels of income and fewer years in school were also associated with poorer oral health status. However, disparities based on having had a dental visit in the past six months were more significant for all oral health measures than those by income and education (123). This study used cluster analysis to examine the mediating effect of dental service utilization on oral health outcomes, considering various socio-demographic variables highly interrelated (123). There were significant indirect effects of racial/ethnic differences on oral health outcomes via having a recent dental visit (OR range 1.2–1.9). The study observed a higher indirect effect among Hispanic women with a higher median income (\$19,000) and higher education level (12 years or more) compared to Hispanic women with a lower median income (\$12,000) and fewer years of education (12 or less) (123). Significant differences in oral

health between non-Hispanic white and Hispanic women remained between the groups (123). This may suggest that the utilization of care may have a stronger influence on oral health than socio-demographic variables.

A qualitative study examined pregnant women's behavior and attitude to understand why women from minority and low-income backgrounds did not or could not seek dental care during pregnancy (130). Investigators found that various stressors in accessing dental care during pregnancy, such as limited time and financial resources to come for a dental visit, stressors related to pregnancy itself, anxiety associated with dental treatment, and long waiting times in the dentist's office (130). Another study also found that dental service utilization could still be low even with insurance coverage if pregnant women already had other children to take care of (131). Misunderstandings of oral health, lack of oral health knowledge (and lack of oral health education), fear and safety concerns on oral health care during pregnancy, low priority given to dental care, and negative past dental experience can all affect dental care-seeking behavior during pregnancy (48, 132-134). Finally, lack of dental insurance, perceived financial barriers, difficulty in finding a dentist, and long waiting times can also be barriers to dental care during pregnancy (133). Their perceived attitude of dental providers and office staff toward pregnant women was also a factor that could prevent pregnant women from seeking dental care (37, 130). Provider's decision to accept pregnant patients or pregnant patients with public health insurance such as Medicaid was also a critical factor (37, 130). These perceived benefits for oral health and perceived barriers to a dental visit during pregnancy can play important roles in improving oral health among pregnant women.

Pregnant women's perception and attitude toward dental care during pregnancy can change with interventions and the availability of accessible dental service (43, 48). By

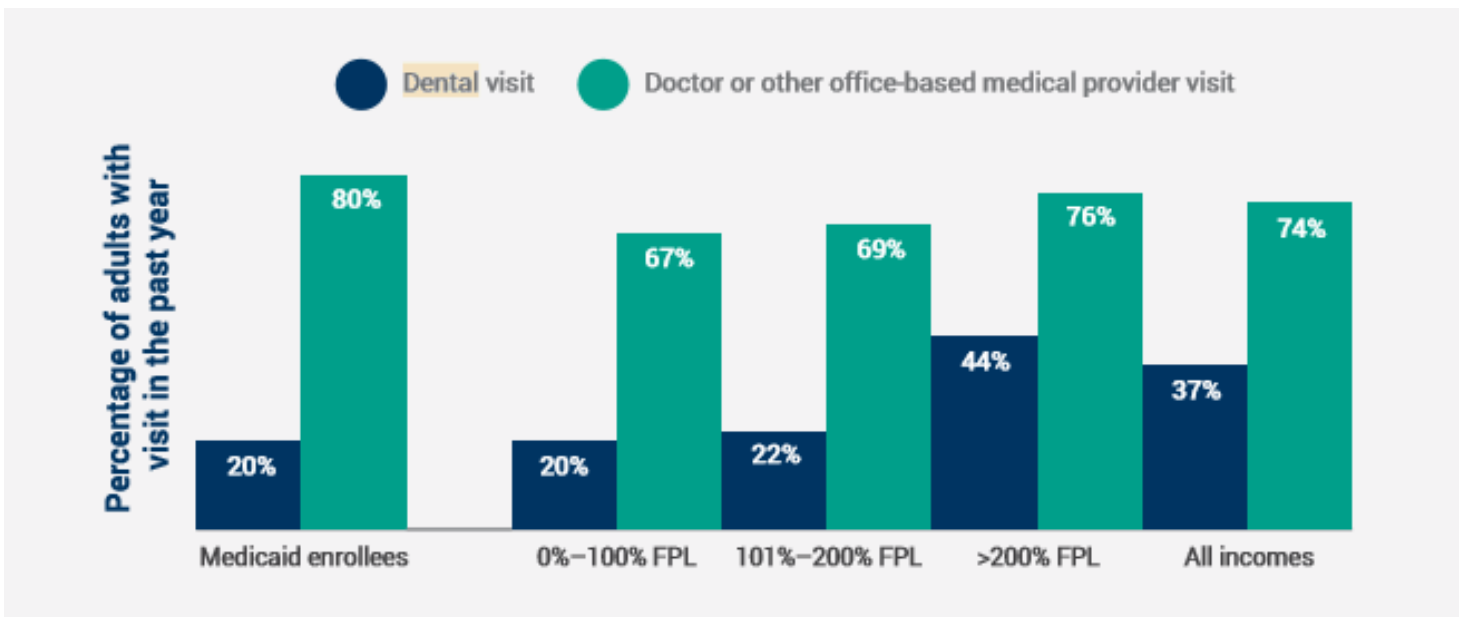
addressing misunderstandings or lack of knowledge, pregnant women who received oral health education, dental supplies, and were scheduled for a dental appointment demonstrated a significant increase in the frequency of brushing and flossing their teeth. This study also showed a marked reduction in the intake of high sugar drinks and reported more than twice as many visits for a dental check-up among women in the intervention group compared to the control group (135). Pregnant women who visited a dentist during pregnancy provided a greater perceived benefit of oral health for themselves and their children, and they were able to overcome fear and discomfort to access the service (130).

Medicaid and dental coverage

Previous research showed that dental service utilization increased when such services were covered by insurance (11, 136). Pregnant women enrolled in Medicaid were shown to face even higher barriers in accessing dental care due to inconsistent dental coverage through the state Medicaid. Medicaid provided health care coverage for pregnant women with family income at or below 133% federal poverty level, and the income eligibility has increased to 138% with the Affordable Care Act in 2014 (33). More than half of the states provided Medicaid coverage to pregnant women with incomes up to 200% of the federal poverty level (33). However, this expansion did not guarantee expanded or even basic dental coverage for adults, including pregnant women enrolled in Medicaid. Unlike Medicaid for children under age 21, which provided comprehensive dental coverage as a part of essential health benefits, dental care has been an optional service for Medicaid-enrolled adults, including pregnant women. The Medicaid and CHIP Payment and Access Commission (MACPAC) and its analysis on 2012 Medical Expenditure Panel Survey (MEPS) showed that 20% of adult Medicaid enrollees age 21 and older

reported a dental visit within the past year while 80% of them reported a visit to any other type of office-based medical provider during the same time period (11, 87). This office-based medical provider visit rate was 13% higher among adults in the Medicaid enrollee than adults with a family income at or below 100% federal poverty level regardless of coverage status. In contrast, the dental visit rate of adult Medicaid enrollees was as low as adults with a family income at or below 100% federal poverty level regardless of health coverage (11) (Fig 6).

Figure 6. Percentage of adults age 21 and older who had a dental visit versus doctor or other office-based medical provider visit in past year, 2012 (11)



Notes: FPL is the federal poverty level. This chart shows utilization for adults beginning at age 21 because the Early and Periodic Screening, Diagnostic, and Treatment (EPSDT) benefit requires coverage of dental services for 19- and 20-year-old Medicaid enrollees. The Medicaid enrollees category includes adults regardless of income level and reflects those with at least one month of Medicaid coverage. (Estimates for enrollees with full-year coverage may differ.) Income groups included all adults regardless of coverage status.

Source: MACPAC Analysis AHRQ 2012

Efforts to increase dental service utilization during pregnancy

There has been multiple studies and program implemented to increase dental service utilization during pregnancy. Interventions include co-location of prenatal and medical facilities, reminders for a dental check-up, and referral to dentists. In a multi-centered randomized controlled trial with pregnant women found that only the intervention group who were provided with oral health education and direct dental care service arrangement showed a substantial improvement in the use of dental service during pregnancy (87.2%) compared to control group who had only oral health education (20.2%) or another intervention group (oral health education and dental referral, 28.3%) (137). A systematic review of a variety of approaches to increase dental service utilization during pregnancy found mixed or no significant intervention effect. These interventions included mailing reminder postcards, coordination with prenatal care visits, and community health advisors (138). Future research needs to test out interventions and incentives that are based on behavioral theory and evidence, such as monetary incentives, gifts, and invitations for free oral health services, to improve dental service utilization during pregnancy (139).

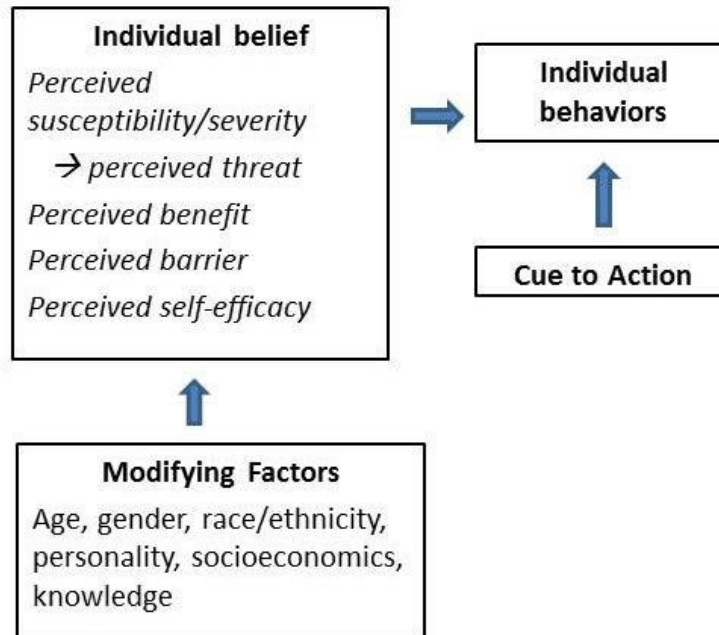
Health Behavioral Model (140)

Based on this comprehensive review of oral health and dental service utilization among pregnant women and its disparities, I hypothesized that women's oral health beliefs would affect or modify the association between socio-demographic variables and dental service utilization during pregnancy. Therefore, I examined the relationships among various socio-demographic variables, oral health beliefs, dental service utilization, and preterm birth as health outcomes based on the Health Belief Model (HBM) (140). HBM is one of the most widely used

conceptual frameworks in health behavior research and interventions (140). HBM was developed by social psychologists in the U.S. Public Health Service to explain why people fail to participate in preventive and screening health services (140, 141). It is based on the value-expectancy theory that behavior is a function of the subjective value of avoiding illnesses and expectation that a particular action may prevent illnesses and associated pain (140). The original HBM model has four constituents of individual belief, modifying factor, cue to action, and individual behavior (Fig 7) (140). However, the primary trigger to the behavior change is the person's beliefs regarding the perceived benefits of the various available actions to reduce the fear.

On the other hand, the potential negative aspects of health-related behavior are called perceived barriers (140). Perceived barriers may include a lack of knowledge, negative emotions related to a particular health behavior or action, and financial consequences. Research showed that perceived barrier is the most powerful predictor for individual behaviors (142). Perceived self-efficacy is a conviction that one can successfully execute the behavior required to produce the outcomes (140, 143).

Figure 7. Original conceptual model: Health Belief Model (140).



HBM has been used for prenatal education on different topics. A randomized controlled trial showed an increase in physical activity during pregnancy when these women received health education based on HBM. (144). In this model, health education included individual goal development based on perceived threats, barriers, benefits, and cues to action (144). HBM-based oral health education models that aimed to change attitudes and beliefs on oral health have been successfully implemented among pregnant women and improved the level of mother's perceived oral health beliefs (145-147). In these educational programs, the facts and graphics of oral diseases and their impact on the fetus were presented to address perceived threats. The advantages of adopting oral hygiene practice addressed the perceived benefit aspect of the model. High costs of dental services and any barriers in accessing dental care were discussed as perceived barriers, and perceived fear and questions about the safety of oral health care during pregnancy were also discussed (145, 146).

Interprofessional Approach

It is also critical for both dental and non-dental primary care providers, who take care of women of child-bearing age to coordinate care and emphasize the importance of oral health during pregnancy (148). However, a recent qualitative study in Maryland on provider's attitude and awareness of dental care during pregnancy found that most obstetric residents and certified nurse-midwives were unaware of the importance of and need for prenatal dental care (149). These prenatal providers reported that they did not receive adequate training in prenatal oral; therefore, they did not discuss dental care with pregnant patients routinely. Another survey was conducted among 240 obstetrics and gynecology residency program directors with a response rate of 40% (150). In the survey, only 39 % of the obstetrics and gynecology residency programs reported that they taught prenatal oral health to their residents.

The lack of awareness of prenatal oral health existed not only among primary care providers for women but also among dentists. In a review of the last ten years' publications on dentists' knowledge of oral health during pregnancy, dentists showed doubts and fears about dental care for pregnant patients (151). Dentists, who were more knowledgeable about periodontal disease, were more likely to counsel pregnant patients (152). This suggested a great need to improve dentists' knowledge and best practices to serve pregnant women to improve and maintain optimal oral health during and after pregnancy (151). The interprofessional oral health workforce is the key to integrating oral health into prenatal care strategies (153, 154). Beyond a mere referral, primary care providers for pregnant patients, including prenatal care and home visiting nurses, and dental providers should collaborate closely from health education to care coordination to advance the oral health of pregnant women and new mothers.

Advancing oral health through generations

While pregnancy is a unique time in a woman's lifespan to experience changes in oral health, it is also a window of opportunity to make positive changes in her oral health as well as the baby's oral health. A longitudinal study followed up pregnant women up to 18 months after delivery and found that both in-person health education with and without the motivational interview technique was effective in bringing a young child to a dentist (155), which was a significant step in creating 'dental home' (156). Through this education, pregnant women had an opportunity to learn about infant oral health care practices, including toothbrushing, fluoridated toothpaste, and not using a bottle during naptime (155). However, there is still a need for more theory- and evidence-based interventions focusing not only on infant oral health but also prenatal oral health with rigorous study design (157). A recent systematic review on oral health promotion interventions during pregnancy found that most interventions focused on infant oral health care, and there was a significant gap in translating scientific evidence and national prenatal oral health guidelines to pregnant women through oral health promotion (157).

CHAPTER 3

METHODS

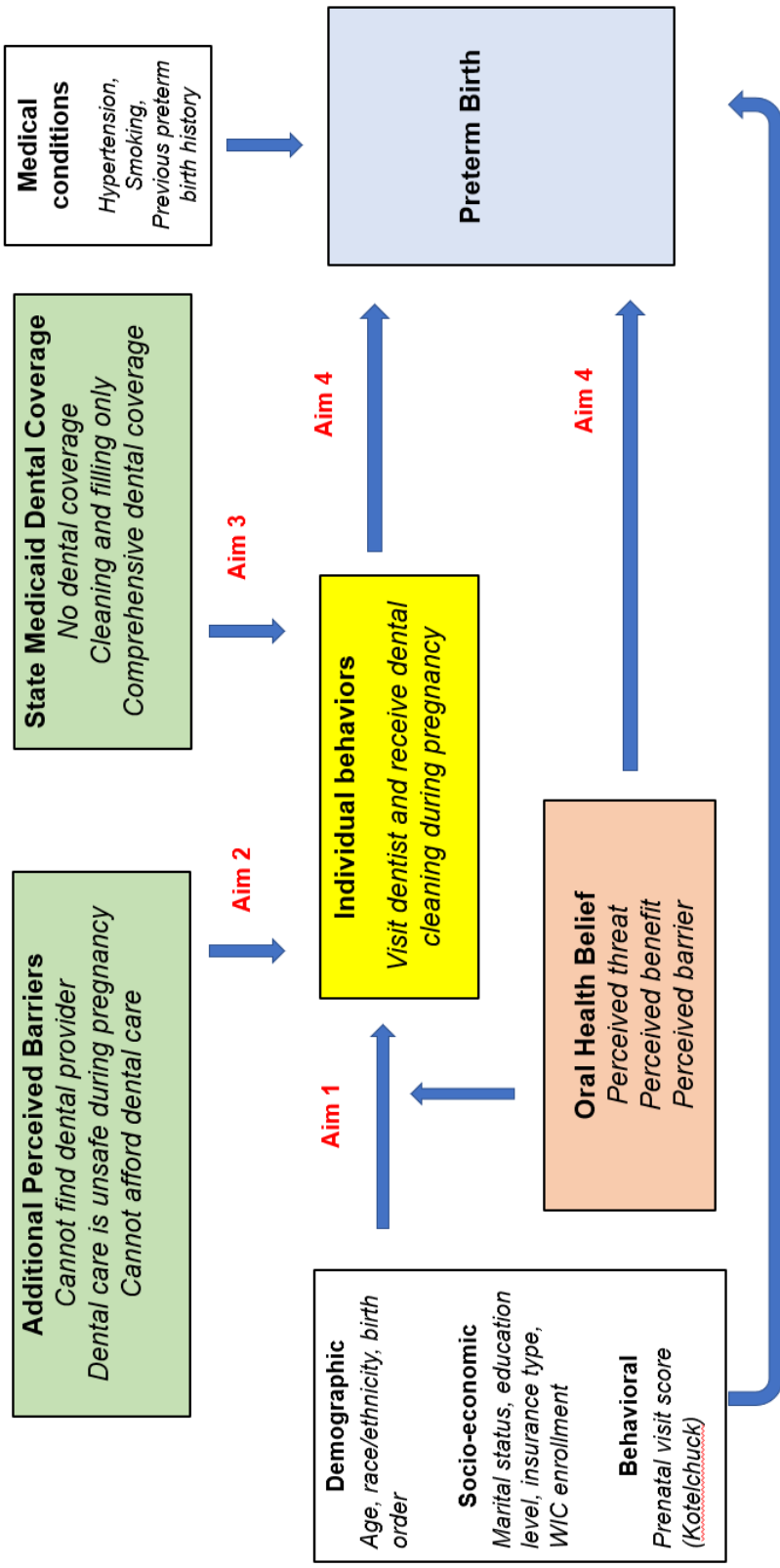
In this proposed study, I aimed to examine the relationships between oral health beliefs and dental service utilization during pregnancy, using the CDC's PRAMS dataset from 2012 to 2015. Accounting for various demographic variables and social determinants of health that may be associated with dental service utilization, I examined the association of oral health beliefs with dental service utilization across race/ethnicity and different insurance types. In previous studies, dental visits during pregnancy were examined as a dependent variable to study the racial/ethnic disparities in accessing dental care or to measure the success of an oral health education program.. In this study, I incorporated subject-reported oral health belief variables (perceived benefits, perceived barriers, and perceived threats) based on HBM (155). I examined how oral health beliefs were associated with dental service utilization during pregnancy across racial/ethnic groups and insurance types. In a subpopulation of women from states that implemented an additional oral health question, the associations of additional perceived barriers with dental service utilization during pregnancy were examined. Secondly, based on the association between poor oral health and adverse outcomes, I examined the relationship between oral health beliefs and preterm birth outcomes using the same dataset. I expect that this study outcome may shed light on the role of oral health beliefs during pregnancy and its association with preterm birth. Lastly, I cross-walked CDC's PRAMS database, and the Medicaid-SCHIP State Dental Association (MSDA)'s national profiles, including state-level Medicaid dental coverage policy for pregnant women enrolled in Medicaid. I was able to find each women's Medicaid dental coverage based on PRAMS' state data and MSDA's state profile for the same year. I examined

how various levels of Medicaid dental coverage were associated with dental service utilization during pregnancy. This information may be critical in designing Medicaid dental coverage and future prenatal oral health program, which can address specific barriers in accessing dental care among Medicaid-enrolled pregnant women. With these proposed ideas, I came up with four research questions and a conceptual model (Fig 8).

Specific aims

- Aim 1. Examine how oral health beliefs are associated with dental service utilization during pregnancy
 - ✓ Aim 1.1 Examine how oral health beliefs are associated with dental service utilization during pregnancy across racial/ethnic groups
 - ✓ Aim 1.2 Examine how oral health beliefs are associated with dental service during pregnancy by insurance types (Medicaid vs. private insurance).
- Aim 2. Examine the association of additional perceived barriers related to provider availability, safety concerns, and affordability of dental care with dental service utilization during pregnancy.
- Aim 3: Examine the association of various levels of Medicaid dental coverage with dental service utilization during pregnancy among women enrolled in Medicaid.
- Aim 4. Examine the association of preterm birth outcomes with oral health beliefs and dental service utilization during pregnancy, considering other socio-demographic-behavioral and medical conditions.

Figure 8. Conceptual Model



Data

Data

PRAMS (158)

The PRAMS data for this study was from 2012 to 2015 (Phase 7), which was the most recent multi-year dataset available. PRAMS, a surveillance project of CDC and state health departments for women who have had a recent birth history, collects state-specific, population-based data on maternal attitudes and experiences before, during, and shortly after pregnancy (158). The database covers about 83% of all U.S. births (158).

Each participating state draws a stratified systematic sample of 100 to 250 new mothers every month from a frame of eligible birth certificates, which leads up to samples between 1,300 and 3,400 women per year. This is enough size for estimating statewide risk factor proportions within 3.5% at 95% confidence. Most states oversample low weight births, and many states stratify samples by mother's race or ethnicity as well. Each state PRAMS office sends out the series of the mailing 2 to 4 months after delivery. Telephone follow-up begins after the mailing of the last questionnaire. The calling period for a batch runs 2 to 3 weeks, and up to 15 call attempts are made to reach a mother. This individual-level data is linked with the mother's birth certificate. The standardized data collection methodology was prescribed in detail in the CDC Model Surveillance Protocol (159, 160).

The minimum overall response rate threshold changed from 60% in 2012 to 55% in 2015 during this phase. Due to this response threshold policy, the number of states with data available varied by year of surveillance (Table 1). In this analysis, the core PRAMS questions were answered by 36 states and New York City (NYC) as a separate regional entity (AK, AL, AR,

CO, CT, DE, GA, HI, IA, IL, LA, MA, MD, ME, MI, MN, MO, NE, NH, NJ, NM, NY, OH, OK, OR, PA, RI, TN, TX, UT, VA, VT, WA, WI, WV, WY, NYC). I included states who met the response rate at least one year during this phase for the Study Aim 1 and 4 (Table 1). For the additional perceived barriers analysis, I included seven states (GA, MD, MN, MO, NY, RI, VT) that implemented the additional standard oral health question. Lastly, 30 states and NYC were included for Medicaid dental service utilization analysis, which exceeded the minimum response rate in 2014 and 2015. Multiplying together the sampling, non-response, and non-coverage components of the weight yield the analysis weight, and this sampling weight was accounted for the study's analysis plan.

The PRAMS consists of three parts: patient-reported core questionnaire, patient-reported standard questionnaire, and birth certificate. All states ask the core questions participated in the phase, while some states choose to include standard questions. In this analysis, responses from two core oral health questions and one standard oral health question were included in the analysis (Table 2) along with variables from birth certificate data.

Table 1. Availability of PRAMS data in the Phase 7

- Data available for release by CDC
- Data not available for release by CDC*
- Did not participate

Questionnaire Phase	Abbreviation	Phase 7			
Site		2015 [≠]	2014	2013	2012 [†]
Alabama	AL	●	●	○	○
Alaska	AK	●	●	●	●
Arizona	AZ	--	--	--	--
Arkansas	AR	●	○	●	●
Colorado	CO	●	○	●	●
Connecticut	CT	●	●	○	--
Delaware	DE	●	●	●	●
District of Columbia	DC	--	--	--	--
Florida	FL	○	○	○	○
Georgia	GA	○	○	●	●
Hawaii	HI	●	●	●	●
Illinois	IL	●	●	●	●
Indiana	IN	--	--	--	--
Iowa	IA	●	●	●	--
Kansas	KS	--	--	--	--
Kentucky	KY	--	--	--	--
Louisiana	LA	●	○	○	○
Maine	ME	●	●	●	●
Maryland	MD	●	●	●	●
Massachusetts	MA	●	●	●	●
Michigan	MI	●	○	●	●
Minnesota	MN	○	○	●	●
Mississippi	MS	○	○	○	○
Missouri	MO	●	●	●	●
Montana	MT	--	--	--	--
Nebraska	NE	●	●	●	●
Nevada	NV	--	--	--	--
New Hampshire	NH	●	●	●	--
New Jersey	NJ	●	●	●	●
New Mexico	NM	●	●	●	●
New York City	NYC	●	●	●	●
New York State	NY	●	●	●	○
North Carolina	NC	○	○	○	○
North Dakota	ND	--	--	--	--

Ohio	OH	●	●	○	●
Oklahoma	OK	●	●	●	●
Oregon	OR	●	○	●	●
Pennsylvania	PA	●	●	●	●
Rhode Island	RI	○	●	●	●
South Carolina	SC	○	○	○	○
South Dakota	SD	--	--	--	--
Tennessee	TN	●	●	●	●
Texas	TX	●	○	○	○
Utah	UT	●	●	●	●
Vermont	VT	●	●	●	●
Virginia	VA	●	○	○	○
Washington	WA	●	●	●	●
West Virginia	WV	●	●	●	●
Wisconsin	WI	●	●	●	●
Wyoming	WY	●	●	●	●
Puerto Rico	PR	--	--	--	--
Total participating sites		41	41	41	38
Total sites available for release		34	28	31	29
Total sites not available for release		7	13	10	9
Percentage of participating sites with data available		83%	68%	76%	76%

*Data did not meet the response rate threshold for the year and can be released only by the site

≠55% response rate threshold for data release by CDC begins

†60% response rate threshold for data release by CDC begins

§65% response rate threshold for data release by CDC begins

¶70% response rate threshold for data release by CDC begins

Table 2. PRAMS oral health questions: Phase 7 (2012-2015)

	Question	Response	States that used this question item
Core 7	<p>At any time during the <i>12 months before</i> you got pregnant with your new baby, did you do any of the following things? For each item, check No if you did not do it or Yes if you did it.</p> <p>I had my teeth cleaned by a dentist or dental hygienist (dental service utilization)</p>	Yes or No	AK, AL, AR, CO, CT, DE, GA, HI, IA, IL, LA, MA, MD, ME, MI, MN, MO, NE, NH, NJ, NM, NY, OH, OK, OR, PA, RI, TN, TX, UT, VA, VT, WA, WI, WV, WY, NYC
Core 24	<p>This question is about the care of your teeth <i>during your most recent</i> pregnancy. For each item, check No if it is not true or does not apply to you or Yes if it is true.</p> <p>a. I knew it was important to care for my teeth and gums during my pregnancy (perceived benefit)</p> <p>b. A dental or other health care worker talked with me about how to care for my teeth and gums (health education)</p> <p>c. I had my teeth cleaned by a dentist or dental hygienist (dental service utilization)</p> <p>d. I had insurance to cover dental care during my pregnancy (perceived barrier)</p> <p>e. I needed to see a dentist for a problem (perceived threat)</p> <p>f. I went to a dentist or dental clinic about a problem (met dental need)</p>	Yes or No	AK, AL, AR, CO, CT, DE, GA, HI, IA, IL, LA, MA, MD, ME, MI, MN, MO, NE, NH, NJ, NM, NY, OH, OK, OR, PA, RI, TN, TX, UT, VA, VT, WA, WI, WV, WY, NYC
Standard Y6	<p>Did any of the following things make it hard for you to go to a dentist or dental clinic about the problem you had during <i>your most recent</i> pregnancy? For each item, check No if it was not something that made it hard for you to go to a dentist during pregnancy or Yes if it was.</p> <p>a. I could not find a dentist or dental clinic that would take pregnant patients (perceived barrier I)</p> <p>b. I could not find a dentist or dental clinic that would take Medicaid patients (perceived barrier IV–Medicaid specific)</p> <p>c. I did not think it was safe to go to the dentist during pregnancy (perceived barrier II)</p> <p>d. I could not afford to go to the dentist or dental clinic (perceived barrier III)</p>	Yes or No	GA, MD, MN, MO, NY, RI, VT

Medicaid-SCHIP State Dental Association (MSDA) 2014 and 2015 National Profile (161)

For the Study Aim 3, I combined the PRAMS datasets with MSDA's national profiles for 2014 and 2015. MSDA collects detailed Medicaid dental coverage information from Medicaid and CHIP Oral Health Programs in all 50 states and Washington D.C. MSDA publishes this resource of national, regional, and state Medicaid dental coverage by the Code on Dental Procedures and Nomenclature (CDT). MSDA National Profile dataset also contains the state Medicaid dental coverage information for Medicaid-enrolled pregnant women adults who are 21 and older.

Based on the MSDA's profile, state Medicaid dental coverage was categorized into three levels for adult pregnant women enrolled in Medicaid: 1) no coverage for the dental cleaning, which is the most basic routine dental procedure, 2) coverage for dental cleaning and fillings only with or without periodontal treatment coverage, 3) comprehensive dental coverage that included dental cleaning, fillings, periodontal, and endodontic treatments (Table 3).

Table 3. State Medicaid dental coverage for 30 states and New York City

Medicaid Dental Coverage Category	Description	States	Number of States	CDT codes
1	No coverage for dental cleaning (with or without emergency dental coverage)	AL, HI, NH, OK, TN, TX, WV	7	Does not cover for D1110, Adult dental prophylaxis
2	Dental coverage for dental cleaning and fillings (with or without periodontal care)	CT, IL, MA, MI, WA, WY	6	Cover for D1110 AND D2140 - D2161 or D2330 - D2394
3	Comprehensive dental coverage, including dental cleaning, fillings, periodontal and endodontic care	AK, AR, CO, IA, ME, MD, MO, NE, NJ, NM, NY, NYC, OR, PA, UT, VA, VT, WI	17 states NYC	Cover for D1110 AND D2140 - D2161 or D2330 - D2394 AND D3220 - D3999 AND D4341 - D4342

Note: CDT codes

D1110: Adult dental prophylaxis (dental cleaning)

D2140 – D2161: Amalgam restoration (dental fillings)

D2330 – D2394: Composite restoration (dental fillings)

D3220 – D3999: Endodontic treatment (root canal treatment)

D4341 – D4342: Scaling and root planing (periodontal treatment)

Cohort Design & Data Cleaning

Population characteristics

Women ages 20 and older who had a single live birth were included in the study. Women with twins and other multiple gestation births or who responded that her baby was not alive at the time of the survey were excluded. I selected maternal socio-demographic variables based on previously studied factors associated with dental service utilization during pregnancy and preterm birth (Table 4). Any women who had “missing”, “blank”, “don’t know” or any other responses not listed in the PRAMS variable dictionary for these variables were excluded from the analyses. A total of 75,029 women were included in the study, who had a single live birth and ages 20 and older. This study sample represented 4,599,366 women across the nation when PRAMS complex weighting and oversampling methodology were accounted for using STATA 15.

The mother’s age was categorized into two groups: 20 -34 and 35 and older. Women ages 35 and older were shown to have an increased risk for preterm birth (80). The race/ethnicity was re-categorized as non-Hispanic white, non-Hispanic black, Hispanic, and others, using both race and ethnicity variables from birth certificates. Asians and other non-Hispanic other races were excluded in the analysis as they were much smaller proportion than other racial/ethnic groups (3-5% of the study population). Maternal education was clustered in completed years of school (0–11, 12, 13 or more): women with less than high school education, high school completion, or beyond high school education.

Table 4. Socioeconomic, demographic, behavioral, and medical variables

	Variable	Questionnaire	Categorization
Demographic variables	State	State	AK, AL, AR, CO, DE, GA, IA, IL, LA, MA, MD, ME, MI, MN, MO, NE, NH, NJ, NM, NY, OH, OK, OR, PA, TN, TX, UT, WA, WI, WV, WY, NYC
	MAT_AGE_NAPHSIS	Maternal age grouped	20-34 35 or older
	HISP_BC	Hispanic?	Yes No
	MAT_RACE (redefined race/ethnic group)	Maternal Race	Non-Hispanic Black Non-Hispanic White Hispanic
	PRE_LB_NAPHSIS	Number of previous live births	First child Previous live birth present
	SEX	Gender of Infant	Female Male
Social variables	MARRIED	Marital Status	Married Other
	PAYCAT	Method of payment at the time of birth	Private insurance Medicaid
	MAT_ED	Maternal Education (Number of years in school)	0-11 (less than high school) 12 (completed high school) 13 and more (beyond high school)
	MAT_WIC	Mother get WIC food during pregnancy?	Yes No
Behavior variable	KOTELCHUCK	Kotelchuck Index	Inadequate Intermediate Adequate Adequate Plus
Birth variable	GEST_WK_NAPHSIS	Clinical estimate of gestational age grouped	< 37 week 37 weeks and more
Medical condition	MM_HBP MOMSMOKE P_PRTERM	Hypertension Smoking Previous preterm births	Yes No

Health insurance status at the time of birth was categorized into Medicaid and private insurance. Other forms of health insurance, such as the Indian Health Service or self-pay, were excluded in the analysis as the proportion of women with such health insurance was less than 3% of the study population. Marital status was categorized into married or other, as indicated in the birth certificate. I included the gender of the infant in the descriptive analysis and included the previous live birth, which was categorized into '*first live birth*' or '*had any previous live birth*' in the multivariate analysis.

The prenatal visit was measured by Kotelchuck index in the birth certificate, a scoring system that considered both timings of prenatal care initiation and the number of prenatal care visits after the first visit (162). The Kotelchuck Index, also called the Adequacy of Prenatal Care Utilization Index, has an underlying assumption that the earlier prenatal care begins, the better health outcomes occur (162). The number of prenatal visits is compared to the expected number of visits for the period between when care begins and the delivery date based on the guideline from the American College of Obstetricians and Gynecologists (162). A ratio of observed to expected visits is calculated and grouped into four categories: inadequate (received less than 50% of expected visits), Intermediate (50%-79%), Adequate (80%-109%), and Adequate Plus (110% or more) (162). Preterm birth was defined with single live birth prior to 37 gestation weeks (79) regardless of birth weights. Other medical conditions related to preterm birth were considered: hypertension, smoking, and previous history of preterm birth. All preterm birth and medical condition variables were binary and were retrieved from birth certificate data (Table 4).

The primary independent variable in the analysis was race/ethnicity, categorized by non-Hispanic white, non-Hispanic black, and Hispanic women. Another primary independent variable was insurance type, categorized by Medicaid or private insurance. Enrollment in Medicaid served

as a proxy for low family income as women needed to have a certain level of current household income and assets to be eligible for Medicaid (163). Medicaid income eligibility can be different by states ranging from 21% to 221% of the federal poverty level (163). All variables were binary, except race, maternal education, and prenatal visit score, categorical.

Women enrolled in Medicaid and WIC enrollment

For the Study Aim 3, I created a subset of women enrolled in Medicaid at the time of delivery in 2014 and 2015. 16,644 women enrolled in Medicaid were included, who represented 966,768 women to examine dental visits during pregnancy by the state Medicaid dental coverage policy. In addition to previously defined socio-demographic variables, I added WIC enrollment in this analysis. Previous research has shown that women enrolled in the WIC program were more likely to visit a dentist than women who were not insured and not enroll in the WIC program after adjusting for other socio-demographic factors (128). WIC enrollment was not included in the other analysis as this variable correlates with insurance types.

Dental variables

All dental variables were binary responses where women responded either ‘yes’ or ‘no’ (Table 5). Any response other than yes or no were excluded. The subject-reported response to the PRAMS core survey question “I had my teeth cleaned by a dentist or dental hygienist” during pregnancy served as an indicator for dental service utilization during pregnancy. Dental cleaning is the most basic form of non-emergency care and preventive dental service. In most cases, dental cleaning is provided as a part of bundled services along with a routine dental exam and oral health education. Pregnant women may receive definitive dental treatment, such as an extraction, without a periodic dental exam and cleaning in emergency cases. However, in most cases, dental exams and cleaning are performed first to create a comprehensive treatment plan before any dental or periodontal treatments are delivered. Therefore, dental visit for dental cleaning serves as an indicator for routine dental care, not emergency visits. I also examined dental service utilization before pregnancy, using the responses to the question, “I had my teeth cleaned by a dentist or dental hygienist any time during the 12 months before pregnancy.” Met dental needs were measured when women reported a dental visit to address dental problems. When women responded they did not or could not visit a dentist during pregnancy despite dental problems, it was considered as unmet dental need (128)

Table 5. Dental variables

	Variable	Questionnaire	Categorization
Dental service variables	PRE_DDS	I had my teeth cleaned by a dentist or dental hygienist	Yes No
	DDS_CLN	I had my teeth cleaned by a dentist or dental hygienist	Yes No
Belief variables	DDS_CARE	I knew it was important to care for my teeth and gums during my pregnancy	Yes No
	DDS_TALK	A dental or other health care worker talked with me about how to care for my teeth and gums	Yes No
	DDS_INS	I had insurance to cover dental care during my pregnancy	Yes No
Met/Unmet needs variables	DDS_PROB	I needed to see a dentist for a problem	Yes No
	DDS_WENT	I went to a dentist or dental clinic about a problem	Yes No
Additional barrier variables	DDS_ACPT	I could not find a dentist or dental clinic that would take pregnant patients	Yes No
	DDS_MEDI	I could not find a dentist or dental clinic that would take Medicaid patients	Yes No
	DDS_SAFE	I did not think it was safe to go to the dentist during pregnancy	Yes No
	DDS_COST	I could not afford to go to the dentist or dental clinic	Yes No

Responses to three PRAMS core questions served as oral health belief variables. The response to the core survey question, “I know it was important to care for my teeth and gums during my pregnancy,” served as an indicator for the perceived benefits that may lead to health behavior, including a dental visit for cleaning and daily oral hygiene practice during pregnancy. Previous research showed that higher oral health knowledge (perceived benefits) led to improved daily oral hygiene practice (42, 47, 139). The response to the core survey question, “I had insurance to cover dental care during my pregnancy,” served as an indicator of the perceived barriers in accessing dental service during pregnancy. Women who responded ‘no’ to this question were expected to have perceived barriers in accessing dental service with a lack of dental coverage. The core survey question, “I needed to see a dentist for a problem,” served as the indicator for perceived threats. For a woman to recognize a problem in the oral cavity, such as pain or discomfort, the disease is often much advanced. Without clinical and radiograph examinations not included in the PRAMS data, subjective recognition of a dental problem may underestimate clinical diagnosis for oral diseases. However, this subjective perception of oral and dental problems can serve as perceived threats that may act as a cue to health-related behavior, which was a dental visit for cleaning in the study. The response to the core survey question, “a dental or other health care worker talked with me about how to care for my teeth and gums,” was not used in the dental visit analysis as most women would receive oral health advice during the dental visit (128). This oral health advice variable was analyzed in unadjusted bivariate models only.

Additional perceived barrier questions were examined in a subpopulation of women who responded to a standard oral health question as a part of their state’s PRAMS survey. These questions asked perceived barriers regarding accessing dental care during pregnancy. These included “I could not find a dentist or dental clinic that would take pregnant patients,” “I did not

think it was safe to go to the dentist during pregnancy,” and “I could not afford to go to the dentist or dental clinic.” There was a Medicaid-specific question, “I could not find a dentist or dental clinic that would take Medicaid patients.” Responses to all these dental variables were binary, yes or no.

State inclusion for each Study Aim

After excluding women with missing values for any of the following variables: mother’s age, race/ethnicity, marital status, insurance type, mother’s education, prenatal visit score (Kotelchuck), hypertension, smoking, previous preterm birth, preterm birth outcomes, and all core dental variables from the PRAMS Phase 7 period from 2012 to 2015, 31 states and NYC (AK, AL, AR, CO, DE, GA, IA, IL, LA, MA, MD, ME, MI, MN, MO, NE, NH, NJ, NM, NY, NYC, OH, OK, OR, PA, TN, TX, UT, WA, WI, WV, WY) were included in the analysis for Study Aim 1 and 3. Seven states implemented the standard (additional) oral health questions (GA, MD, MN, MO, NY, RI, VT) in the PRAMS Phase 7 survey. After excluding for women with missing values for any of the following variables, responses from five states were included for the analysis for Study Aim 2 (GA, MD, MN, MO, NY): mother’s age, race/ethnicity, marital status, insurance type, mother’s education, prenatal visit score (Kotelchuck), and all core dental variables.

Lastly, a subpopulation of women who were enrolled in Medicaid at the time of delivery in 2014 and 2015 was created for the analysis of Study Aim 3. After excluding women with missing values in mother’s age, race/ethnicity, marital status, insurance type, mother’s education, prenatal visit score (Kotelchuck), WIC enrollment, and all core dental variables, 30 states and NYC were included in the analysis (AK, AL, AR, CO, CT, HI, IA, IL, MA, MD, ME, MI, MO, NE, NH, NJ, NM, NY, NYC, OK, OR, PA, TN, TX, UT, VT, VA, WA, WI, WV, WY). DE, LA, and OH were omitted from the total study population for the analyses in Study Aim 1 and 4 when created this Medicaid

subpopulation. DE changed its Medicaid dental policy from no coverage in 2014 to limited dental coverage for teeth cleaning in 2015. LA provided dental coverage for dental cleaning without dental fillings. OH provided Medicaid coverage for a dental cleaning, fillings, and endodontic treatment but did not provide coverage for periodontal treatment in both 2014 and 2015. Therefore, responses from these states were excluded from the Medicaid-enrolled women subpopulation.

Human subject

This was a retrospective cross-sectional study using de-identified secondary data from PRAMS dataset and did not involve any intervention or interaction with individuals. I obtained data agreement from CDC, and the study received an exemption from the Institutional Review Board (IRB) of the Johns Hopkins School of Public Health. All study materials were kept in a password-protected server.

Statistical analysis and analytical variables

I used STATA 15.0 to account for PRAMS complex weighting and oversampling methodology, using the STATA coding provided by the CDC PRAMS team. Weighted percentages were used for all analyses. Descriptive analysis and chi-square analysis were performed to assess the bivariate association between variables for each study aim, and multivariate logistic regression analysis was performed adjusting for other variables, listed in Table 4. Analyses for Study Aim 1 and 4 were performed in the identical study population, and the analysis for Study Aim 2 and 3 was performed on different subpopulations of women. All socio-demographic variables, prenatal score, and medical condition information came from individual birth certificates, whereas dental variables were from the PRAMS survey (Table 6).

Table 6. Key Dependent and Independent Variables – PRAMS and MSDA 2014 and 2015

National Profiles

Study Aim	Variable Type	Variable Name	Description
1	Dependent variable	Dental visit during pregnancy	I had my teeth cleaned by a dentist or dental hygienist during my most recent pregnancy
1.1	Independent variable	Race/ethnicity	Non-Hispanic white, Non-Hispanic black, Hispanic
1.2	Independent variable	Insurance type	Private insurance, Medicaid
1	Independent variable	Perceived benefits	I knew it was important to care for my teeth and gums during my pregnancy
1	Independent variable	Perceived barriers	I had insurance to cover dental care during my pregnancy
1	Independent variable	Perceived threats	I could not afford to go to the dentist or dental clinic
2	Dependent variable	Dental visit during pregnancy	I had my teeth cleaned by a dentist or dental hygienist during my most recent pregnancy
2	Independent variable	Additional perceived barrier I	I could not find a dentist or dental clinic that would take pregnant patients
2	Independent variable	Additional perceived barrier II	I did not think it was safe to go to the dentist during pregnancy
2	Independent variable	Additional perceived barrier III	I could not afford to go to the dentist or dental clinic
2	Independent variable	Additional perceived barrier IV	I could not find a dentist or dental clinic that would take Medicaid patients
3	Dependent variable	Dental visit during pregnancy	I had my teeth cleaned by a dentist or dental hygienist during my most recent pregnancy
3	Dependent variable	Met dental needs	Responded ‘Yes’ to “I needed to see a dentist for a problem,” AND responded ‘Yes’ to “I went to a dentist or dental clinic about a problem.”
3	Independent variable	State Medicaid dental coverage (MSDA)	1. No coverage for dental cleaning 2. Dental coverage for cleaning and fillings 3. Comprehensive dental coverage
4	Dependent variable	Preterm birth	Birth prior to 37 gestation weeks
4	Independent variable	Dental visit during pregnancy	I had my teeth cleaned by a dentist or dental hygienist during my most recent pregnancy
4	Independent variable	Perceived benefit	I knew it was important to care for my teeth and gums during my pregnancy
4	Independent variable	Perceived barrier	I had insurance to cover dental care during my pregnancy
4	Independent variable	Perceived threat	I could not afford to go to the dentist or dental clinic

Aim 1 . Examine how oral health beliefs are associated with dental service utilization during pregnancy

A total of 75,029 women ages 20 and older with single live birth and no missing values for selected variables were included in the study. This study sample represented 4,599,366 women in 31 states and NYC when PRAMS complex weighting and oversampling methodology were accounted for the analysis. I examined the distribution of baseline characteristics across racial/ethnic groups, which included socio-demographic variables (mother's age, marital status, insurance type, education level, previous live birth, the gender of baby), adequacy of prenatal care (Kotelchuck index), and dental service utilization and oral health belief during pregnancy.

Unadjusted bivariate analysis was performed with chi-square test to examine the differences in dental service utilization and oral health belief by race/ethnicity. In addition, met and unmet dental needs were analyzed in each racial/ethnic group among women who reported having a dental problem during pregnancy. I designed multivariate logistic regression models to examine the adjusted OR of dental service utilization during pregnancy as well as prior to pregnancy with 95% confidence intervals (CI). The adjusted OR of oral health belief, including perceived benefits of oral health, perceived barriers in accessing dental services, and perceived threats of dental problems during pregnancy, were examined across different racial/ethnic groups. The response to the survey question, "I knew it was important to take care of my teeth and gums during pregnancy," served as the indicator for perceived oral health benefits. The response to the survey question, "I had insurance to cover dental care during my pregnancy," served as the indicator of the absence of perceived oral health barriers. In other words, if a woman responded 'Yes' to this survey question, I considered she did not perceive barriers in accessing dental care during pregnancy. If women responded 'no,' they perceived barriers in accessing

dental care during pregnancy. The response to a survey question of whether women needed to see a dentist for a problem was an indicator of perceived threats. I also examined the adjusted OR for met dental needs among women who perceived a dental problem during pregnancy. These models were adjusted for other socio-demographic variables and prenatal scores. These socio-demographic and prenatal covariates were tested for multi-collinearities in the total PRAMS population and found not to be correlated at the level where those covariates needed to be combined or eliminated from the analysis.

After analyzing the adjusted OR for dental service utilization and oral health beliefs across race/ethnicity, I examined the combined effect of race/ethnicity and oral health beliefs by testing the interaction of these variables. In a separate model, I examined the adjusted OR for dental service utilization and oral health beliefs between different health insurance types, Medicaid or private insurance. The interaction between health insurance types and oral health belief variables were tested as well.

Aim 2. Examine the association between additional perceived barriers in provider availability, safety concerns, and affordability for dental care and dental services utilization during pregnancy.

A subpopulation of 1,943 women from five states (GA, MD, MN, MO, NY) that implemented a standard oral health standard question on perceived barriers represented 149,829 women in these five states. Unadjusted bivariate analysis was performed with chi-square test to examine differences in baseline characteristics across different racial/ethnic groups of women.

In multivariate logistic regression models, the adjusted OR for difficulties in finding dentists who accepted pregnant patients, concerns regarding the safety of dental care during pregnancy, and the ability to afford dental care during pregnancy were analyzed across different

racial/ethnic groups of women. Then, I examined the adjusted OR for a dental visit for cleaning during pregnancy when each of these additional perceived barriers was added to the baseline multivariate logistic regression model. One of the additional perceived barriers was a Medicaid-specific question, which asked if there was difficulty in finding a dentist who accepted patients enrolled in Medicaid. This analysis was performed in a subset of women enrolled in Medicaid in these five states (1,107 observations, representing 84,311 women).

Aim 3: Examine how various levels of Medicaid dental coverage are associated with oral health beliefs and dental service utilization during pregnancy among women enrolled in Medicaid.

In Study Aim 3, the associations between state Medicaid dental coverage level and dental variables were examined. MSDA's 2014 and 2015 profile and PRAMS 2014 and 2015 datasets on 30 states and NYC were cross-walked and created a subpopulation of 16,644 Medicaid-enrolled women. The state Medicaid dental coverage for adult pregnant women age 21 and older was categorized into three levels: 1) no coverage for a dental cleaning during pregnancy, which is the most basic preventive dental procedure before other dental treatments, 2) coverage only for dental cleaning and restoration, with or without periodontal treatment, and 3) comprehensive dental coverage, including periodontal and endodontic treatment (Table 3).

Unadjusted bivariate analysis was performed with chi-square test to examine differences in baseline characteristics, dental service utilization, and oral health belief across state Medicaid dental coverage policy categories. In multivariate logistic regression models, the adjusted OR for dental visit for cleaning during pregnancy were examined by Medicaid dental coverage level, holding other variables constant, including race/ethnicity, mother's age, marital status, mother's education level, prenatal visit score, previous live birth as well as WIC enrollment. WIC

enrollment was a new variable added to this analysis. As WIC enrollment limits annual family income similar to Medicaid eligibility, this variable was not included in other analyses but applied for this Medicaid-enrolled women analysis. The adjusted OR for oral health belief and met dental needs by different Medicaid dental coverage levels were examined adjusted for other variables. The met dental needs were performed in a subset of women who reported they had a dental problem during pregnancy (4,807 women, represented 271,534 women enrolled in Medicaid at the time of delivery).

Aim 4. Examine the preterm birth outcomes in association with oral health beliefs and dental service utilization during pregnancy, considering other socio-demographic-behavioral and medical factors.

The analyses for Study Aim 4 was performed on the identical study population with Study Aim 1, including 75,029 women who represented 4,599,366 women. In this analysis, I examined the association between preterm birth outcome and dental variables, including dental visits for cleaning and oral health beliefs during pregnancy. The preterm birth was defined as a single live birth prior to 37 gestation weeks. This dependent variable was categorized binomially: preterm or full-term birth. Unadjusted bivariate analysis was performed with chi-square test to examine differences in baseline characteristics and preterm birth outcomes across racial/ethnic groups of women. The preterm birth rate was calculated in the weighted percentage for each dental variable, including dental service utilization and oral health beliefs.

It is worth noting that dental visits for cleaning served as an independent variable in this analysis. The relationships between dental cleaning before and during pregnancy on

preterm birth outcomes were examined considering other socio-demographic variables, prenatal visit scores, and medical conditions (hypertension, smoking, and previous preterm birth). It was critical to examine the association between dental service utilization and preterm birth outcome adjusted for prenatal visit scores, which could show how these women accessed prenatal care compared to dental care. The multivariate logistic regression model was designed to examine the adjusted OR of preterm birth in relation to dental visits for cleaning during and prior to pregnancy, oral health beliefs, adjusting for other socio-demographics, prenatal visit scores, and medical risk variables. There was a limitation in the study analysis as the temporal relationship between oral health belief, and dental service utilization was not known in the study population. To address this limit, the oral health belief variables and dental service utilization variables were analyzed separately for their association with preterm birth outcomes. Then, the associations between oral health belief variables and preterm birth were examined in stratified groups of women based on a reported dental visit during pregnancy.

CHAPTER 4

RESULTS

Study Aim 1: Examine how oral health beliefs are associated with dental service utilization during pregnancy

Unadjusted bivariate analysis for overall study population characteristics

After exclusion criteria was applied, a total of 75,029 women were included in the study from the PRAMS database from 2012 to 2015, who had a single live birth and were 20 and older at the time of delivery. This study sample represented 4,599,366 women when PRAMS complex weighting and oversampling methodology were accounted. More than two-thirds of this study population (69.6%) was non-Hispanic white, 13.7% was non-Hispanic black, and 16.7% was Hispanic women (Table 7). Chi-square test (χ^2) was performed and the result was considered significant at $p < 0.05$. The majority of women were between 20 and 34 years (83.6%). While 63.8% of women were married at the time of birth, marital status varies by racial/ethnic groups. Compared to non-Hispanic white women (73.8%), non-Hispanic black women had a significantly lower proportion of women (χ^2 , $p < 0.0001$) who were married at the time of birth (29.2%). More than one-third of women (37.5%) reported the most recent birth was their first live birth. Medical insurance was categorized into private insurance (58.3%) and Medicaid (41.7%). While 70.6% of non-Hispanic white women were covered by private health insurance, only 28.7% of Hispanic women and 31.9% of non-Hispanic black women were covered by private health insurance for the most recent birth. Overall, 89.7% of women reported they had completed high school or had education beyond high school. While only 4.9% of non-Hispanic white women reported to have

less than high school education, 12.2% of non-Hispanic black women and 30.8% of Hispanic women reported less than high school education (χ^2 , $p < 0.0001$). More than three out of four women (77.7%) had prenatal visit scores (Kotelchuck Index) of “adequate” or “adequate plus”. Compared to non-Hispanic white women (8.0%), the proportion of women who reported inadequate prenatal score was much higher in non-Hispanic black (17.9%) and Hispanic women (15.7%) (χ^2 , $p < 0.0001$).

Table 7. Characteristics of the study cohort for the Study Aim 1 and 4

Respondent characteristics	Total		Non-Hispanic white		Non-Hispanic black		Hispanic		P
	n	Total %	n	weighted %	n	weighted %	n	weighted %	
Maternal race									
Non-Hispanic white	3,201,780	69.61%							
Non-Hispanic black	628,369	13.66%							
Hispanic	769,217	16.72%							
Maternal age (years)									
20-34	3,846,130	83.62%	2,670,969	83.42%	539,221	85.81%	635,940	82.67%	0.0001
35 and older	753,235	16.38%	530,811	16.58%	89,147	14.19%	133,277	17.33%	
Marital status									
Married	2,933,358	63.78%	2,362,242	73.78%	183,300	29.17%	387,816	50.42%	0.0000
Other	1,666,008	36.22%	839,538	26.22%	445,069	70.83%	381,401	49.58%	
Medical insurance									
Private insurance	2,683,285	58.34%	2,261,592	70.64%	200,627	31.93%	221,066	28.74%	0.0000
Medicaid	1,916,080	41.66%	940,188	29.36%	427,742	68.07%	548,151	71.26%	
Maternal education (years)									
0-11	470,955	10.24%	157,526	4.92%	76,870	12.23%	236,559	30.75%	0.0000
12	1,038,879	22.59%	613,675	19.17%	200,160	31.85%	225,044	29.26%	
13 and more	3,089,532	67.17%	2,430,579	75.91%	351,338	55.91%	307,615	39.99%	
Prenatal visit (Kotelchuck Index)									
Inadequate	490,752	10.67%	257,044	8.03%	112,722	17.94%	120,986	15.73%	0.0000
Intermediate	534,284	11.62%	355,044	11.09%	84,976	13.52%	94,263	12.25%	
Adequate	2,189,576	47.61%	1,601,145	50.01%	255,625	40.68%	332,806	43.27%	
Adequate Plus	1,384,754	30.11%	988,547	30.87%	175,045	27.86%	221,162	28.75%	
Previous livebirth									
First Child	1,723,844	37.48%	1,278,635	39.94%	216,464	34.45%	228,745	29.74%	0.0000
Gender of baby									
Boy	2,351,087	51.12%	1,633,266	51.01%	319,064	50.78%	398,757	51.84%	0.5034
Girl	2,248,215	48.88%	1,568,514	48.99%	309,240	49.22%	370,460	48.16%	
Medical Conditions									
Hypertension	320,462	6.97%	219,360	6.85%	57,967	9.22%	43,135	5.61%	0.0000
Smoking	449,797	9.78%	376,198	11.75%	49,849	7.93%	23,750	3.09%	0.0000
History of previous preterm birth									
Present	151,868	3.37%	98,556	3.08%	29,150	4.64%	27,163	3.53%	0.0000
Preterm birth (<37 weeks)									
Preterm birth	324,987	7.07%	200,955	6.28%	67,686	10.77%	56,346	7.33%	0.0000

Unadjusted bivariate analysis for dental visit for cleaning during pregnancy

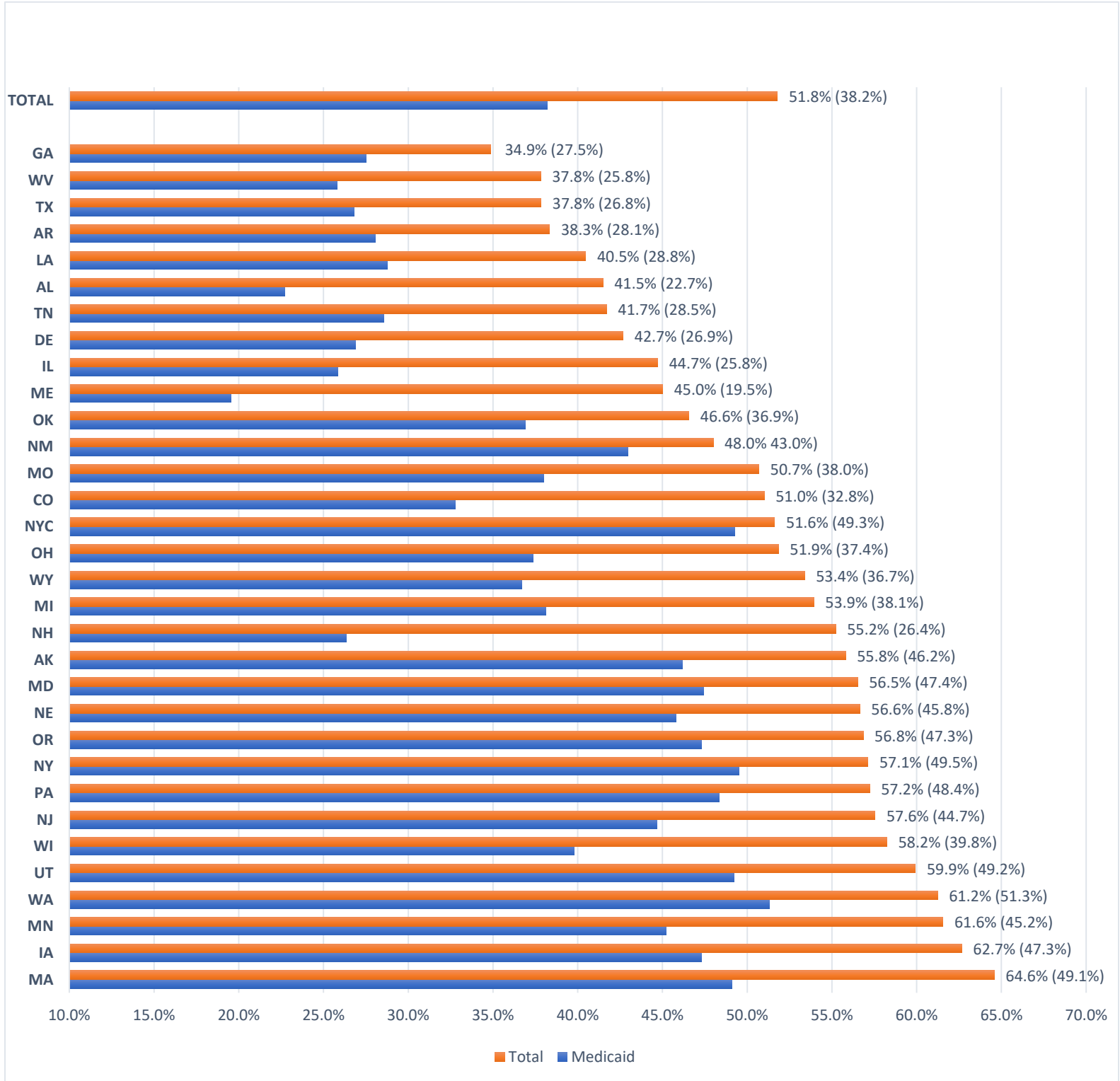
Unadjusted bivariate analysis was performed for dental variables across racial/ethnic groups of women (Table 8). All dental variables showed a significant difference (χ^2 , $p < 0.0001$) among racial/ethnic groups. In the total study population, 59.2% of women reported they visited a dentist for teeth cleaning for 12 months before they became pregnant, and 51.8% of the overall proportion of women reported at least one dental visit for cleaning during pregnancy. When analyzed by state, the proportion of women who had a dental visit for cleaning during pregnancy ranged from 34.9% to 64.6% (Fig 9). There were racial/ethnic differences in dental visits for cleaning during pregnancy. The proportion of women who responded that they had a dental visit for cleaning during pregnancy was much lower in non-Hispanic black women (41.5%) and Hispanic women (44.3%) compared to non-Hispanic white women (57.4%) (χ^2 , $p < 0.0001$). When stratified by health insurance types, 61.5% of women with private insurance visited a dentist for a cleaning, whereas only 38.2% of women enrolled in Medicaid visited a dentist for cleaning during pregnancy (χ^2 , $p < 0.0001$). When analyze by state, the proportion of Medicaid-enrolled women who had a dental visit for cleaning during pregnancy ranged from 19.5% to 51.3% (Fig 9). Among women with private insurance, non-Hispanic black women (45.9%) and Hispanic women (52.3%) had a lower rate of dental visit during pregnancy compared to non-Hispanic white women (63.8%), but such disparity was not observed among women enrolled in Medicaid (Table 8) When the dental visit for cleaning during pregnancy was examined over four years of period from 2012 to 2015, the proportion of women who had a dental visit during pregnancy was reduced from 53.2% to 49.6% (Fig 10), and the difference was significant between 2012 and 2015 ($p < 0.05$). The same downward trend was observed in women who had private health insurance as well as women enrolled in Medicaid (Fig 11).

Table 8. Dental service utilization and oral health beliefs by race/ethnicity

Dental outcomes	Total %	Non-Hispanic White (weighted %)	Non-Hispanic Black (weighted %)	Hispanic (weighted %)	P
Dental visit before pregnancy	59.22%	63.95%	49.78%	47.24%	0.0000
Dental visit during pregnancy	51.79%	57.43%	41.51%	44.30%	0.0000
Dental visit during pregnancy - Private insurance	61.49%	63.77%	45.93%	52.32%	0.0000
Dental visit during pregnancy - Medicaid	38.20%	36.72%	38.70%	40.34%	0.0014
Know importance of oral health during pregnancy	90.61%	93.21%	86.94%	82.75%	0.0000
Report dental insurance during pregnancy	75.28%	78.19%	73.71%	64.46%	0.0000
Report dental insurance during pregnancy - Private	83.38%	83.75%	84.61%	78.49%	0.0000
Report dental insurance during pregnancy - Medicaid	63.94%	64.81%	68.60%	58.81%	0.0000
Have to see dentist for a problem during pregnancy	19.82%	18.83%	26.16%	18.74%	0.0000
Unmet dental needs during pregnancy*	34.49%	32.31%	40.82%	36.39%	0.0000
Private Insurance	24.56%	22.53%	34.42%	32.42%	0.0000
Medicaid	41.11%	41.83%	42.69%	37.44%	0.0760
Met dental needs during pregnancy*	65.51%	67.69%	59.18%	63.61%	0.0000

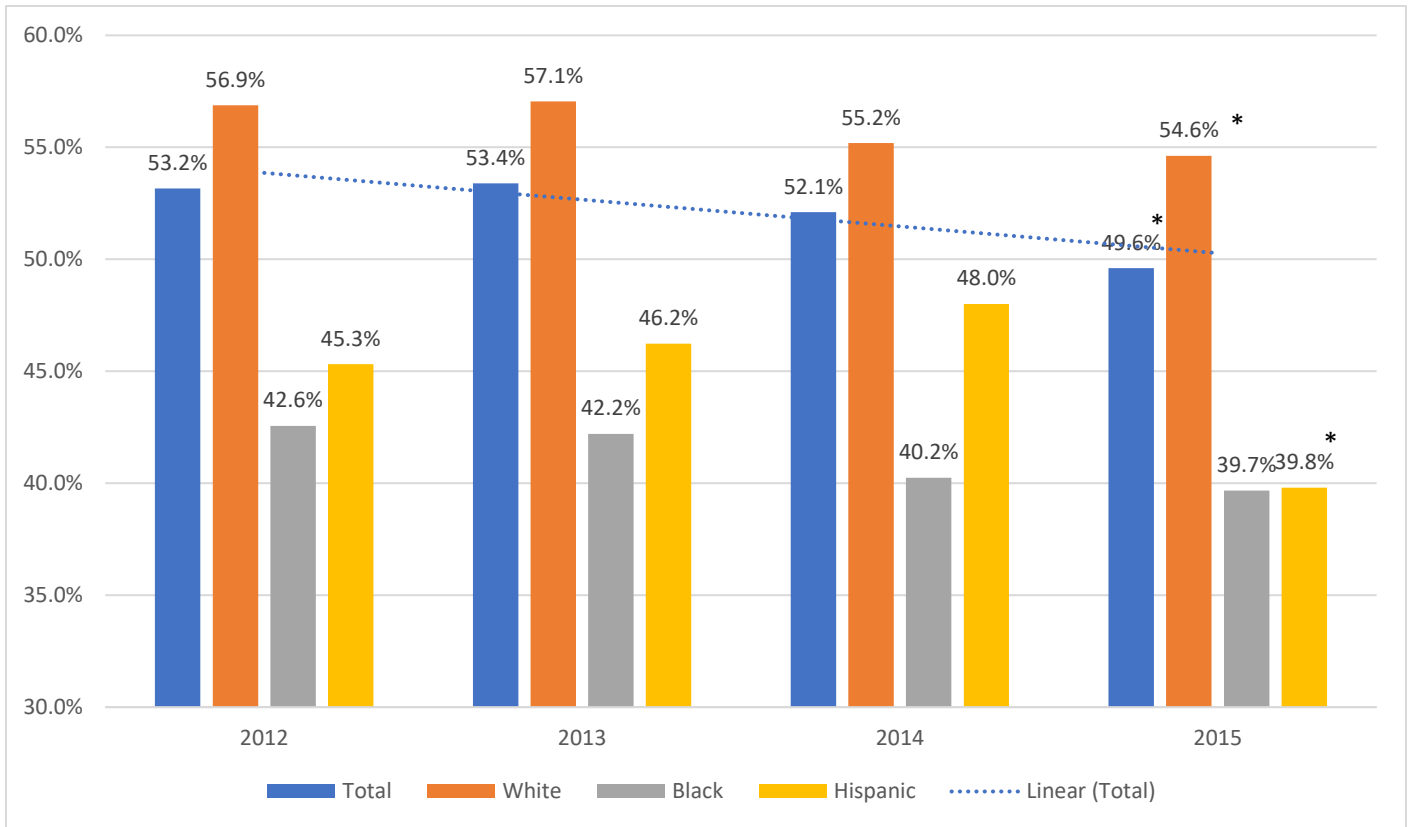
*Women who did not go to dentist during pregnancy among women who reported they have dental problem (observation = 15,626, representing 906,719.)

Figure 9. Dental visit for cleaning during pregnancy by state from 2012 to 2015



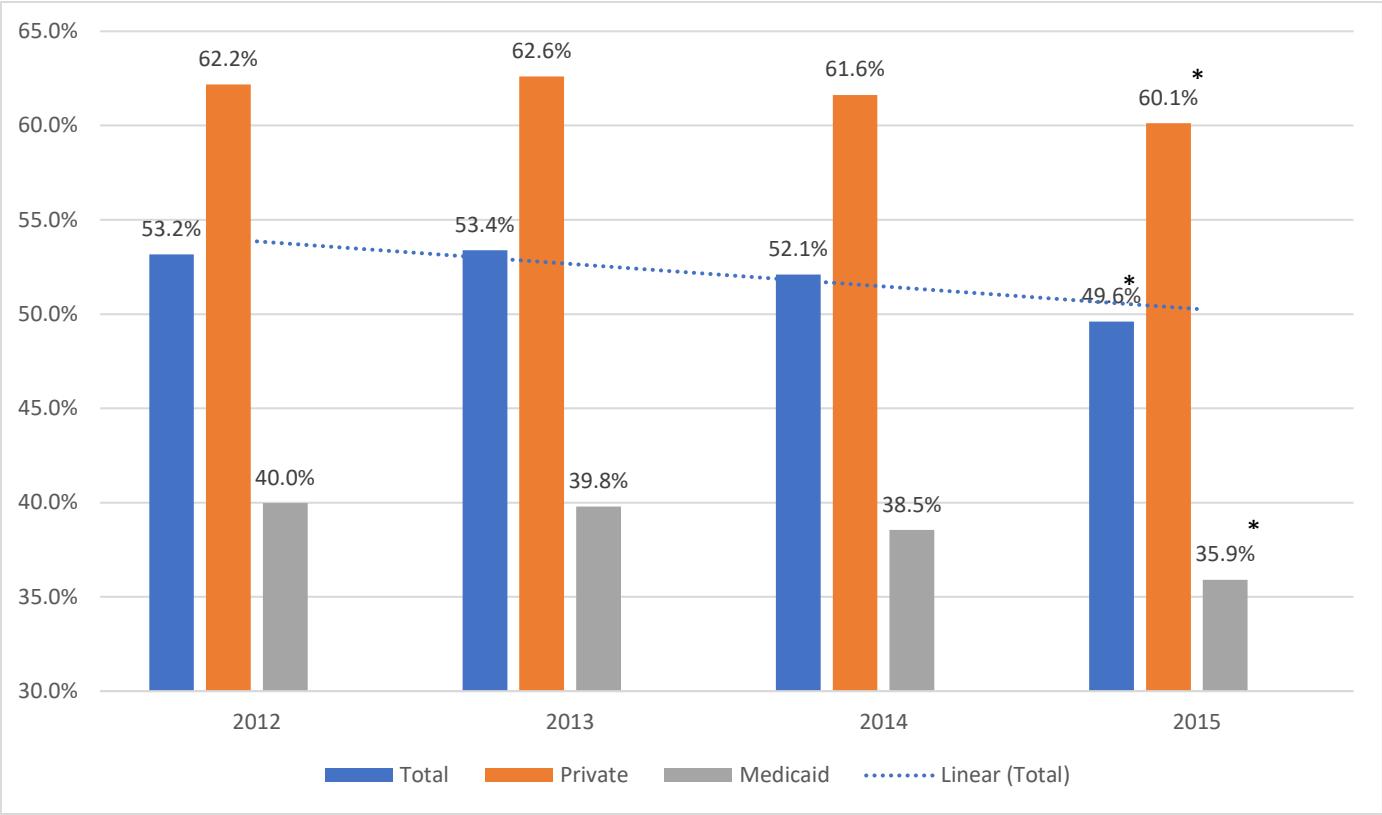
*Note: percentages in the parenthesis indicate proportion of Medicaid-enrolled women who had a dental visit during pregnancy

Figure 10. Dental visit for cleaning during pregnancy by race/ethnicity from 2012 to 2015



* p <0.05, reference 2012

Figure 11. Dental visit for cleaning during pregnancy by insurance type from 2012 to 2015



* p <0.05, reference 2012

Unadjusted bivariate analysis for oral health beliefs during pregnancy

More than nine out of ten women responded that they perceived the importance of oral health during pregnancy (90.6%) (Table 8). Compared with non-Hispanic white women (93.2%), however, the proportion of women who perceived benefits was lower in non-Hispanic black (86.9%) and Hispanic women (82.8%) (χ^2 , $p < 0.0001$). Perceived barriers were measured by the response to the survey question, “I had insurance to cover dental care during pregnancy.” 83.4% of women covered by private insurance responded that they had dental coverage during pregnancy, while only 63.9% of women enrolled in Medicaid reported that they had dental coverage during pregnancy. One out of five women reported dental problems (perceived threats) during pregnancy (19.8%). Non-Hispanic black women had a significantly higher proportion of women (χ^2 , $p < 0.0001$) who reported a dental problem during pregnancy (26.2%) compared to non-Hispanic whites (18.8%) or Hispanic women (18.7%). More than one of three women with dental problems (34.5%) did not receive dental care despite their perceived needs, which indicated the unmet oral health care needs. The unmet oral health care needs were the highest among non-Hispanic black women (40.8%), compared to non-Hispanic white women (32.3%) and Hispanic women (36.4%). When the unmet dental needs were examined by insurance types, women with private health insurance showed significantly lower unmet dental needs (24.6%) compared to women enrolled in Medicaid (41.1%) (χ^2 , $p < 0.0001$). While non-Hispanic black women (34.4%) and Hispanic women (32.4%) with private health insurance showed higher unmet dental needs compared to non-Hispanic white women with private health insurance (22.5%), such racial disparity in unmet dental needs were not observed among women enrolled in Medicaid (Table 8). About half of the women (52.4%) received oral health education during pregnancy, and Hispanic women reported the lowest rate (45.7%) among racial/ethnic groups.

Four out of five women (79.6%) who received oral health education also visited a dentist for cleaning during pregnancy even though it was not known if both oral health education and dental cleaning happened during the same visit. Women with private health insurance were more likely to receive oral health education (56.5%) than women enrolled in Medicaid (46.6%). (Table 8).

Multivariate logistic regression model for dental service utilization

When mother's age, marital status, medical insurance type, mother's education, prenatal visit score, and previous live birth were held constant, Hispanic women had significantly lower odds of visiting a dentist for cleaning prior to pregnancy (OR=0.91, 95% CI [0.84-0.98]) compared to non-Hispanic white women (Table 9). Non-Hispanic black women did not have a statistical difference in pre-pregnancy dental visits for cleaning compared to non-Hispanic white women. Women enrolled in Medicaid had more than 50% lower odds of visiting a dentist before pregnancy compared to women covered by private health insurance (OR=0.42, 95% CI [0.40-0.44]) when other variables were held constant.

Different pattern of racial/ethnic disparity was noted for dental visit during pregnancy (Table 9). When the listed socio-demographic and prenatal visit score variables above were held constant, non-Hispanic black women had 15% lower odds of visiting a dentist for cleaning during pregnancy compared to non-Hispanic white women (OR=0.85, 95% CI [0.80-0.91]). There was no difference in dental visits during pregnancy between Hispanic women and non-Hispanic white women. Women enrolled in Medicaid showed significantly lower odds of visiting a dentist for cleaning during pregnancy compared to women covered by private health insurance (OR=0.54, 95% CI [0.51-0.57]). Mothers' with education beyond high school had 30% higher odds in visiting a dentist for cleaning during pregnancy compared to women who had less than high school education (OR=1.30, 95% CI [1.18-1.42]). However, mothers with high school completion had slightly lower odds in visiting a dentist compared to women who had less than high school education (OR=0.90, 95% CI [0.82-0.99]). Compared to women with inadequate prenatal care, women with prenatal care visit scores in intermediate, adequate, and adequate plus categories showed higher odds of dental visits for cleaning during pregnancy (Table 9).

Table 9. Multivariable logistic regression analysis for dental visit for cleaning

Respondent characteristic	Total %	Dental visit for cleaning (12 months prior to pregnancy)				Dental visit for cleaning (during pregnancy)			
		O.R	S.E	95% C.I.	P	O.R	S.E	95% C.I.	P
Maternal age (years)									
20-34	83.62%	<i>ref</i>				<i>ref</i>			
35 and older	16.38%	1.31	0.045	1.23 - 1.41	0.000	1.23	0.038	1.16 - 1.31	0.000
Maternal race									
Non-Hispanic white	69.61%	<i>ref</i>				<i>ref</i>			
Non-Hispanic black	13.66%	0.99	0.036	0.92 - 1.06	0.763	0.85	0.030	0.80 - 0.91	0.000
Hispanic	16.72%	0.91	0.035	0.84 - 0.98	0.015	0.95	0.036	0.88 - 1.02	0.168
Marital status									
Married	63.78%	1.37	0.040	1.29 - 1.45	0.000	1.33	0.038	1.25 - 1.40	0.000
Other	36.22%	<i>ref</i>				<i>ref</i>			
Medical insurance									
Private	41.66%	<i>ref</i>				<i>ref</i>			
Medicaid	58.34%	0.42	0.01	0.40 - 0.44	0.000	0.54	0.016	0.51 - 0.57	0.000
Maternal education (year)									
0-11	10.24%	<i>ref</i>				<i>ref</i>			
12	22.59%	1.05	0.051	0.96 - 1.16	0.285	0.90	0.043	0.82 - 0.99	0.029
13 and more	67.17%	1.64	0.077	1.50 - 1.80	0.000	1.30	0.060	1.18 - 1.42	0.000
Prenatal visit (Kotelchuck Index)									
Inadequate	10.67%	<i>ref</i>				<i>ref</i>			
Intermediate	11.62%	1.33	0.070	1.20 - 1.48	0.000	1.29	0.065	1.16 - 1.42	0.000
Adequate	47.61%	1.32	0.056	1.22 - 1.44	0.000	1.32	0.055	1.21 - 1.42	0.000
Adequate Plus	30.11%	1.29	0.057	1.18 - 1.41	0.000	1.28	0.056	1.18 - 1.40	0.000
Previous livebirth									
First livebirth	37.48%	0.98	0.025	0.93 - 1.03	0.455	1.01	0.024	0.97 - 1.06	0.550
Not first livebirth	62.52%	<i>ref</i>				<i>ref</i>			

Multivariate logistic regression model for oral health beliefs

Both non-Hispanic black (OR=0.70, 95% CI [0.58-0.72]) and Hispanic women (OR=0.49, 95% CI [0.42-0.52]) had a significantly lower odds of perceiving oral health benefits compared to non-Hispanic white women when other socio-demographic and prenatal visit score variables were held constant (Table 10). Women enrolled in Medicaid also showed a significantly lower odds of perceiving oral health benefits during pregnancy compared to women covered by private health insurance (OR=0.76, 95% CI [0.69-0.84]). Women whose most recent birth was their first live birth had significantly lower odds of perceiving oral health benefit during pregnancy compared to women who already had another child before the most recent birth (OR=0.71, 95% CI [0.65-0.78]).

While Hispanic women had lower odds of perceiving dental coverage compared to non-Hispanic white women (OR=0.80, 95% CI [0.75-0.89]), non-Hispanic black women had higher odds of perceiving dental coverage compared to non-Hispanic white women (OR=1.32, 95% CI [1.10-1.28]) when holding other variables constant (Table 10). Women enrolled in Medicaid showed 58% lower odds of perceiving dental coverage during pregnancy compared with women covered by private health insurance (OR=0.42, 95% CI [0.39-0.45]).

Table 10. Multivariable logistic regression analysis for oral health beliefs: perceived benefits and perceived barriers (lack of self-reported dental coverage during pregnancy)

Respondent characteristic	Total %	Perceived oral health benefits during pregnancy				Perceived dental coverage during pregnancy			
		O.R	S.E	95% C.I.	P	O.R	S.E	95% C.I.	P
Maternal age (years)									
20-34	83.62%	<i>ref</i>				<i>ref</i>			
35 and older	16.38%	1.11	0.065	0.99 - 1.24	0.086	1.07	0.041	1.00 - 1.16	0.061
Maternal race									
Non-Hispanic white	69.61%	<i>ref</i>				<i>ref</i>			
Non-Hispanic black	13.66%	0.70	0.036	0.58 - 0.72	0.000	1.32	0.047	1.10 - 1.28	0.000
Hispanic	16.72%	0.49	0.026	0.42 - 0.52	0.000	0.80	0.034	0.75 - 0.89	0.000
Marital status									
Married	63.78%	1.25	0.062	1.13 - 1.38	0.000	0.98	0.033	0.92 - 1.05	0.648
Other	36.22%	<i>ref</i>				<i>ref</i>			
Medical insurance									
Private	41.66%	<i>ref</i>				<i>ref</i>			
Medicaid	58.34%	0.76	0.039	0.69 - 0.84	0.000	0.42	0.014	0.39 - 0.45	0.000
Maternal education (year)									
0-11	10.24%	<i>ref</i>				<i>ref</i>			
12	22.59%	1.13	0.078	0.99 - 1.30	0.067	1.22	0.061	1.11 - 1.34	0.000
13 and more	67.17%	1.58	0.109	1.38 - 1.80	0.000	1.42	0.070	1.30 - 1.57	0.000
Prenatal visit (Kotelchuck Index)									
Inadequate	10.67%	<i>ref</i>				<i>ref</i>			
Intermediate	11.62%	1.31	0.111	1.11 - 1.55	0.001	1.40	0.080	1.25 - 1.57	0.000
Adequate	47.61%	1.37	0.092	1.20 - 1.56	0.000	1.45	0.066	1.32 - 1.58	0.000
Adequate Plus	30.11%	1.46	0.102	1.27 - 1.67	0.000	1.51	0.072	1.38 - 1.66	0.000
Previous livebirth									
First livebirth	37.48%	0.71	0.031	0.65 - 0.78	0.000	1.02	0.030	0.96 - 1.08	0.522
Not first livebirth	62.52%	<i>ref</i>				<i>ref</i>			

Hispanic women showed significantly lower odds of perceiving perceived dental

problems compared to non-Hispanic white women (OR=0.61, 95% CI [0.55-0.67]), but there was no difference between non-Hispanic black women and non-Hispanic white women (Table 11). Women enrolled in Medicaid showed more than twice higher odds of the perceiving threats in a form of dental problems during pregnancy compared to women covered by private health insurance (OR=2.10, 95% CI [1.95-2.25]) when holding other socio-demographic and prenatal visit variables constant. Lastly, among women who perceived dental problems during pregnancy, there was no racial/ethnic difference in visiting a dentist to address the dental problems, which indicated met dental needs (Table 11). However, there was significant unmet dental needs among women enrolled in Medicaid. Women enrolled in Medicaid had 40% lower odds of meeting dental needs when they perceived dental problems compared to women covered by private health insurance (OR=0.60, 95% CI [0.53-0.68]). Women who were married at the time of birth had 43% higher odds in meeting dental needs compared to women who were not married (OR=1.43, 95% CI [1.27-1.62]). Higher prenatal visit score was also associated with higher odds in meeting the dental needs (Table 11).

Table 11. Multivariable logistic regression analysis for perceived threats and met dental needs

Respondent characteristic	Total %	Perceived threat of dental problem during pregnancy				Met dental needs during pregnancy*			
		O.R	S.E	95% C.I.	P	O.R	S.E	95% C.I.	P
Maternal age (years)									
20-34	83.62%	<i>ref</i>				<i>ref</i>			
35 and older	16.38%	0.94	0.038	0.87 - 1.02	0.156	1.05	0.090	0.89 - 1.24	0.544
Maternal race									
Non-Hispanic white	69.61%	<i>ref</i>				<i>ref</i>			
Non-Hispanic black	13.66%	0.94	0.038	0.87 - 1.01	0.106	0.92	0.063	0.80 - 1.05	0.219
Hispanic	16.72%	0.61	0.030	0.55 - 0.67	0.000	1.05	0.090	0.89 - 1.24	0.561
Marital status									
Married	63.78%	0.70	0.024	0.65 - 0.75	0.000	1.43	0.087	1.27 - 1.62	0.000
Other	36.22%	<i>ref</i>				<i>ref</i>			
Medical insurance									
Private	41.66%	<i>ref</i>				<i>ref</i>			
Medicaid	58.34%	2.10	0.075	1.95 - 2.25	0.000	0.60	0.038	0.53 - 0.68	0.000
Maternal education (years)									
0-11	10.24%	<i>ref</i>				<i>ref</i>			
12	22.59%	1.01	0.053	0.91 - 1.12	0.835	0.92	0.079	0.78 - 1.09	0.343
13 and more	67.17%	0.82	0.043	0.74 - 0.91	0.000	1.05	0.089	0.89 - 1.24	0.564
Prenatal visit (Kotelchuck Index)									
Inadequate	10.67%	<i>ref</i>				<i>ref</i>			
Intermediate	11.62%	1.01	0.062	0.90 - 1.14	0.833	1.48	0.165	1.19 - 1.84	0.000
Adequate	47.61%	0.95	0.047	0.86 - 1.04	0.258	1.55	0.133	1.31 - 1.83	0.000
Adequate Plus	30.11%	0.98	0.0497	0.89 - 1.08	0.665	1.57	0.138	1.32 - 1.87	0.000
Previous livebirth									
First livebirth	37.48%	0.75	0.023	0.70 - 0.79	0.000	1.07	0.064	0.95 - 1.20	0.266
Not first livebirth	62.52%	<i>ref</i>				<i>ref</i>			
* Women who did not go to a dentist during pregnancy to address a dental problem during pregnancy									

Combined effect of race/ethnicity and oral health beliefs

The interaction terms between race/ethnicity and perceived benefits, race/ethnicity and perceived barriers, and race/ethnicity and perceived threats were added separately to the baseline multivariate model one at a time to examine interaction between these variables (Table 12). There was a significant interaction between perceived oral health variables and racial/ethnic group, indicating that the relationship of race/ethnicity with dental visit during pregnancy varies by perceived oral health beliefs.

Compared to non-Hispanic white women who did not perceive the importance of oral health (the reference group), non-Hispanic black women without this perceived oral health benefit did not have a significant difference in dental visits when controlled for other socio-demographic variables and prenatal visit scores. With the perceived benefits, non-Hispanic white women had 4.8 times higher odds (OR=4.84, 95% CI [4.27-5.49]) in visiting a dentist during pregnancy compared to the reference group. Being non-Hispanic black, however, attenuated this positive association between perceived oral health benefits and dental visits. Non-Hispanic black women who perceived oral health benefits had 3.7 times higher odds in visiting a dentist during pregnancy compared to non-Hispanic black women who did not perceive these benefits (OR=3.69, 95% CI [2.95-4.62]).

There was an opposite pattern of association for perceived barriers, measured by self-reported dental coverage. Compared to non-Hispanic white women who perceived barriers in accessing dental care with a lack of dental coverage, non-Hispanic black women with this perceived barrier had 36% lower odds in visiting dentists (OR=0.64, 95% CI [0.53-0.76]). Non-Hispanic white women without these perceived barriers had 4.9 times higher odds (OR=4.86, 95% CI [4.53-5.21]) in visiting a dentist during pregnancy. Being non-Hispanic black women

accentuated this positive association, and non-Hispanic black women who reported they had dental coverage during pregnancy had more than 6 times higher odds of visiting dentists than the reference group (OR=6.35, 95% CI [5.32-7.57]).

Lastly, I examined the combined effect of perceived threats and race/ethnicity (Table 12). Non-Hispanic white women who perceived threats of dental problems had 1.4 times higher odds in visiting a dentist for cleaning during pregnancy compared to non-Hispanic white women did not perceive dental problems when holding socio-demographic and prenatal visit variables constant. Non-Hispanic black (OR=1.76, 95% CI [1.55-2.00]) were more likely to have a dental visit for cleaning when they perceived threats of dental problems compared to the reference group.

Table 12. Combined effect of oral health beliefs and race/ethnicity for dental visit during pregnancy.

Perceived oral health benefits X Race	OR
Not perceiving oral health benefits X White	1.00 (ref)
Not perceiving oral health benefits X Black	1.15 (0.89 – 1.47)
Perceiving oral health benefits X White	4.84 (4.27 – 5.49) **
Perceiving oral health benefits X Black	3.69 (2.95-4.62) **
Perceived barrier (lack of dental coverage) X Race	OR
Perceiving barriers (lack of dental coverage) X White	1.00 (ref)
Perceiving barriers (lack of dental coverage) X Black	0.64 (0.53 – 0.76) **
Not perceiving barriers (have dental coverage) X White	4.86 (4.53 – 5.21) **
Not perceiving barriers (have dental coverage) X Black	6.35 (5.32 – 7.57) **
Perceived threat (dental problems) X Race	OR
Not perceiving threats (no dental problems) X White	1.00 (ref)
Not perceiving threats (no dental problems) X Black	0.81 (0.75 – 0.87) **
Perceiving threats (dental problems) X White	1.41 (1.31 – 1.51) **
Perceiving threats (dental problems) X Black	1.76 (1.54 – 2.00) **

Adjusted for age, marital status, insurance type, education level, previous live birth, prenatal visit score

** p<0.001

Combined effect of medical insurance and oral health belief

In a separate model, I tested out the combined effect of oral health beliefs and insurance type, either Medicaid or private insurance (Table 13). Interaction analysis between oral health belief and insurance type found that perceived oral health benefits did not significantly moderate the association of Medicaid enrollment and dental visit during pregnancy. In contrast, compared to women with private insurance with perceived barriers in accessing dental care with a lack of dental coverage, women enrolled in Medicaid with such barriers had almost 50% lower odds in visiting dentist (OR=0.52, 95% CI [0.46-0.58]). Compared to the reference group, women with private insurance without this perceived barrier had more than 4 times higher odds in visiting dentists (OR=4.42, 95% CI [4.08-4.79]). Being enrolled in Medicaid accentuated this association. Medicaid-enrolled women without perceived barriers in accessing dental care had more than 6 times higher odds in visiting dentists during pregnancy (OR=6.03, 95% CI [5.49-6.62]). Again, Medicaid-private insurance disparity gap became wider when women perceived barriers in accessing dental care with a lack of dental coverage during pregnancy.

Table 13. Combined effect of oral health beliefs and health insurance type for dental visit during pregnancy.

Perceived oral health belief X Insurance Type	OR
Not perceiving oral health benefits	1.00 (ref)
Perceiving oral health benefits	4.62 (4.19 – 5.10) **
Perceived barrier (lack of dental coverage) X Insurance Type	OR
Perceiving barriers (lack of dental coverage) X Private Insurance	1.00 (ref)
Perceiving barriers (lack of dental coverage) X Medicaid	0.52 (0.46 – 0.58) **
Not perceiving barriers (have dental coverage) X Private Insurance	4.42 (4.08 – 4.79) **
Not perceiving barriers (have dental coverage) X Medicaid	6.03 (5.49 – 6.62) **
Perceived threat (dental problems) X Insurance Type	OR
Not perceiving threats (no dental problems) X Private Insurance	1.00 (ref)
Not perceiving threats (no dental problems) X Medicaid	0.49 (0.46 – 0.52) **
Perceiving threats (dental problems) X Private Insurance	1.34 (1.23 – 1.46) **
Perceiving threats (dental problems) X Medicaid	1.69 (1.56 – 1.83) **

Adjusted for age, marital status, race/ethnicity, education level, previous live birth, prenatal visit score

** p<0.001

Study Aim 2: Examine the association of additional perceived barriers related to provider availability, safety concerns, and affordability of dental care with dental service utilization during pregnancy.

Unadjusted bivariate analysis for overall study population characteristics and dental service utilization

Among the total study population of women who were 20 and older with a single live birth, a subpopulation of 1,943 women was created, who responded to an additional PRAMS standard oral health question. These women represented 149,829 women from five states (GA, MD, MN, MO, NY) between 2012 and 2015. The overall characteristics of this subpopulation were similar with those of the total study population for Study Aim 1 (Table 7) A few differences included greater proportion of non-Hispanic black women (20.6%) and smaller proportion of Hispanic women (11.0%) compared to the total population. Also, there was a lack of significant difference in mother's age between racial/ethnic groups (Table 14). Unlike the total study population, the unadjusted bivariate analysis did not show racial/ethnic disparities for dental service utilization and oral health belief variables (Table 15). The proportion of women who responded that they had at least one dental visit for cleaning (61.2%) during pregnancy was higher than that of the total population (51.8%) (Table 7). The most significant difference was observed with perceived dental needs. This subpopulation showed much greater proportion of women with perceived dental problems during pregnancy (94.9%), compared to the total study population (19.8%). Overall, this sub-population had less racial/ethnic disparities in dental service utilization and oral health beliefs, but greater dental needs during pregnancy compared to the total study population.

Table 14. Characteristics of the study cohort for the Study Aim 2.

Repondent Characteristics	Total		Non-Hispanic white		Non-Hispanic black		Hispanic		P
	n	Total %	n	weighted %	n	weighted %	n	weighted %	
State									
Georgia (GA)	11,842	7.90%							
Maryland (MD)	34,907	23.30%							
Minnesota (MN)	12,259	8.18%							
Missouri (MO)	48,798	32.57%							
New York (NY)	42,024	28.05%							
Maternal race									
Non-Hispanic white	102,409	68.35%							
Non-Hispanic black	30,902	20.62%							
Hispanic	16,518	11.02%							
									0.4463
Maternal age (years)									
20-34	127,300	84.96%	87,871	85.80%	25,522	82.59%	13,906	84.19%	
35 and older	22,529	15.04%	14,538	14.20%	5,380	17.41%	2,612	15.81%	
									0.0000
Marital status									
Married	73,253	48.89%	57,190	55.84%	9,247	29.92%	6,816	41.26%	
Other	76,577	51.11%	45,219	44.16%	21,655	70.08%	9,703	58.74%	
									0.0000
Medical insurance									
Private insurance	65,518	43.73%	52,720	51.48%	8,434	27.29%	4,364	26.42%	
Medicaid	84,312	56.27%	49,690	48.52%	22,468	72.71%	12,154	73.58%	
									0.0000
Maternal education (years)									
0-11	21,437	14.31%	11,566	11.29%	3,977	12.87%	5,893	35.68%	
12	44,382	29.62%	30,090	29.38%	9,764	31.60%	4,528	27.41%	
13 and more	84,011	56.07%	60,753	59.32%	17,161	55.53%	6,097	36.91%	
									0.0000
Prenatal visit (Kotelchuck Index)									
Inadequate	20,102	13.42%	11,413	11.14%	6,410	20.74%	2,279	13.80%	
Intermediate	17,779	11.87%	12,066	11.78%	3,806	12.32%	1,908	11.55%	
Adequate	66,896	44.65%	46,948	45.84%	12,576	40.70%	7,372	44.63%	
Adequate Plus	45,052	30.07%	31,982	31.23%	8,110	26.24%	4,960	30.03%	
									0.0207
Previous livebirth									
First livebirth	48,842	32.60%	36,148	35.30%	7,696	24.90%	4,999	30.26%	
									0.0121
Gender of baby									
Boy	77,130	51.48%	53,576	52.32%	15,041	48.67%	8,513	51.54%	
Girl	72,700	48.52%	48,833	47.68%	15,862	51.33%	8,005	48.46%	
									0.6210

Table 15. Dental service utilization and oral health beliefs by race/ethnicity.

Dental outcomes		Total %	Non-Hispanic White weighted %	Non-Hispanic Black weighted %	Hispanic weighted %	P
	Dental visit before pregnancy	50.51%	50.81%	50.35%	48.92%	0.9237
	Dental visit during pregnancy	61.20%	60.83%	61.28%	63.32%	0.8647
	Know importance of oral health during pregnancy	91.53%	92.65%	90.53%	87.92%	0.2289
	Have dental insurance during pregnancy	80.14%	80.76%	82.84%	71.25%	0.0229
	Have to see dentist for a problem during pregnancy	94.87%	95.35%	95.65%	90.47%	0.0668
*	Unmet dental needs during pregnancy	30.24%	29.52%	33.68%	28.11%	0.4232
*	Met dental needs during pregnancy	69.76%	70.48%	66.32%	71.89%	0.4232
Additional barriers in accessing dental care during pregnancy						
	Not able to find dentist accept pregnant patient	11.95%	9.53%	17.45%	16.65%	0.0012
	Does not think it is safe to go to dentist during pregnancy	15.11%	13.18%	20.16%	17.63%	0.0251
	Cannot afford to go to dentist	21.98%	20.95%	19.15%	33.66%	0.0024
Medicaid population						
**	Not able to find dentist accept Medicaid	22.47%	23.46%	21.96%	19.34%	0.6942

* Women who did not go to dentist during pregnancy among women who reported they have dental problem (observation = 1,837 representing 141,772)

** Women who could not find dentist who accept Medicaid among women enrolled in Medicaid (observation = 1,107 representing 84,311)

Unadjusted bivariate analysis for oral health beliefs: additional perceived barriers

For the additional perceived barriers in accessing dental care during pregnancy, there were significant racial/ethnic differences (Table 15). About one in eight women (12.0%) reported that they were not able to find a dentist during pregnancy, who accepted pregnant patients. Perceived barriers were higher in non-Hispanic black women (17.5%) and Hispanic women (16.7%) compared to non-Hispanic white women (9.5%) (χ^2 , $p=0.0012$). For perceived barriers concerning the safety of dental care during pregnancy, a greater proportion of non-Hispanic black women (20.2%) were concerned about the safety of dental service during pregnancy compared to non-Hispanic white women (13.2%) (χ^2 , $p=0.0251$). More than one in five women (22.0%) reported that they could not afford to go to a dentist during pregnancy, and a greater proportion of Hispanic perceived this barrier (33.7%) compared to non-Hispanic black women (19.2%) and non-Hispanic white women (21.0%) (χ^2 , $p=0.0024$). The Medicaid specific barrier question, “I was not able to find a dentist who accepts Medicaid,” was examined in a subset of 1,107 women who were enrolled in Medicaid at the time of birth and responded to this additional oral health question. These women represented 84,311 women enrolled in Medicaid in these five states. More than one in five women enrolled in Medicaid (22.5%) reported that they perceived barriers of inability in finding a dentist who accepted Medicaid during pregnancy. However, there were no significant difference in perceiving this barrier of Medicaid provider availability across racial/ethnic groups of Medicaid-enrolled women.

Multivariate logistic regression models for additional perceived barriers

Holding other socio-demographic variables constant, including age, marital status, insurance type, mother's education, prenatal visit scores, and previous live birth, non-Hispanic black women had 70% higher odds of perceiving barriers in finding a dentist who accepted pregnant patients compared to non-Hispanic white women (OR=1.70, 95% CI [1.07-2.68]) (Table 16). There was no significant difference between Hispanic and non-Hispanic white women. Women enrolled in Medicaid had more than 2.5 times greater odds in difficulty in finding dentist who accepted pregnant patients compared to women covered by private health insurance (OR=2.52, 95% CI [1.49-4.31]). On the other hand, there were no difference between racial/ethnic groups as well as between insurance types concerning safety of dental care during pregnancy when holding other socio-demographic variables constant. For the perceived barriers in affordability of dental care during pregnancy, Hispanic women reported significantly higher odds in perceiving this barrier compared to non-Hispanic white women (OR=1.62, 95% CI [1.02-2.55]). However, there was no difference in perceiving this barrier between women enrolled in Medicaid and women covered by private health insurance. In a subset of women enrolled in Medicaid, there was no difference in perceiving difficulty in finding a dentist who accepted Medicaid across racial/ethnic groups of women.

Multivariate logistic regression models for dental service utilization with additional perceived barriers

Next, I performed a multivariate logistic regression analysis to examine the association between a dental visit for cleaning during pregnancy with additional perceived barriers (Table 17). In the baseline model without additional perceived barriers, there were no significant difference between racial/ethnic groups or was there a difference in visit to a dentist during pregnancy between insurance types when holding other variables constant, including mother's age, race/ethnicity, marital status, insurance type, education level, prenatal visit scores and previous live birth (Table 17). Upon this baseline model, each perceived barrier was added to examine the association between these perceived barriers in accessing dental care during pregnancy (Table 18). Women who reported they had difficulties in finding a dentist who accepted pregnant patients had almost 70% lower odds in visiting a dentist for cleaning during pregnancy compared to women who did not perceive this barrier (OR=0.31, 95% CI [0.20-0.46]). A similar finding was observed for women enrolled in Medicaid. Women who perceived difficulty in finding a dentist who accepted Medicaid had 64% lower odds in visiting a dentist for cleaning during pregnancy compared to Medicaid-enrolled women who did not perceive this barrier (OR=0.36, 95% CI [0.24-0.52]). The perceived barriers in the safety of dental care during pregnancy had a significant association with a dental visit for cleaning during pregnancy. Women who perceived dental care was unsafe during pregnancy had 77% lower odds in visiting a dentist for cleaning during pregnancy compared to women who did not had this concern during pregnancy (OR=0.23, 95% C.I.[0.15 – 0.33]). Women who perceived difficulty in affording dental care during pregnancy had 82% lower odds in visiting a dentist for cleaning compared to women who did not report this perceived barrier (OR=0.18, 95% CI [0.14-0.25]).

Table 17. Multivariable logistic regression analysis for dental visit for cleaning during pregnancy

Respondent characteristics		Total %	Dental visit for cleaning (during pregnancy)			
			O.R	S.E	95% C.I.	P
Perceived Barrier						
	Cannot find dentist who accept pregnant pt	11.95%				
	Don't think it is safe to see dentist during	15.11%				
	Cannot afford cost for dental care	21.98%				
	Cannot find dentist who accept Medicaid					
Maternal age (years)						
	20-34	84.96%	ref			
	35 and older	15.04%	1.01	0.187	0.70 - 1.45	0.952
Maternal race						
	Non-Hispanic white	68.35%	ref			
	Non-Hispanic black	20.62%	1.26	0.195	0.93 - 1.70	0.141
	Hispanic	11.02%	1.49	0.347	0.94 - 2.35	0.088
Marital status						
	Married	48.89%	1.20	0.171	0.91 - 1.59	0.190
	Other	51.11%	ref			
Medical insurance						
	Private insurance	43.73%	ref			
	Medicaid	56.27%	0.88	0.136	0.65 - 1.19	0.416
Maternal education (years)						
	0-11	14.31%	ref			
	12	29.62%	1.37	0.288	0.91 - 2.07	0.134
	13 or more	56.07%	2.20	0.458	1.46 - 3.31	0.000
Prenatal visit (Kotelchuck Index)						
	Inadequate	13.42%	ref			
	Intermediate	11.87%	1.28	0.308	0.79 - 2.05	0.314
	Adequate	44.65%	1.96	0.384	1.33 - 2.88	0.001
	Adequate Plus	30.07%	2.19	0.444	2.47 - 3.26	0.000
Previous livebirth						
	First livebirth	32.60%	1.35	0.186	1.03 - 1.77	0.029
	Not first livebirth	67.40%	ref			

Table 18. Multivariable logistic regression analysis for dental visit for cleaning during pregnancy with additional perceived barriers

Respondent characteristics	Dental visit for cleaning (during pregnancy)					Dental visit for cleaning (during pregnancy)					Dental visit for cleaning (during pregnancy)*							
	Total %	O.R	S.E	95% C.I.	P	O.R	S.E	95% C.I.	P	O.R	S.E	95% C.I.	P	O.R	S.E	95% C.I.	P	
Perceived Barrier																		
Cannot find dentist who accept pregnant pt	11.95%	0.31	0.063	0.20 - 0.46	0.000													
Don't think it is safe to see dentist during	15.11%					0.23	0.044	0.15 - 0.33	0.000									
Cannot afford cost for dental care	21.98%									0.18	0.0275	0.14 - 0.25	0.000					
Cannot find dentist who accept Medicaid														0.36	0.069	0.24 - 0.52	0.000	
Maternal age (years)																		
20-34	84.96%	ref																
35 and older	15.04%	1.00	0.192	0.69 - 1.46	0.995	ref				1.01	0.200	0.69 - 1.49	0.948	ref	0.96	0.283	0.54 - 1.71	0.881
Maternal race																		
Non-Hispanic white	68.35%	ref				ref								ref				
Non-Hispanic black	20.62%	1.36	0.216	1.00 - 1.86	0.050	1.39	0.226	1.01 - 1.91	0.045	1.19	0.197	0.86 - 1.64	0.302	1.31	0.242	0.91 - 1.88	0.148	
Hispanic	11.02%	1.54	0.361	0.97 - 2.44	0.067	1.58	0.364	1.00 - 2.48	0.049	1.85	0.444	1.16 - 2.96	0.010	1.91	0.529	1.11 - 3.29	0.019	
Marital status																		
Married	48.89%	1.22	0.175	0.92 - 1.62	0.158	1.19	0.172	0.89 - 1.59	0.236	1.13	0.167	0.85 - 1.51	0.401	1.02	0.188	0.71 - 1.46	0.931	
Other	51.11%	ref				ref				ref				ref				
Medical insurance																		
Private insurance	43.73%	ref				ref				ref								
Medicaid	56.27%	0.96	0.148	0.71 - 1.30	0.809	0.93	0.146	0.68 - 2.15	0.627	1.13	0.167	0.84 - 1.51	0.401					
Maternal education (years)																		
0-11	14.31%	ref				ref								ref				
12	29.62%	1.20	0.256	0.79 - 1.82	0.399	1.38	0.313	0.89 - 2.15	0.155	1.32	0.295	0.85 - 2.05	0.214	1.54	0.367	0.97 - 2.46	0.069	
13 or more	56.07%	1.86	0.391	1.23 - 2.81	0.003	2.12	0.474	1.36 - 3.28	0.001	2.07	0.457	1.35 - 3.19	0.001	1.47	0.348	0.93 - 2.34	0.101	
Prenatal visit (Kotelchuck Index)																		
Inadequate	13.42%	ref				ref				ref				ref				
Intermediate	11.87%	1.19	0.296	0.73 - 1.94	0.474	1.27	0.317	0.78 - 2.07	0.334	1.17	0.300	0.71 - 1.93	0.542	0.93	0.281	0.52 - 1.68	0.817	
Adequate	44.65%	1.91	0.389	1.28 - 2.85	0.001	1.94	0.401	1.29 - 2.91	0.001	1.88	0.374	1.27 - 2.78	0.001	2.10	0.486	1.33 - 3.30	0.001	
Adequate Plus	30.07%	2.25	0.473	1.29 - 3.40	0.000	2.08	0.435	1.38 - 3.14	0.000	2.06	0.425	1.37 - 3.08	0.000	2.78	0.672	1.73 - 4.46	0.000	
Previous livebirth																		
First livebirth	32.60%	1.36	0.188	1.03 - 1.78	0.027	1.45	0.202	1.11 - 1.91	0.007	1.44	0.207	1.09 - 1.91	0.011	1.09	0.213	0.75 - 1.60	0.649	
Not first livebirth	67.40%	ref				ref				ref				ref				

* Women whose birth was paid by Medicaid and reported they could not find dentist who accept Medicaid (obs 1,107, representing 84,311 women)

Study Aim 3: Examine the association of various levels of Medicaid dental coverage with dental service utilization during pregnancy among women enrolled in Medicaid.

Unadjusted bivariate analysis for overall study population characteristics

The associations between state Medicaid dental coverage level and dental variables were examined in a subpopulation of 16,644 Medicaid-enrolled women who represented 966,768 women, using PRAMS and MSDA 2014 and 2015 datasets. Thirty states and NYC were categorized by their Medicaid dental coverage level for pregnant women 21 and older (Table 3): 1) No Medicaid dental coverage for cleaning (*no coverage*), 2) Medicaid dental coverage for dental cleaning and fillings (*limited coverage*), and 3) *comprehensive coverage*, that included cleaning, fillings, periodontal and endodontic for Medicaid-enrolled pregnant women age 21 and older.

About one in three women (31.6%) lived in states with no Medicaid coverage for dental cleaning for pregnant women (Table 19). Racial/ethnic distribution was significantly different among the three groups of states with different Medicaid dental coverage. States with no Medicaid dental coverage for pregnant women ages 20 and older had a greater proportion of Hispanic women (35.5%) compared to states with comprehensive Medicaid dental coverage (31.0%). Medicaid-enrolled women with no dental coverage were more likely to have inadequate prenatal visits (22.3%) compared to women with comprehensive coverage (16.7%). WIC enrollment was also higher among women with no dental coverage (76.4%) during pregnancy compared to women with comprehensive Medicaid dental coverage during pregnancy.

Table 19. Characteristics of the study cohort for the Study Aim 3: Women enrolled in Medicaid.

Respondant characteristics	Total		No coverage		Cleaning & fillings		Comprehensive		P
	n	Total %	n	weighted %	n	weighted %	n	weighted %	
Medicaid dental coverage									
No coverage for dental cleaning	305,356	31.58%							
Cleaning and fillings	206,015	21.31%							
Comprehensive dental coverage	455,429	47.11%							
Maternal age (years)									0.1258
20-34	845,581	87.46%	271,702	88.98%	178,787	86.78%	395,092	86.75%	
35 and older	121,218	12.54%	33,654	11.02%	27,228	13.22%	60,337	13.25%	
Race/Ethnicity									0.0105
Non-Hispanic white	451,367	46.69%	134,541	44.06%	96,687	46.93%	220,139	48.34%	
Non-Hispanic black	201,371	20.83%	63,112	20.67%	44,003	21.36%	94,256	20.70%	
Hispanic	314,062	32.48%	107,703	35.27%	65,324	31.71%	141,034	30.97%	
Marital status									0.9262
Married	362,131	37.46%	115,274	37.75%	76,572	37.17%	170,285	37.39%	
Other	604,668	62.54%	190,081	62.25%	129,443	62.83%	285,144	62.61%	
Maternal education, years									0.0555
0-11	203,771	21.08%	68,768	22.52%	43,021	20.88%	91,982	20.20%	
12	356,756	36.90%	117,649	38.53%	74,396	36.11%	164,711	36.17%	
13 or more	406,272	42.02%	118,939	38.95%	88,598	43.01%	198,735	43.64%	
Prenatal visit (Kotelchuck Index)									0.0000
Inadequate	175,967	18.20%	68,147	22.32%	31,637	15.36%	76,182	16.73%	
Intermediate	113,000	11.69%	32,619	10.68%	26,307	12.77%	54,074	11.87%	
Adequate	399,626	41.33%	124,571	40.80%	82,776	40.18%	192,279	42.22%	
Adequate Plus	278,206	28.78%	80,019	26.21%	65,294	31.69%	132,893	29.18%	
Previous livebirth									
First Child	277,170	28.67%	85,084	27.86%	58,486	28.39%	133,600	29.33%	0.5447
WIC enrollment									
Enrolled in WIC	710,373	73.48%	233,265	76.39%	151,820	73.69%	325,288	71.42%	0.0027

Unadjusted bivariate analysis for dental service utilization and oral health beliefs

Dental service utilization and oral health beliefs were examined by Medicaid dental coverage levels (Table 20). Overall, there was only 37.4% of women who reported a dental visit for cleaning during pregnancy, remarkably lower compared to prenatal visit. 81.8% of Medicaid-enrolled pregnant women had at least intermediate or higher prenatal visit scores. There was a significant linear relationship between dental visit for cleaning during pregnancy and state's Medicaid dental coverage level (Fig 12). Medicaid-enrolled women with no dental coverage were less likely to have at least one dental cleaning during pregnancy (26.7%) compared to women with limited dental coverage (36.6%) or comprehensive dental coverage (44.8%). This pattern of dental service utilization by state Medicaid dental coverage was also observed for dental visit prior to pregnancy.

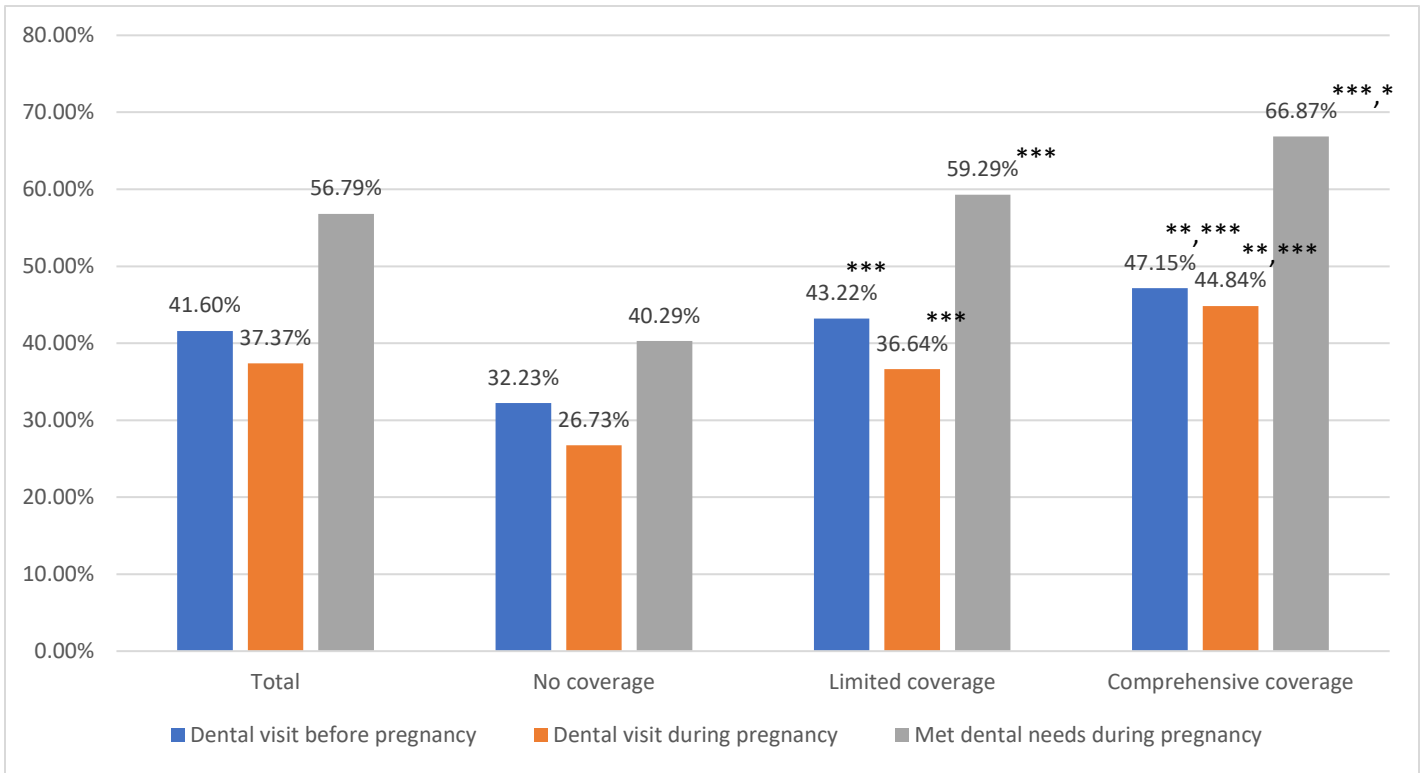
Women with no Medicaid dental coverage during pregnancy (81.8%) were less likely to perceive oral health benefits during pregnancy compared to women with limited dental coverage (88.1%) or comprehensive dental coverage (88.4%) (Table 20). Compared to women with limited dental coverage (64.4%) and comprehensive Medicaid dental coverage (77.0%), only two out of five women (39.9%) with no Medicaid dental coverage reported that they had dental coverage during pregnancy. There was no significant difference in the perceived threats of dental problems during pregnancy among women with different levels of Medicaid dental coverage. The met dental needs were analyzed among women who perceived threats of dental problems during pregnancy (observation= 4,807, representing 271,534). Women with no Medicaid dental coverage during pregnancy were less likely to meet dental needs (40.3%) compared to women with comprehensive Medicaid dental coverage (66.9%, $p < 0.0001$) (Fig 12).

Table 20. Dental service utilization and oral health beliefs by Medicaid dental coverage

Dental outcomes	Total %	No coverage weighted %	Limited coverage weighted %	Comprehensive coverage weighted %	P
Dental visit before pregnancy	41.60%	32.23%	43.22%	47.15%	0.0000
Dental visit during pregnancy	37.37%	26.73%	36.64%	44.84%	0.0000
Know importance of oral health during pregnancy	86.21%	81.78%	88.07%	88.35%	0.0000
Have dental insurance during pregnancy	62.60%	39.94%	64.39%	76.98%	0.0000
Have to see dentist for a problem during pregnancy	28.19%	28.67%	27.21%	28.32%	0.6500
* Unmet dental needs during pregnancy	43.21%	59.71%	40.71%	33.13%	0.0000
* Met dental needs during pregnancy	56.79%	40.29%	59.29%	66.87%	0.0000

* Women who reported they have dental problem (observation = 4,807, representing 271,534.)

Figure 12. Dental service utilization and met dental needs by Medicaid dental coverage level



* p < 0.05, reference: limited coverage

** p < 0.0001, reference: limited coverage

*** p < 0.0001, reference: no dental coverage

Multivariate logistic regression model for dental outcomes among women enrolled in Medicaid

When holding maternal age, marital status, mother's education, prenatal visit score, WIC enrollment, and previous live birth constant, Hispanic Medicaid-enrolled women had higher odds of the dental visit for cleaning during pregnancy compared to non-Hispanic white women (OR=1.19, 95% CI [1.04-1.37]) (Table 21). There was no difference between non-Hispanic black and non-Hispanic white women. Prenatal visit score was significantly associated with a dental visit during pregnancy, but WIC enrollment was not significantly associated with a dental visit during pregnancy.

In the subsequent analysis, I added the state Medicaid dental coverage variable into this baseline multivariate logistic regression model. Compared to women with no Medicaid dental coverage for cleaning during pregnancy, women with limited Medicaid dental coverage had 1.6 times higher odds in visiting a dentist for cleaning during pregnancy (OR=1.56, 95% CI [1.32-1.85]). Women with comprehensive Medicaid dental coverage had more than twice higher odds in visiting a dentist for cleaning during pregnancy compared to women without Medicaid dental coverage for cleaning (OR=2.22, 95% CI [1.91-2.59]) when holding other variables constant.

Table 21. Multivariable logistic regression analysis for dental visit for cleaning among Medicaid-enrolled women.

Respondent characteristics	Total %	Dental visit for cleaning (during pregnancy)				Dental visit for cleaning (during pregnancy)			
		O.R	S.E	95% C.I.	P	O.R	S.E	95% C.I.	P
Dental coverage level									
No coverage for cleaning	31.58%					ref			
Limited (cleaning and fillings)	21.31%					1.56	0.134	1.32 - 1.85	0.000
Comprehensive coverage	47.11%					2.22	0.173	1.91 - 2.59	0.000
Maternal age (years)									
20-34	87.46%	ref				ref			
35 and older	12.54%	1.08	0.093	0.92 - 1.28	0.350	1.05	0.089	0.89 - 1.24	0.569
Maternal race									
Non-Hispanic white	46.69%	ref				ref			
Non-Hispanic black	20.83%	1.08	0.067	0.96 - 1.22	0.217	1.09	0.069	0.96 - 1.24	0.163
Hispanic	32.48%	1.19	0.084	1.04 - 1.37	0.012	1.23	0.086	1.07 - 1.41	0.003
Marital status									
Married	37.46%	1.04	0.061	0.92 - 1.16	0.522	1.05	0.061	0.94 - 1.18	0.406
Other	62.54%	ref				ref			
Maternal education (years)									
0-11	21.08%	ref				ref			
12	36.90%	1.07	0.086	0.91 - 1.25	0.398	1.07	0.085	0.92 - 1.25	0.382
13 or more	42.02%	1.18	0.095	1.01 - 1.38	0.036	1.17	0.094	1.00 - 1.37	0.054
Prenatal visit (Kotelchuck Index)									
Inadequate	18.20%	ref				ref			
Intermediate	11.69%	1.47	0.159	1.19 - 1.82	0.000	1.40	0.151	1.13 - 1.73	0.002
Adequate	41.33%	1.43	0.123	1.20 - 1.69	0.000	1.37	0.119	1.16 - 1.63	0.000
Adequate Plus	28.78%	1.48	0.132	1.24 - 1.76	0.000	1.41	0.127	1.18 - 1.68	0.000
Previous livebirth									
First livebirth		0.99	0.061	0.88 - 1.12	0.874	0.98	0.060	0.87 - 1.10	0.740
Not first livebirth		ref				ref			
WIC enrollment									
Enrolled WIC		1.12	1.171	1.00 - 1.27	0.057	1.17	0.071	1.04 - 1.32	0.010
non-enrolled WIC		ref				ref			

Women with limited or comprehensive Medicaid dental coverage were more likely to perceive oral health benefits during pregnancy than women with no dental coverage during pregnancy (Table 22). Compared to women with no dental coverage, both women with limited (OR=1.57, 95% CI [1.25-1.98]) and comprehensive Medicaid dental coverage (OR=1.62, 95% CI [1.32-1.98]) had 1.6 times higher odds in perceiving oral health benefits during pregnancy. Compared to women with no dental coverage during pregnancy, women with comprehensive Medicaid dental coverage had more than five times higher odds of reporting dental coverage during pregnancy (OR=5.16, 95% CI [4.46-5.98]) (Table 23).

There was no significant difference in perceiving threats in the form of dental problems during pregnancy among women across different levels of state Medicaid dental coverage (Table 23). However, there was a difference in meeting dental needs during pregnancy by state Medicaid dental coverage when women perceived dental problems. Compared to women with no Medicaid dental coverage pregnancy, women with comprehensive Medicaid dental coverage had almost three times higher odds in meeting dental needs during pregnancy (OR=2.96, 95% CI [2.31-3.81]) when holding other variables constant. Women with limited Medicaid dental coverage had almost more than twice higher odds in meeting dental needs compared to women with no dental coverage (OR=2.12, 95% CI [1.60 – 2.81])

Table 22. Multivariable logistic regression analysis for oral health beliefs in Medicaid-enrolled women: perceived benefits and perceived barriers.

Respondent characteristics	Total %	Perceived oral health benefits during pregnancy				Perceived lack of barriers in accessing dental care during pregnancy			
		O.R	S.E	95% C.I.	P	O.R	S.E	95% C.I.	P
Dental coverage level									
No coverage for cleaning	31.58%	--			--	--			--
Limited (cleaning and fillings)	21.31%	1.57	0.184	1.25 - 1.98	0.000	2.72	0.225	2.31 - 3.19	0.000
Comprehensive coverage	47.11%	1.62	0.166	1.32 - 1.98	0.000	5.16	0.386	4.46 - 5.98	0.000
Maternal age (years)									
20-34	87.46%	ref				ref			
35 and older	12.54%	1.13	0.161	0.85 - 1.50	0.392	0.84	0.077	0.70 - 1.01	0.062
Maternal race									
Non-Hispanic white	46.69%	ref				ref			
Non-Hispanic black	20.83%	0.66	0.064	0.54 - 0.79	0.000	1.32	0.092	1.16 - 1.52	0.000
Hispanic	32.48%	0.46	0.047	0.37 - 0.56	0.000	0.88	0.073	0.82 - 1.11	0.113
Marital status									
Married	37.46%	1.11	0.106	0.92 - 1.34	0.256	0.87	0.056	0.76 - 0.98	0.027
Other	62.54%	ref				ref			
Maternal education (years)									
0-11	21.08%	ref				ref			
12	36.90%	1.17	0.141	0.93 - 1.49	0.179	1.28	0.113	1.07 - 1.52	0.006
13 or more	42.02%	1.58	0.193	1.24 - 2.01	0.000	1.27	0.112	1.07 - 1.51	0.007
Prenatal visit (Kotelchuck Index)									
Inadequate	18.20%	ref				ref			
Intermediate	11.69%	1.21	0.202	0.87 - 1.68	0.258	1.53	0.176	1.22 - 1.91	0.000
Adequate	41.33%	1.23	0.156	0.96 - 1.58	0.103	1.61	0.146	1.25 - 1.93	0.000
Adequate Plus	28.78%	1.44	0.193	1.10 - 1.87	0.007	1.57	0.150	1.31- 1.90	0.000
Previous livebirth									
First livebirth	28.67%	0.67	0.065	0.56 - 0.81	0.000	0.94	0.066	0.82 - 1.08	0.365
Not first livebirth	71.33%	ref				ref			
WIC enrollment									
Enrolled WIC	73.48%	1.13	0.113	0.93 - 1.37	0.228	1.44	0.094	1.27 - 1.64	0.000
non-enrolled WIC	26.52%	ref				ref			

Table 23. Multivariable logistic regression analysis for perceived threats and met dental needs among Medicaid-enrolled women.

Respondent characteristics	Total %	Perceived threat of dental problem during pregnancy				Met dental needs during pregnancy*			
		O.R	S.E	95% C.I.	P	O.R	S.E	95% C.I.	P
Dental coverage level									
No coverage for cleaning	31.58%	--			--	--			--
Limited (cleaning and fillings)	21.31%	0.91	0.079	0.77 - 1.08	0.298	2.12	0.305	1.60 - 2.81	0.000
Comprehensive coverage	47.11%	0.97	0.074	0.83 - 1.13	0.682	2.96	0.378	2.31 - 3.81	0.000
Maternal age (years)									
20-34	87.46%	ref				ref			
35 and older	12.54%	0.92	0.092	0.76 - 1.12	0.424	1.06	0.188	0.75 - 1.50	0.722
Maternal race									
Non-Hispanic white	46.69%	ref				ref			
Non-Hispanic black	20.83%	0.78	0.051	0.69 - 0.89	0.000	1.04	0.117	0.84 - 1.30	0.722
Hispanic	32.48%	0.47	0.041	0.39 - 0.55	0.000	1.01	0.151	0.75 - 1.35	0.964
Marital status									
Married	37.46%	0.73	0.047	0.65 - 0.83	0.000	1.26	0.141	1.01 - 1.56	0.043
Other	62.54%	ref				ref			
Maternal education (years)									
0-11	21.08%	ref				ref			
12	36.90%	1.03	0.089	0.87 - 1.21	0.771	1.03	0.146	0.78 - 1.36	0.836
13 or more	42.02%	1.03	0.089	0.87 - 1.22	0.760	1.01	0.144	0.76 - 1.33	0.951
Prenatal visit (Kotelchuck Index)									
Inadequate	18.20%	ref				ref			
Intermediate	11.69%	0.98	0.114	0.78 - 1.23	0.882	1.72	0.326	1.18 - 2.49	0.005
Adequate	41.33%	0.96	0.086	0.81 - 1.15	0.665	1.62	0.229	1.23 - 2.14	0.001
Adequate Plus	28.78%	0.95	0.087	0.80 - 1.14	0.591	1.69	0.246	1.27 - 2.25	0.000
Previous livebirth									
First livebirth	28.67%	0.78	0.053	0.69 - 0.89	0.000	1.15	0.135	0.91 - 1.45	0.231
Not first livebirth	71.33%	ref				ref			
WIC enrollment									
Enrolled WIC	73.48%	1.24	0.085	1.09 - 1.42	0.001	1.12	0.131	0.89 - 1.41	0.339
non-enrolled WIC	26.52%	ref				ref			

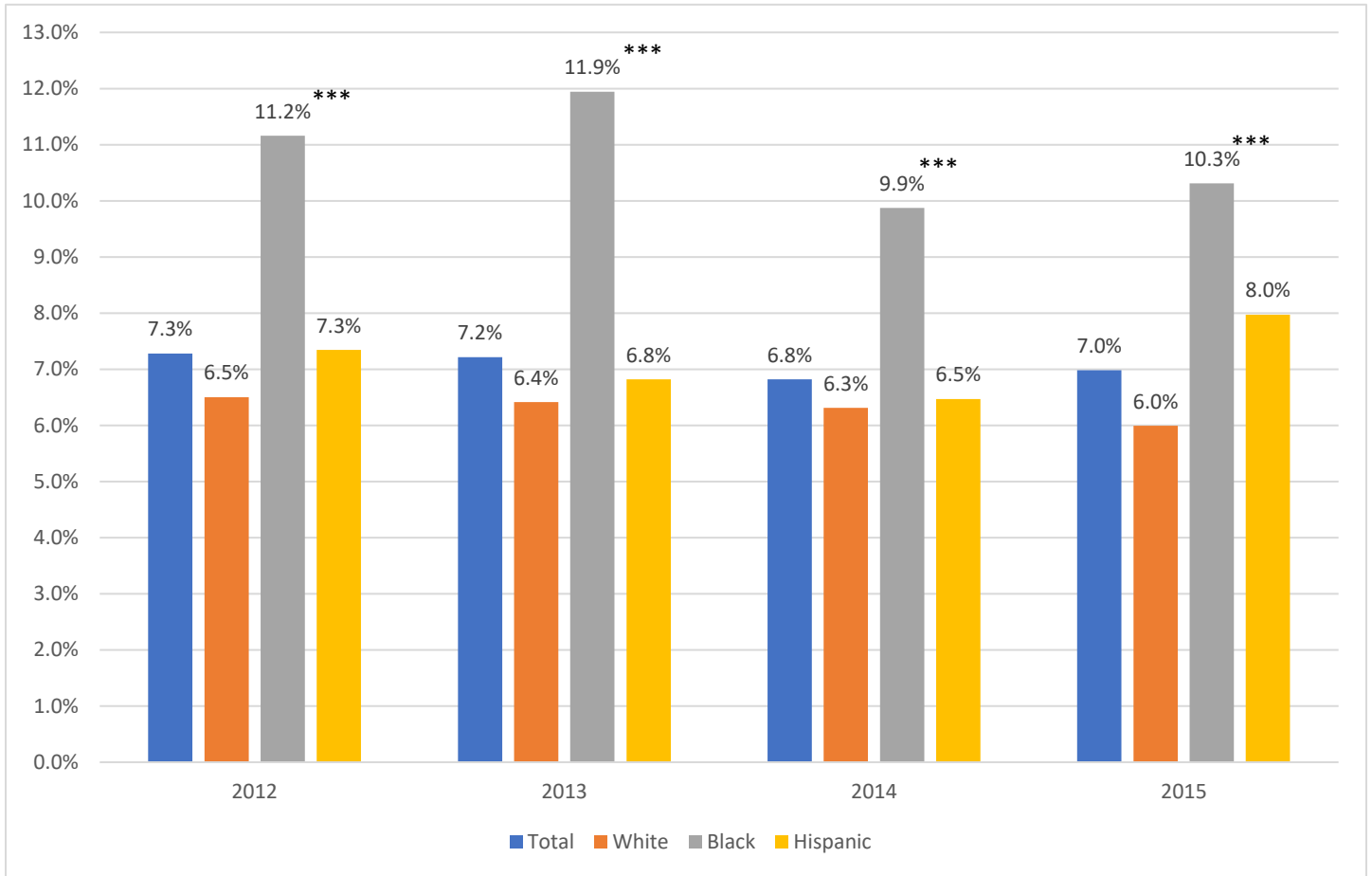
* Women who had to see dentist for a problem during pregnancy (obs 4,807, representing 271,534 women)

Study Aim 4: Examine the association of preterm birth outcomes with oral health beliefs and dental service utilization during pregnancy, considering other socio-demographic-behavioral and medical conditions.

Unadjusted bivariate analysis for overall characteristics

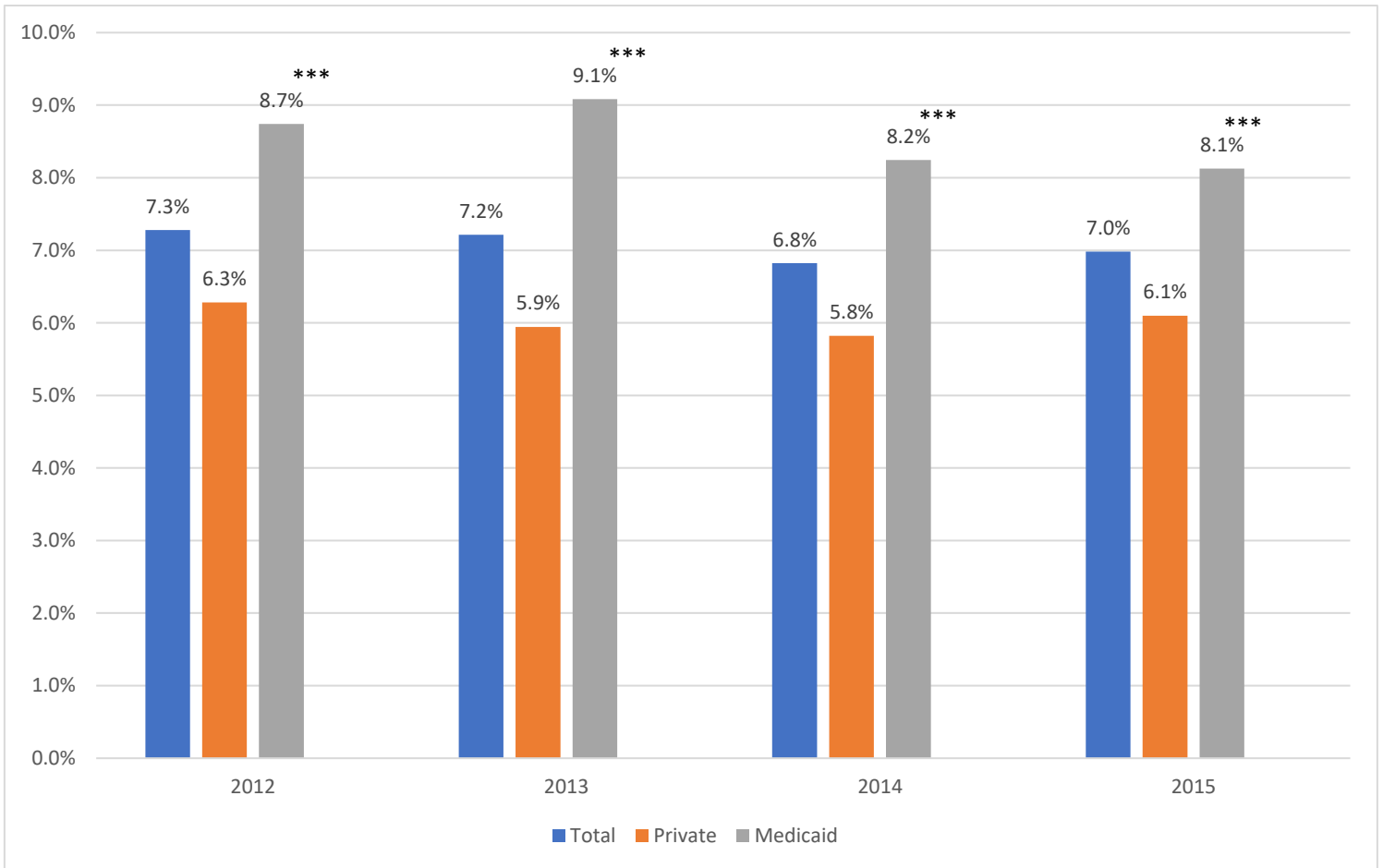
This analysis examined the association between dental variables and preterm birth outcomes. The analysis was performed on the same study population cohort as Study Aim 1; the total study population of 75,029 women with recent single liveborn birth who represented 4,599,366 women. Basic characteristics of race/ethnicity, marital status, insurance type, maternal education, and prenatal visit were listed in Table 7. Non-Hispanic white had a greater proportion of women who smoked at the time of delivery (11.8%) compared to non-Hispanic black women (7.9%) and Hispanic women (3.1%) (chi2, $p < 0.0001$). Non-Hispanic black women were more likely to have hypertension at the time of delivery (9.2%) compared to non-Hispanic white women (6.7%) and Hispanic women (5.6%). Non-Hispanic black women were also more likely to have previous preterm birth history (4.6%) compared with non-Hispanic white women (3.1%) and Hispanic women (3.5%). The overall preterm birth outcome was 7.1% of the total study population, and non-Hispanic black women had a significantly higher proportion of women with the preterm birth outcome (10.8%) compared to non-Hispanic white women (6.3%) and Hispanic women (7.3%) (chi2, $p < 0.0001$) (Table 7). The preterm birth rate over four-year period was examined by race/ethnicity (Fig 13), insurance type (Fig 14), and by state (Fig 15). Non-Hispanic black women and women enrolled in Medicaid consistently had higher preterm birth rates compared to other corresponding groups.

Figure 13. Preterm birth by race/ethnicity from 2012 to 2015



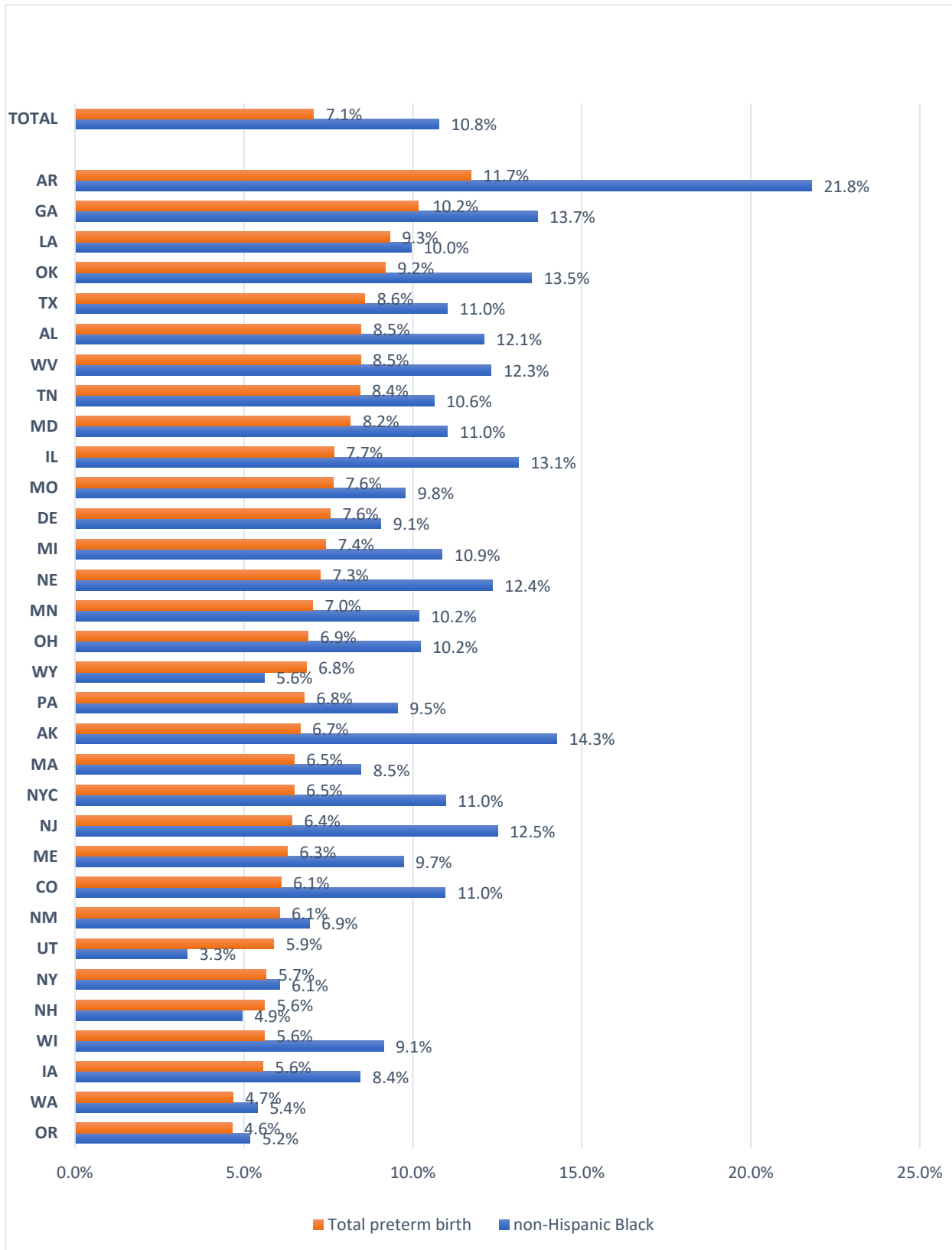
*** p < 0.0001 reference to non-Hispanic white women

Figure 14. Preterm birth by insurance type from 2012 to 2015



*** p < 0.0001 reference to women with private insurance

Figure 15. Preterm birth by state from 2012 to 2015



Unadjusted bivariate analysis for dental variable and preterm birth outcomes

Additional unadjusted bivariate analyses were performed between dental variables and preterm birth. The weighted percentage for preterm birth was calculated and tested with chi-square analysis for binomial responses to each dental variable (Table 24). Women who reported a dental visit for cleaning before (6.5%) and during pregnancy (6.4%) had a smaller proportion of women who had preterm birth outcomes compared to women without dental visits before pregnancy (7.9%) or during pregnancy (7.7%). This difference was statistically significant (chi2, $p < 0.0001$). Women who perceived oral health benefits had a significantly lower preterm birth rate (6.9%) compared to women who did not perceive the benefits (9.1%) (chi2, $p < 0.0001$). Women who perceived threats of dental problems during pregnancy had a significantly higher preterm birth rate (8.1%) compared to women who did not report these perceived threats (6.8%) (chi2, $p < 0.0001$) (Table 24).

Table 24. Unadjusted bivariate analysis for preterm outcome in relation to dental service utilization and oral health beliefs

Dental outcomes		Preterm Birth		
		n	Weighted %	P
Dental visit before pregnancy				0.0000
	Yes	176402	6.48%	
	No	148585	7.92%	
Dental visit during pregnancy				0.0000
	Yes	153459	6.44%	
	No	171528	7.74%	
Perceived benefits (Know importance of oral health during pregnancy)				0.0000
	Yes	285646	6.85%	
	No	39341	9.11%	
Perceived lack of barriers (Have dental insurance during pregnancy)				0.0441
	Yes	239586	6.92%	
	No	85401	7.51%	
Perceived threats (Have to see dentist for a problem during pregnancy)				0.0000
	Yes	74000	8.12%	
	No	250986	6.81%	

Multivariate logistic regression models for preterm birth outcomes

I performed multivariable logistic regression on preterm birth outcomes, holding other socio-demographic variables constant, including mother's age, race/ethnicity, marital status, insurance type, mother's education, prenatal visit score, medical conditions that were known to be preterm birth risk factors (hypertension, smoking, previous preterm birth), and previous live birth. Non-Hispanic black women had 62% higher odds of preterm birth compared with non-Hispanic white women (OR=1.62, 95% CI [1.47-1.80]); there was no significant difference in preterm birth outcomes between Hispanic and non-Hispanic white women. Women enrolled in Medicaid also showed 12% higher odds of preterm birth compared to women covered by private health insurance (OR=1.12, 95% CI [1.02-1.24]). Maternal education and prenatal visit score had a significant association with preterm birth outcomes. While women with intermediate (OR=0.50, 95% CI [0.42-0.60]) and adequate prenatal visit scores (OR=0.35, 95% CI [0.31-0.41]) had lower odds of preterm birth, women with adequate plus prenatal score had more than two times higher odds of preterm birth compared to women who had an inadequate prenatal visit score (OR=2.03, 95% C.I.[1.79 – 2.30]).

Next, I added each dental variable to this baseline multivariate logistic regression model, holding other socio-demographic and medical risk variables constant (Table 25, Table 26). The association with preterm birth was significant only for perceived benefits (OR=0.79, 95% CI [0.69-0.91]) (Table 20). When stratified by dental visit during pregnancy, the association of perceived oral health benefits with preterm birth was significant only among women who did not have a dental visit for cleaning during pregnancy (OR=0.81, 95% CI [0.70-0.96], p=0.013). Dental visit for cleaning during and before pregnancy was not significantly associated with lower preterm birth outcomes (Table 26).

Table 25. Multivariate logistic regression for dental variables and preterm birth outcomes.

Respondent Characteristics	Total %	Preterm Birth				Preterm birth			
		O.R	S.E	95% C.I.	P> t	O.R	S.E	95% C.I.	P> t
Perceived benefits (Know importance of oral health during pregnancy)									
Yes	90.61%					0.79	0.057	0.69 - 0.91	0.001
No	9.39%					ref			
Maternal age (years)									
20-34	83.62%	ref				ref			
35 and older	16.38%	1.19	0.061	1.07 - 1.31	0.001	1.19	0.061	1.08 - 1.32	0.001
Maternal race									
Non-Hispanic white	69.61%	ref				ref			
Non-Hispanic black	13.66%	1.62	0.084	1.47 - 1.80	0.000	1.60	0.084	1.45 - 1.78	0.000
Hispanic	16.72%	1.07	0.067	0.95 - 1.21	0.260	1.05	0.065	0.93 - 1.18	0.438
Marital status									
Married	63.78%	0.95	0.046	0.86 - 1.04	0.267	0.95	0.047	0.86 - 1.05	0.304
Other	36.22%	ref				ref			
Medical insurance									
Private insurance	58.34%	ref				ref			
Medicaid	41.66%	1.12	0.056	1.02 - 1.24	0.020	1.12	0.056	1.02 - 1.23	0.024
Maternal education (years)									
0-11	10.24%	ref				ref			
12	22.59%	0.88	0.069	0.75 - 1.03	0.102	0.88	0.069	0.76 - 1.03	0.109
13 or more	67.17%	0.76	0.058	0.65 - 0.88	0.000	0.77	0.058	0.66 - 0.89	0.000
Prenatal visit (Kotelchuck Index)									
Inadequate	10.67%	ref				ref			
Intermediate	11.62%	0.50	0.046	0.42 - 0.60	0.000	0.50	0.046	0.42 - 0.60	0.000
Adequate	47.61%	0.35	0.025	0.31 - 0.41	0.000	0.36	0.025	0.31 - 0.41	0.000
Adequate Plus	30.11%	2.03	0.129	1.79 - 2.30	0.000	2.05	0.129	1.81 - 2.32	0.000
Previous livebirth									
First livebirth	37.48%	1.26	0.053	1.16 - 1.37	0.000	1.25	0.053	1.15 - 1.36	0.000
Not first livebirth	62.52%	ref				ref			
Medical Conditions (at the time of delivery)									
Hypertension	6.97%	2.53	0.131	2.29 - 2.80	0.000	2.53	0.131	2.28 - 2.80	0.000
Smoking	9.78%	1.16	0.074	1.02 - 1.31	0.022	1.16	0.074	1.02 - 1.31	0.023
Previous preterm birth	3.37%	3.58	0.291	3.05 - 4.20	0.000	3.59	0.290	3.07 - 4.21	0.000

Table 26. Multivariate logistic regression analysis for perceived oral health benefits and preterm birth outcome.

	Total %	Preterm Birth			
		O.R*	S.E	95% C.I.	P> t
Dental service utilization					
Dental visit for cleaning prior to pregnancy	59.22%	0.93	0.038	0.86 - 1.01	0.092
Dental visit for cleaning during pregnancy	51.79%	0.93	0.037	0.86 - 1.00	0.075
Oral health belief					
Perceived lack of barriers (Have dental insurance during pregnancy)	75.28%	0.99	0.046	0.90 - 1.08	0.806
Perceived threats (Have to see dentist for a problem during pregnancy)	19.82%	1.06	0.051	0.97- 1.17	0.206
Perceived benefits (Know importance of oral health during pregnancy)	90.61%	0.79	0.057	0.69 - 0.91	0.001
Perceived benefits (among women with dental visit during pregnancy)**	55.21%	0.75	0.115	0.56 - 1.01	0.062
Perceived benefits (among women without dental visit during pregnancy)***	44.79%	0.82	0.066	0.70 - 0.86	0.013

*When controlled for age, race/ethnicity, marital status, insurance type, maternal education, prenatal visit, medical risks (hypertension, smoking, previous preterm history), and birth order (first live birth or not)

**Among 38,178 women representing 2,381,849 women who had a dental visit for cleaning during pregnancy

***Among 36,851 women representing 2,217,517 women who did not have dental visit for cleaning during pregnancy

CHAPTER 5

DISCUSSION

Racial/ethnic disparities and dental service utilization during pregnancy

This was a retrospective cross-sectional study on the PRAMS survey dataset on 75,029 women with a recent single live birth, who represented about 4.6 million women ages 20 and older. In this study population, about half of the women (51.8%) reported that they had at least one dental visit for cleaning during the most recent pregnancy (Table 8). This is an improvement from the previous multi-state study on PRAMS dataset from 2004 to 2006, where only 39.7% of women reported they had dental cleaning during the most recent pregnancy (37). CDC's PRAMS data on nine states in 2011 showed that 43.1% of women reported that they had a dental visit for cleaning during pregnancy (164). The current study's dental visit rate during pregnancy was also higher than state-based PRAMS analysis in West Virginia (129) and Maryland (128). However, it is alarming that about half of the women in the U.S. still do not or cannot access the most basic form of preventive dental care during pregnancy. When analyzed by state, the range of dental visit rate during pregnancy was wide, from 34.9% in Georgia to 64.6% in Massachusetts (Fig 9).

The racial/ethnic disparities in dental visit for cleaning during pregnancy persisted in this study, as shown in previous research (37). Unadjusted bivariate analysis showed that non-Hispanic black women (41.5%) and Hispanic (44.3%) women were less likely to visit a dentist for cleaning during pregnancy compared to non-Hispanic white women (57.4%). This racial/ethnic disparity pattern was observed in oral health beliefs during pregnancy as well. Unadjusted bivariate analysis showed that non-Hispanic black women and Hispanic women were less likely to perceive the importance of oral health benefits, and Hispanic women were more likely to perceive barriers in accessing dental care with a lack of dental coverage during

pregnancy (Table 8).

There were clear differences in racial/ethnic groups in their socio-demographic characteristics (Table 7). The majority of non-Hispanic black women (70.8%) and Hispanic women (49.6%) were not married at the time of birth compared to non-Hispanic white women (26.2%). The proportion of women with inadequate prenatal visits was also higher among non-Hispanic black women (17.9%) and Hispanic women (15.7%) compared to non-Hispanic white women (8.0%). The proportions of women who were enrolled in Medicaid at the time of birth and women who have not completed high school education were also significantly higher among non-Hispanic black women and Hispanic women. These patterns of socio-demographic characteristics across racial/ethnic groups were similar to the total survey population when women from all ages were counted without excluding women with any missing variables. Therefore, it was necessary to build multivariate regression models adjusted with these socio-demographic and prenatal visit variables to examine the association between dental service utilization and oral health beliefs across racial/ethnic groups.

The current study found that non-Hispanic black women had 15% lower odds in visiting a dentist for cleaning during pregnancy (OR=0.85, 95% CI [0.80-0.91]) compared to non-Hispanic white women when adjusted for mother's age, marital status, insurance type, mother's education, prenatal visit scores, and previous live birth (Table 9). There was no such difference between Hispanic women and non-Hispanic white women. In the previous PRAMS studies, both Hispanic and non-Hispanic black women had significantly lower dental service utilization for cleaning during pregnancy compared to non-Hispanic white women when adjusted for mothers' age, income, education, insurance type, and other variables (37). To further examine this racial/ethnic disparity in dental service utilization during pregnancy, especially among non-

Hispanic black women, multivariate logistic regression models were created, including oral health belief variables (Table 10, 11). When adjusted for other socio-demographic factors and prenatal visit scores, non-Hispanic black and Hispanic women were less likely to perceive the importance of oral health during pregnancy compared to non-Hispanic white women, but there was no difference in met dental needs.

The multivariate logistic regression analysis with interaction terms a significant interaction between perceived oral health belief variables and racial/ethnic groups, indicating that the relationship of race and dental visits during pregnancy varies by perceived oral health beliefs. The black-white disparity gap in dental visits during pregnancy became wider when women perceived barriers in accessing dental care during pregnancy with a lack of self-reported dental coverage. Compared to non-Hispanic white women who perceived barriers in accessing dental care with a lack of dental coverage, non-Hispanic black women with this perceived barrier had 36% lower odds in visiting dentists (Table 12). Being black accentuated the positive association of self-reported dental coverage and dental visits during pregnancy. Self-reported dental coverage, the indicator for perceived barriers in accessing dental care, had a stronger association with dental visits during pregnancy in non-Hispanic black women (OR=6.35) and non-Hispanic white women (OR=4.86). This association of perceived barriers in accessing dental care with dental visits confirmed the previous HBM studies, which found that perceived barriers in accessing care were shown to be a powerful predictor for health behavior (140, 142). The current study findings suggested that perceived barriers could be even more powerful predictor for non-Hispanic black women. The analysis also showed the associations of perceived oral health benefits during pregnancy was much stronger than the associations of dental visits with prenatal visit score or mother's educational level. This also confirmed the previous HBM research

findings stating perceived benefits have been considered the primary trigger of behavior change; in this case, dental service utilization during pregnancy (140).

Such disparities in dental visits during pregnancy or significant interactions between perceived barriers with a lack of dental coverage and dental visits during pregnancy were not observed between Hispanic women and non-Hispanic white women, which was contrary to the previous multi-state PRAMS study (37). Compared to non-Hispanic white women, non-Hispanic black women were less likely to perceive oral health benefits, less likely to perceive barriers in accessing dental care with self-reported dental coverage, and no difference in perceived threats in the form of dental problems (Table 10, 11). On the other hand, Hispanic women were less likely to perceive oral health benefits, were more likely to perceive barriers with a lack of dental coverage and were less likely to perceive threats than non-Hispanic white women. The oral health belief variables were less favorable in visiting a dentist for cleaning among Hispanic women than non-Hispanic black women based on HBM. However, Hispanic women showed no difference in dental visits for cleaning during pregnancy compared to non-Hispanic white women. A systemic review based on Rhode Island PRAMS data from 2012 to 2015 showed that Hispanic women had 38% higher odds for obtaining preventive dental care during pregnancy compared to the non-Hispanic white population when other demographic covariates in the study were taken into account (41). In another study on Hispanic populations, foreign-born Hispanics reported the highest oral health-related quality of life measures despite having the least access to dental care, but such finding was not present among US-born Hispanics (162). As PRAMS questions were not specifically designed to examine the oral health beliefs of women based on HBM, there were not enough questions to test and validate different aspects of oral health beliefs: perceived benefits, perceived barriers, perceived threats, and perceived self-efficacy.

Future PRAMS questionnaire can consider to modifying and adapting existing validated oral health belief measures and validate them for research studies on oral health beliefs during pregnancy (145, 165). Also, future research needs to further investigate the association of oral health and oral health care with the immigration history of Hispanics to understand how oral health beliefs and dental service utilization of Hispanic women are different from non-Hispanic black women and also among Hispanic women varied by their immigration history.

Both non-Hispanic black women and Hispanic women showed a stronger association of perceived threats with dental visits during pregnancy. This is an interesting finding as the multivariable logistic regression analysis showed no difference in perceiving dental problems during pregnancy between non-Hispanic white and non-Hispanic black women. Hispanic women were less likely to perceive such dental problems than non-Hispanic white women (Table 11). From the clinical perspective, this finding may suggest that these racial/ethnic groups may visit dentists through routine dental care and check-up when they perceive such dental problems and not prior to they perceive the problems. Future research needs to examine the periodicity of routine dental visits for cleaning in pregnant women from different racial/ethnic groups and if they report dental problems at their dental visit for cleaning. A prospective cohort study or quasi-experimental study may be able to identify temporal information between perceived oral health beliefs and dental services utilization.

In addition to these racial/ethnic differences in oral health beliefs, it is worth noting that women who had the first baby had significantly lower odds of perceiving oral health benefits during pregnancy compared to women who already have other children (OR=0.71, Table 10). Policymakers and researchers should identify and consider specific perceived barriers or lack of perceived benefits reported by the target pregnant women population to design programs that

address those barriers and meaningfully support pregnant women in accessing dental care during pregnancy. Moreover, a long-term policy analysis will be beneficial to understand the change in dental service utilization over time. The current study found that the trend of the dental visit for cleaning during pregnancy from 2012 and 2015 was decreasing (Fig 10), with a drastic reduction in dental visits among Hispanic women from 48.0% in 2014 to 39.8% in 2015. Future research needs to identify the root causes of such a trend by racial/ethnic groups and by insurance type: Medicaid vs. private dental insurance.

Additional perceived barriers: Provider availability, safety concerns, and affordability for dental care during pregnancy

Subpopulation analysis was performed on 1,943 women who responded to the additional PRAMS standard oral health question from 2012 to 2015. These women represented 149,829 women in states of GA, MD, MN, MO, and NY. While the overall characteristics of this subset of women were similar to those of the total study population for the core PRAMS survey analysis in Study Aim 1, this sub-population of women were more likely to perceive and report dental problems during pregnancy (94.9%) compared to the total study population (19.8%). Also, there was a lack of racial/ethnic disparities in dental visits during pregnancy when adjusted for mother's socio-demographic variables and prenatal visit scores (Table 17).

Among this subpopulation of women, about one in eight women (12%) responded that they were not able to find dentists who accepted pregnant patients. When adjusted for socio-demographic variables, including mother's age, marital status, insurance type, mother's education, prenatal visit score, and previous live birth, non-Hispanic black women had 70% higher odds of perceiving barriers in finding dentist who accepted pregnant patients compared to

non-Hispanic white women (Table 16). There was no difference in perceiving barriers in provider availability between Hispanic and non-Hispanic white women. It is worth noting that non-Hispanic black women were more likely to report dental coverage during pregnancy than non-Hispanic white women in this subpopulation (Table 15). Women who could not find a dental provider had 69% lower odds in visiting dentists for cleaning during pregnancy compared to women who did not perceive these barriers (Table 18). Medicaid-enrolled women perceived additional barriers in finding a dental provider who accepted Medicaid.

Dental coverage alone may not be enough to connect women to dental care during pregnancy. Care coordination and navigation should be carefully integrated into prenatal care programs to ensure that pregnant women with dental coverage can actually receive timely care by dental providers. While dental treatments are safe throughout pregnancy and effective in improving and maintaining oral health (34-36), dental providers may fear in providing dental services to pregnant patients, which includes radiographs and local anesthesia (151). Dental providers should be trained in the best practices of prenatal oral health care following the national and state guidelines, and they need to know that the consequences of not treating an active oral disease during pregnancy may outweigh the possible risk presented for standard dental care (166). Previous research has shown that dentists who were more knowledgeable about the connection between oral health and overall health during pregnancy were more likely to counsel pregnant patients (152). The consortium of dental schools and medical schools can embrace the national guidelines and prenatal oral health resources to educate the next generation of healthcare providers capable of improving the oral health of pregnant women. Besides, there needs to be a system and policy level supports in providing dental care for pregnant women as an integrated part of prenatal and primary care packets by creating quality oral health measures for pregnant

women and designing meaningful incentives for both patients and providers. To meet this need, the National Maternal and Child Oral Health Resource Center recently published a series of oral health quality measures for pregnant women in collaboration with national professional organization and the Department of Health and Human Services (167).

While 15% of women said they thought it was not safe to go to dentists during pregnancy, there was no difference in the perceived safety of dental care across race/ethnicity and between different insurance type when adjusted for other socio-demographic variables (Table 16). However, these women concerned about the safety of dental care during pregnancy had 77% lower odds of visiting a dentist for cleaning during pregnancy (Table 18). Therefore, it is critical to educate pregnant women about the importance of oral health and the safety of oral health care during pregnancy to encourage them to visit dentists. Both national and state prenatal oral health guidelines state that oral health care, including restorative and periodontal treatment, dental radiograph, and local anesthesia, is safe and effective at any time during pregnancy to improve and maintain the oral health of pregnant women (15, 34, 117, 132, 168). The fetal dose from a dental radiograph, including cone-beam CT, has been estimated to be between 0.009 milli-Sievert (μSv) and 7.97 μSv , which was less than the estimated daily natural background dose received by the fetus (169). The use of an apron with lead shielding and thyroid shield can reduce the dose to the fetus even further, and pregnancy should not be a reason to postpone clinically justified dental radiographic examination (169, 170). It is essential that care providers to communicate these guidelines and scientific findings in a way that pregnant women can understand to address this perceived barrier in accessing dental care during pregnancy.

The most significant perceived barrier in this analysis was the affordability of dental care during pregnancy. Women who perceived this barrier during pregnancy had 82% lower odds of

visiting dentists for cleaning than women who did not perceive the barrier (Table 18). The perceived affordability of dental care can be a distinct barrier, in addition to insurance dental coverage, as it is possible to perceive barriers in affording dental care even with dental coverage during pregnancy. Compared to most primary care and preventive services that are free or at low cost in most public or private health plans, the definition of primary or prenatal dental care has not been standardized, and the cost of the most evidence-based preventive and caries management procedures may not be affordable for adults beneficiaries. Commonly, diagnostic services, such as a 6-month dental exam, dental cleaning, and radiographs, are considered basic procedures. Restorations for dental caries, one of the most common dental problems, are often considered as surgical and specialty procedures with an annual limit in periodicity/frequency. Both public and private dental plans have a vast range of co-pay, deductible, and annual cap amount for dental procedures. Pregnant women may not consider dental care affordable even with dental coverage, with the vast differences in the definition of primary dental services and coverage variability and limitation. There is a clear need for future research to examine how different dental plans are associated with perceived affordability among pregnant women among different racial/ethnic groups and by insurance type to design dental coverage plans that meet the needs of pregnant women. Future research should also examine various beneficiaries' perceived barriers in accessing dental care during pregnancy to ultimately design dental plans and coordination of care that address such barriers in a meaningful yet effective way (Table 27).

Table 27. Perceived barriers in accessing dental care during pregnancy and structural racism

Perceived barriers	Research questions	Structural racism
Provider availability	<p>What are the barriers in finding dentists during pregnancy?</p> <ol style="list-style-type: none"> 1. Proximity 2. Work schedule 3. Clinic schedule not available 4. Not accepting pregnant patients 5. Provider in-network not available 6. Insurance not accepted (private insurance or Medicaid) 	<p>Systematic disinvestment in public and private sectors in the neighborhood</p> <p>Neighborhood not attractive for healthcare providers</p> <p>Public transportation is not accessible</p>
Affordability	<p>What are the barriers in affording dental care during pregnancy?</p> <ol style="list-style-type: none"> 1. Lack of dental insurance 2. Have dental insurance, but high co-pay, annual limit 3. Not sure about which services are covered 4. Work schedule 	<p>Administrative burden for insurance enrollment and comprehension (barriers with literacy and health literacy level)</p> <p>Dental insurance tied to employment</p> <p>Lack of public dental insurance</p>
Safety concerns	<p>What are the barriers in concerning the safety of dental care during pregnancy?</p> <ol style="list-style-type: none"> 1. Concern about harmful effect 2. Informed by providers or family member not to receive dental care 3. Concern specifically about radiographs 	<p>Lack of availability for the integrated oral health education by dental and medical providers</p> <p>Lack of oral health education in multi-language</p>

Overall, the analysis for Study Aim 1 and 2 revealed significant black-white disparities in dental service utilization during pregnancy, which was widened when non-Hispanic black women perceive barriers in accessing care with a lack of dental coverage or difficulty in finding providers. It is worth noting that extensive research has been conducted to identify this black-white disparity in prenatal visits (79, 171). A recent study on barriers in early prenatal visit for non-Hispanic black women reported that only 75% of non-Hispanic black women initiated prenatal care during the first trimester compared to non-Hispanic white women (89%) (171). The study quantified how various factors contributed to racial gaps in prenatal care by combining county-level U.S. census data with the Early Childhood Longitudinal Study. Socioeconomic characteristics like education and family income contributed more than half of this disparity in prenatal care initiation between non-Hispanic black and non-Hispanic white women (171). Other factors that contributed to this disparity included maternal age, number of previous pregnancies, and insurance types. Interestingly, prenatal care facilities' location explained about 8.3% of black-white gaps in the adequacy of care, but not for the disparity between Hispanic-white gaps. The geographical location of doctors and hospitals may matter for non-Hispanic black women to received prenatal care compared to non-Hispanic white women, but such difference was absent between Hispanic women and non-Hispanic white women. Other reports also pointed out that black women were more likely to experience stressful life events and racism before or during pregnancy than non-Hispanic white women (79), which could affect timely prenatal care utilization. Non-Hispanic black women may experience additional sources of stress and barriers in accessing dental services during pregnancy beyond the oral health beliefs and socio-demographic characteristics considered in the current study.

This findings from the current study and previous findings in prenatal care study calls for

future studies that centered around institutional racism or structural racism in a broader, societal perspective (172). Structural racism is defined as the totality of ways in which societies foster racial discrimination, via mutually reinforcing inequitable systems that in turn reinforce discriminatory beliefs, values, and distribution of resources (172, 173). It affects housing, education, employment, and access to health care. While there have been many efforts in conceptualizing structural racism, there is still a need to discuss structural racism as a root cause of racial health disparities. One of the main examples of structural racism is residential segregation, which can systemically lead to harmful exposure to environment, limited access to health care, utilization, and substandard quality of care (172). Black neighborhoods may not be able to attract healthcare providers and health-promoting resources, disproportionately exposing black residents to a racially-biased health care system. Previous research reported adverse birth outcomes among black women related to residential segregation and structural racism (174, 175).

Policymakers and providers should understand their target population by examining women's perceived barriers in accessing dental care during pregnancy. The solution to address the racial/ethnic disparities may include expanding dental coverage, as observed in the interaction analysis. However, it can be more than coverage. Non-Hispanic black women may face difficulties in finding dental providers in their community as observed in the subpopulation analysis. Policymakers should diagnose the inequity in dental service utilization with a systems perspective and design "community-specific" and "multisector" interventions as shown in the Purpose Build Community model in Georgia in 1995 (172). In addition to building a system that supports high-standard care facilities and providers to work in marginalized communities, policymakers should also invigorate non-health sectors that may affect timely access to prenatal dental and medical care. Those can include transportation, housing, and employment. As

structural racism deeply integrated into thoughts, behavior, and society of people, it needs to be tackled by a systems approach and perspectives of minorities.

Disparities in dental service utilization during pregnancy in Medicaid-enrolled women during pregnancy

In this study, women enrolled in Medicaid had 46% lower odds in visiting a dentist for cleaning during pregnancy compared to women with private health insurance when adjusted for socio-economic and prenatal variables constant, including mother's age, race/ethnicity, marital status, mother's education, prenatal visit score, and previous live birth (Table 9). Oral health disparities also persisted for all oral health belief variables among women enrolled in Medicaid. They were less likely to perceive oral health benefits, more likely to report perceived barriers in accessing dental care with a lack of dental coverage, and more likely to perceive dental problems during pregnancy when adjusted for other variables (Table 10, 11). When dental problems were perceived during pregnancy, this disparity was **compounded**. Women enrolled in Medicaid had 40% lower odds in visiting a dentist to address the dental problems compared to women covered by private health insurance when adjusted for race/ethnicity, prenatal visit scores, and other socio-demographic variables (Table 11).

Enrollment in Medicaid itself is a predictor for poor health outcomes as Medicaid beneficiaries share some of the key socio-demographic factors, such as low family income and inadequate health literacy, which can impact their access to health services (87-92). Pregnant women enrolled in Medicaid were shown to face even higher barriers in accessing dental care due to inconsistent dental coverage through the state Medicaid. In 2014, 28 states covered preventive dental services for adult Medicaid enrollees, and only 17 states provided

comprehensive adult dental benefits, including diagnostic, preventive, some restorative and surgical services, and periodontal therapies under the adult Medicaid program (11, 33). Some states have expanded dental coverage for pregnant Medicaid enrollees in addition to existing adult dental benefits through Section 1115 demonstration waivers or the Consolidated Omnibus Budget Reconciliation Act of 1985 (11, 33). However, in 2014, 13 states still did not cover for routine dental cleaning to Medicaid-enrolled pregnant women, which was the most basic preventive care (33, 161). While the evidence for the association between periodontal health and birth outcomes was growing, 21 states did not provide periodontal treatment coverage for pregnant women enrolled in Medicaid in the same year (33, 161). This is a systems-level barrier in accessing dental care for Medicaid-enrolled women. Dental care for adult pregnant women enrolled in Medicaid was often treated as an add-on or optional services, likewise dental coverage for Medicaid-enrolled adults. The current study also found a significant low dental service utilization among women enrolled in Medicaid, compared to their prenatal service utilization. While 81.8% of this Medicaid pregnant women had at least intermediate or higher prenatal visit scores, only about one-third of women (37.4%) reported that they had at least one dental visit for cleaning during pregnancy (Table 19, 20). Those dental care budgets for adult Medicaid-enrollees were often cut out when states faced financial constraints (11, 176). The list of dental services covered by Medicaid for pregnant women can also fluctuate depending on the state's budget status. When a state reduced or eliminated dental benefits, unmet dental needs and emergency dental visits among adult Medicaid enrollees increased, and utilization of preventive dental services decreased (11, 177, 178).

This study found a clear positive relationship between dental variables and the state's Medicaid dental coverage level (Fig 12). When adjusted for socio-demographic variables,

including mother's age, marital status, education level, prenatal visit score, WIC enrollment, and previous live birth, Medicaid-enrolled women with comprehensive dental coverage had twice higher odds to visit a dentist for cleaning and three times higher odds to meet the dental needs during pregnancy compared to women without dental coverage for cleaning during pregnancy (Table 21, 23). Previous studies showed that unmet dental needs and emergency dental visits among adult Medicaid enrollees increased, and utilization of preventive dental services decreased when a state reduced or eliminated dental benefits for their enrollees (11, 177, 178). The interaction analysis between oral health belief and insurance type found a significant interaction between perceived barriers and a lack of self-reported dental coverage and Medicaid enrollment during pregnancy. When women perceived barriers in dental care with a lack of dental coverage, privately-insured women had twice higher odds in visiting dentists for cleaning during pregnancy. With self-reported dental coverage during pregnancy, women enrolled in Medicaid had six times higher odds of visiting a dentist than the reference group of privately insured women without self-reported dental coverage (Table 13). Being enrolled in Medicaid accentuated the positive association of self-reported dental coverage with dental visits during pregnancy, and the study found that Medicaid-private insurance disparity gap in dental visits became narrower when they reported dental coverage during pregnancy.

The variability in dental coverage for Medicaid-enrolled women is a significant barrier in accessing dental care during pregnancy. While Medicaid exempts pregnant women from most of the out-of-pocket costs for primary care services, the level of dental coverage for pregnant women enrolled in Medicaid varies across states. Nine states had set an annual maximum cap amount for dental services, limiting access to timely and necessary dental care for Medicaid-enrolled adults (11). Pre-authorization for dental services also produced administrative burden

and turned providers away in signing up to serve Medicaid-enrolled patients (11, 33). There was also a system-level challenge. As non-mandatory care, states could define and change the definition for the amount, duration, and scope of the dental services covered for Medicaid-enrolled adults, including pregnant women. The definition of primary dental care has not been consistent across the state Medicaid program, and there is a strong need to streamline dental care coverage for Medicaid-enrolled women as for Medicaid-enrolled children. It is also critical to educate Medicaid-enrolled pregnant women about their dental coverage. In the current study, 23% of Medicaid-enrolled women in states that offered comprehensive dental coverage through Medicaid, and 36% of Medicaid-enrolled women in states that offered limited dental coverage responded that they did not have dental coverage during pregnancy (Table 20). If pregnant women did not perceive their dental coverage during pregnancy, it could act as a perceived barrier in visiting a dentist for routine care regardless of the actual coverage status.

The difference in perceived oral health benefits was observed by various levels of Medicaid dental coverage. Women with limited or comprehensive Medicaid dental coverage were more likely to perceive the benefits of oral health during pregnancy than women without Medicaid dental coverage after adjusted for other socio-demographic and prenatal visit score variables (Table 22). Possibly, women with Medicaid dental coverage received oral health education at their dental visit during pregnancy as oral health instruction is often provided with a dental exam and cleaning for the new or routine dental check-up visit. Future research with prospective study design should include temporal information of oral health education and dental visit during pregnancy to confirm how oral health beliefs and dental visit are related.

Provider availability was another significant factor besides dental coverage in accessing dental care during pregnancy for Medicaid-enrolled women. The current study found that these

barriers in finding dentists who accepted pregnant women were much stronger among women enrolled in Medicaid. Women enrolled in Medicaid had 2.5 times higher odds in difficulty finding dentists who accepted pregnant patients during pregnancy compared to women covered by private health insurance when adjusted for other socio-demographic variables and prenatal visit scores (Table 16). Moreover, more than one in five women enrolled in Medicaid (22.5%) could not find dentists who accepted Medicaid during pregnancy (Table 15). Medicaid-enrolled women who had difficulty in finding dentists had 64% lower odds in visiting a dentist for cleaning during pregnancy (Table 18). With a lack of awareness of prenatal oral health, dentists may have doubts and fears in providing dental care to pregnant women and turn them away unless they present urgent dental needs. Moreover, it is not mandatory for dental providers to accept Medicaid. In 2015, about one-third of dentists in the U.S. reported that they accepted patients enrolled in Medicaid or the Children's Health Insurance Program. However, the acceptance rate varied by dentist gender, age, and dental specialty (179). The proportion of dentists who accepted Medicaid ranged from 15.4% to 85.5%, depending on states (179). Administrative burdens in treating patients enrolled in Medicaid should be addressed along with the adequate Medicaid reimbursement rate. From the series of analyses on Medicaid-enrolled women, coordinated dental coverage and provider availability were found to be the primary culprits for the disparities in dental service utilization and oral health beliefs among women enrolled in Medicaid.

A multi-dimensional approach is critical from policy to practice levels to address these disparities among Medicaid-enrolled women during pregnancy. If states do not have dental coverage in place for Medicaid-enrolled pregnant women, they must carefully examine the evidence-based findings regarding oral health and oral health care during pregnancy. With coordinated support from the federal government and national organizations, states should define

primary dental services for pregnant women, as in the Medicaid dental coverage for children. Duration of coverage is another issue to be streamlined across states. Most dental coverage for Medicaid-enrolled pregnant women ends within 60 days after delivery. Postnatal oral health care and education for mothers were shown to be associated with improved oral health knowledge among mothers and young children's oral health (61-69, 180). Children of mothers with postnatal oral health education had fewer decayed surfaces up to one year after the intervention (180), and postnatal oral health education for the mother with a newborn child also changed the mother's feeding practices, such as the later introduction of sugary food or beverage (173). Therefore, dental coverage should be included in a postnatal primary care package for women enrolled in Medicaid, and the postnatal period should be carefully designed to be aligned with medical guidelines from national health professional organizations. With all these benefits and significance, it is critical for states to define a consistent and universal primary oral health care during and after pregnancy and integrate it into Medicaid programs.

States with existing limited or comprehensive Medicaid dental coverage policy for adult pregnant women need to identify specific barriers in accessing dental care during pregnancy to connect Medicaid beneficiaries to dental services. The current study found that more than 50% of women with limited or comprehensive dental coverage through state Medicaid did not access dental visits for cleaning during pregnancy (Table 20). If pregnant women do not know that they are eligible for dental coverage, the state Medicaid program should design prenatal oral health education programs to address those specific barriers. If there is difficulty in finding dental providers who provide dental care for pregnant women, states can implement various incentives and loan repayment programs to encourage dental providers to care for Medicaid-enrolled pregnant women. Besides residential segregation by structural racism, additional segregation by

class and socio-economic status limit access to timely and quality prenatal care, including dental care. Policymakers need to design supporting programs and incentives for high-quality providers and facilities to serve people in marginalized communities. These include the loan payment programs for dental faculty and dental providers willing to serve Health Professional Shortage Areas or incentives for dental providers who accept patients enrolled in Medicaid. Lastly, the administrative burden for the beneficiary should also be considered. A study on dental service utilization among Medicaid-enrolled pregnant women in Oregon found that the mean dental utilization rate decreased for pregnant women and non-pregnant women even with the expansion of coverage, possibly due to complex administrative processes in the enrollment and maintenance of Medicaid coverage (131). Care coordination and navigation should be culturally sensitive and appropriate for the target population's health literacy level.

Some innovative initiatives have addressed the barriers in dental service utilization among Medicaid-enrolled adults. In Iowa, all Medicaid enrollees received diagnostic dental care, and enrollees who received routine dental examinations per year became eligible to receive enhanced dental benefits (11). Teledentistry is another way to reduce barriers in accessing routine dental care, more so with the COVID-19 crisis. In 2015, California Medicaid started to pay for dental services delivered by hygienists in consultation with dentists through under remote dentist supervision (11). This strategy could reduce barriers to missing workdays or transportation for low-income pregnant women. In Minnesota and Alaska, mid-level dental providers have been created as new types of dental professionals to perform limited dental services at a lower cost and primarily serve people with low-income (11). These examples indicated that systems-level approaches could address the specific oral health needs of the Medicaid-population, including pregnant women.

There have been other national and international efforts in integrating oral health into existing health systems and community infrastructure, especially for underserved children. In the U.S., the Affordable Care Act incorporated dental benefits for children from low-income families as one of ten essential health benefits. Through this coverage, U.S. children enrolled in Medicaid can receive comprehensive dental care. Childsmile is Scotland's national oral health program for children, connecting children to primary care dental service providers from birth, including home support (181). It also applies fluoride varnish for children aged three and up in schools and nurseries of the most underserved areas, tackling the residential segregation of marginalized communities. It provides a basic oral hygiene kit with toothbrush and fluoridated toothpaste to every child by the age of five. In Indonesia, the national government uses a "dental Immunization" approach with online caries risk assessment tools to provide customized caries preventive interventions in collaboration with community members, schools, and partnering organizations. By positioning preventive dental intervention as the concept of "immunization," school principals and community leaders were trained and empowered in integrating oral health into the primary care and education sector. "Dental immunization" has expanded to a national program that is more understandable to health care professionals and community members (182). The future oral health program and policy should learn from these existing cases for children, and researchers need to build more evidence in improving oral health and total health outcomes for pregnant women to secure the oral health of women at child-bearing age and their children.

Preterm birth, dental service utilization, and oral health beliefs

The preterm birth outcomes were examined in association with dental utilization and oral health belief variables among the total study population of 75,029 women who represented about

4.6 million women ages 20 and older with recent history of single live birth from 2012 to 2015. The overall preterm birth outcome reported in the PRAMS-linked birth certificate data was 7.1%, and non-Hispanic black women had a significantly higher proportion of women with the preterm birth outcome (10.8%) compared to non-Hispanic white women (6.3%) and Hispanic women (7.3%) (Table 7). National data from the National Vital Statistics System showed that the preterm birth rate among black women was 13% in 2014 and 14% in 2016 while white women had a preterm birth rate of 9% both in 2014 and 2016 (78, 83, 183). The current study population had lower preterm birth rates across racial/ethnic groups compared to the national study as it excluded women younger than 20 and multiple gestations. When total PRAMS dataset including women with all ages and women with any missing variables except preterm birth outcomes were included, 8.5% of the total study population had a preterm birth and non-Hispanic black women had 12.1% of preterm birth outcome.

When adjusted for mother's socio-demographic variables as well as medical risks for preterm birth, including hypertension, smoking, and previous preterm birth history, non-Hispanic black women had 62% higher odds of preterm birth compared with non-Hispanic white women, which was consistent with previous research. Historically, preterm birth has been higher among black women. Race/ethnicity is interwoven with multiple social, economic, and cultural issues, and the precise cause of this disparity is not clearly known (184). Social determinants of health, such as maternal educational level, family income, housing situation, partner support as well as community factors can also play an important role in accounting for these disparities in preterm birth outcomes (79, 92, 185, 186). In the current study, women with intermediate and adequate prenatal visit scores had significantly lower preterm birth outcomes than women with inadequate prenatal visit scores. On the other hand, women who had adequate plus prenatal score categories

had more than two times higher odds of preterm birth outcome compared to women who had an inadequate prenatal visit (OR=2.03) (Table 25). These women may have more frequent prenatal visits than recommended for healthy pregnancy due to potential health risks, thus have a higher risk for preterm birth.

There was no difference in preterm birth outcomes in association with a dental visit during or prior to pregnancy in the multivariate regression model, holding other variables that were shown to be associated with preterm birth constant (Table 26). This finding was contrary to the previous multi-state PRAMS study based on the dataset from 2004 to 2006 (44). In this PRAMS study, women who did not receive dental cleaning were at higher risk for premature birth (OR=1.23) compared to women who had a dental visit for cleaning during pregnancy, when adjusted for age, income, education, insurance status before pregnancy, adequacy of prenatal care, smoking, multiple gestation, and maternal morbidities (diabetes, hypertension, placental problems, kidney/bladder infections). The current analysis found a significant association between perceived oral health benefits and preterm birth outcomes (Table 25). Women who perceived the importance of oral health during pregnancy had 21% lower odds of preterm birth compared to women who responded that they did not perceive the importance of oral health during pregnancy.

While the causality of preterm birth related to dental care cannot be generated from the current study analysis, the results can be interpreted in various clinical perspectives. First, it is unlikely that one-time dental visit for cleaning during pregnancy can improve the periodontal and prenatal outcomes of pregnant women. The majority of epidemiological studies have confirmed positive associations between periodontal disease and adverse birth outcomes (7, 19, 20, 24, 25, 28, 31). However, studies on treatment for periodontitis and improved birth outcomes were mixed

and inconsistent (7, 25, 32, 100-109, 111, 113-117). The recent Cochrane review concluded that access and utilization of periodontal treatment might not directly impact preterm birth outcomes, possibly due to heterogeneity of case definitions of periodontal disease and successful outcomes of periodontal treatment across studies, ineffective intervention, inappropriate timing of intervention, and irreversible damage from existing periodontitis (25). Secondly, it is important to note that access and utilization of dental care do not necessarily mean improved oral health, which should be measured by clinical exams. Multiple dental cleanings and oral health education could decrease gingivitis effectively in pregnant women measured by plaque and gingival index scores (118), which confirmed by clinical exams. This outcome was missing as clinical evaluation was not a part of the PRAMS survey. Lastly, it is not only treatment delivered at a dental facility but also daily oral hygiene practice, which is necessary to improve women's periodontal status. Pregnant women's health beliefs and attitudes towards oral health matters to improve home oral hygiene practice and outcomes. Previous research showed that higher oral health knowledge (perceived benefits) led to improved daily oral hygiene practice (42, 47, 139) and pregnant women who received oral health education and dental supplies showed a significant increase in the frequency of brushing and flossing their teeth and a marked reduction in the intake of high sugar drinks compared to the control group (135).

The current study's finding on the significant association of perceived oral health benefits and the preterm birth outcome may highlight the importance of perceived oral health belief as a potential precursor of good oral hygiene practice, including daily toothbrushing, flossing, and mouth rinse. Perceived oral health benefits may also play a more important role when women did not or could not visit a dentist for dental cleaning. When stratified by dental visits for cleaning during pregnancy, the current study showed that women who did not have a dental visit for

cleaning during pregnancy had a significant association of perceived oral health benefits with preterm birth outcomes (OR=0.81, p=0.013). It is also likely that women who visited dentist during pregnancy received oral health education, which possibly led to increased perceived oral health benefits. Future research with prospective study design will provide the temporal relationship between perceived oral health benefits, dental visits, and preterm birth outcomes.

This outcome should not be interpreted as oral health belief is more important than dental visits for cleaning in preventing preterm birth. In fact, preterm birth has complicated relationships with various factors in women's life (79). It is critical to realize that comprehensive and integrated oral health education and dental care should be designed and provided to pregnant women to improve oral health and possibly the health of pregnant women. Future research should examine home oral health practice, perceived oral health beliefs, and various forms of dental service utilization to identify the relationship between oral health and health outcomes, including birth outcomes.

Oral health beliefs, behavior, and barriers in pregnant women and continuity of oral health

The associations between oral health beliefs and dental service utilization were examined across racial/ethnic groups and different insurance type for women with a recent birth history. It is important to acknowledge that these elements are multi-directionally connected, along with vast arrays of socio-demographic factors beyond what were included in the study. While oral health beliefs can change health behavior as indicated in HBM, pregnant women's perceptions and attitudes toward dental care during pregnancy can change with interventions and the availability of accessible dental service (43, 48). Pregnant women who visited a dentist during pregnancy expressed a greater perceived benefit of oral health for themselves and their children,

and they were able to overcome fear and discomfort to access the service (130). Even without a lack of temporal information of events, the current study added valuable findings in the body of evidence regarding oral health beliefs and oral health disparities across race/ethnicity and among Medicaid-enrolled women.

Pregnancy is a golden opportunity to secure oral health of mothers and their children. Existing prenatal and postnatal programs should integrate oral health education through interprofessional approaches to help pregnant women and mothers of young children perceive the value of oral health, improve daily dental hygiene practice, and access to dental services during pregnancy. A pilot study with a home-visiting health education program for first-time mothers showed a significant increase in mothers brushing their children's teeth twice a day when oral health was integrated into prenatal care program (153). There was also a significant reduction in the mean number of dental caries among children up to two years old when oral health education was given with referral intervention or dental evaluation to pregnant women (62). A comprehensive approach with face-to-face oral health education with dental referrals through home visiting showed that children with mothers in the intervention group resulted in 1.5 times more likely to be caries-free. Children of mothers with prenatal oral health education and dental evaluation had increased oral health service uptake as well as improved oral health outcomes, including less dental caries (61). A longitudinal study which followed mother-child dyads from pregnancy to adolescence showed that the adolescents in the intervention group with periodic oral health education and care for mothers and children had a share of 89.6% caries-free dentition compared to the adolescents in the control group who revealed 56.7% of caries-free dentition (67).

A mother's knowledge of oral health and access to oral health care for herself and her baby can also critically impact the establishment of a dental home for her child. A dental home concept is derived from the American Academy of Pediatrics' definition of a medical home (187, 188). The American Academy of Pediatric Dentistry strongly recommends establishing a dental home for children as early as six months of age and no later than 12 months of age (156, 189). Previous studies have shown that children with a dental home are more likely to receive routine oral health care (190). Moreover, young children with a dental home had a reduced number of non-preventive dental treatments, minimizing the high-cost emergency department visits for dental and oral health-related issues (191-193). Taken together with findings from this study, pregnancy is a window of opportunity to secure and advance the oral health of women and their children. Efforts to reduce disparities in dental service utilization and oral health beliefs should be shared by both health care providers and policymakers.

Strengths & Limitations

This study analysis was based on two national datasets, CDC's PRAMS database, and MSDA National Profiles, to examine elements that affect dental service utilization during pregnancy. PRAMS is a nationally representative dataset, which includes both birth certificate variables and survey responses regarding their recent birth event. The study population represented almost half a million women with recent birth history. The last multi-state PRAMS data analysis on dental cleaning during pregnancy was published in 2012 based on PRAMS dataset from 2004 to 2006 (37). Therefore, the current analysis on 31 states and New York City for the dental variables during pregnancy was meaningful to update the status of dental service utilization during pregnancy. In addition, MSDA's State Medicaid dental coverage profiles were

mapped with PRAMS by state-level to examine how state Medicaid dental policy was associated with dental service utilization and unmet dental needs in pregnant women enrolled in Medicaid. This was the first study that cross-walked these two datasets by state-level to examine the association of Medicaid dental coverage level and dental service utilization during pregnancy.

The richness of information reported by women on oral health beliefs in accessing dental services during pregnancy provided meaningful insights in identifying specific barriers as well as disparities across race/ethnicity and different insurance types. Previous research focused on dental service utilization during pregnancy and its associated health outcomes based on claim and clinical data. Compared to these studies, the current study included a theory-based model of HBM and subject-reported oral health belief variables to understand the disparities in dental service utilization from the patient's perspective. Oral health beliefs were all shown to be significantly associated with dental service utilization during pregnancy, even after accounting for various socio-demographic factors. Health services and genetics were shown to contribute only 40% of premature death: behavior and social/environmental context were shown to be the major causes of determinants of premature death (194). To evaluate oral health care, we also need to understand perceived oral health benefits, perceived barriers in accessing timely dental care, and perceived threats of dental problems that may affect dental service utilization during pregnancy.

Patient-reported outcomes research plays a significant role in bringing patients' voices into research and policy design and understanding the target population's needs, especially women's perceived needs regarding oral health and access to timely dental care. Exploring and describing oral health beliefs can lead to improved systems of care and health promotion that are specific to the target populations: racial/ethnic groups, first-time mothers, or pregnant women

enrolled in Medicaid or WIC programs (195). The findings from the current study regarding to the association between perceived benefits and preterm birth outcomes pointed out the need for future research to include oral health beliefs in prenatal health care strategies. Future research should include data collection regarding home oral hygiene practice and other aspects of oral health beliefs that were not asked in the current PRAMS questionnaire.

There are limitations related to the retrospective cross-sectional study design. First, responses to the additional PRAMS oral health question were collected in five states only, comparing to the core questions that were asked in all states participated in PRAMS Phase 7. Therefore, future research needs to confirm the findings regarding the additional barriers in provider availability and safety concern of dental care among a larger national sample. Secondly, this retrospective cross-sectional analysis could not provide temporal information. Women could start to perceive the benefits of oral health after they had a dental visit during pregnancy, or they went for a dental visit because they perceived the benefits prior to dental visits during pregnancy. Future research with a prospective design should test the temporal relationships between oral health beliefs and dental service utilization during pregnancy. Lastly, subject-reported outcomes bring richness in information, but recall bias may be an issue as the mothers were surveyed two to four months after delivery. Also, perceived dental problems and reported dental visits were not able to be confirmed by medical records or clinical examinations. As dental caries and periodontal disease can present without perceived symptoms, it is possible that perceived dental problems were underestimated (196). On the other hand, if respondents intentionally selected answers that were socially desirable through mail or phone interview, variables such as dental visits or perceived oral health benefits could possibly be overestimated. Women's interpretations of survey questions could also vary by women's health literacy, English proficiency, and level of education

(197). Future prospective studies on oral health belief may be able to address the causal relationship between oral health belief and dental service utilization. In addition, those reported responses can be confirmed by clinical examinations and medical records to prevent either over- or under-estimation. There is also a limitation at a systems level. While MSDA provided national profiles of the straight Medicaid dental coverage, it is possible that Medicaid managed care plans provide additional dental benefits to Medicaid-enrolled women beyond state requirements (11, 198, 199). This information was not included in either PRAMS or MSDA datasets.

There are needs for future research on pre-pregnancy period. PRAMS dataset for the Phase 7 included only one question regarding a dental visit for cleaning prior to pregnancy. Recent studies showed that treatment for periodontitis during pregnancy may be too late to prevent placental colonization of intraoral pathogens that may affect fetoplacental unit (200). It may be important to conduct research among women at childbearing age to examine the association of dental service utilization and oral health beliefs in preconceptional period with adverse birth outcomes.

In this analysis, income variables from the PRAMS dataset were not included. There were a couple of reasons for this decision. In previous research, both family income and mothers' education levels were used as indicators for the socio-economic status. Income measures at a single point in time and based on the previous year's annual income can limit information about current economic advantage or disadvantage (201). Income is also known as a fluctuating demographic variable with unemployment, disability, or retirement (202). Unlike income, once education is attained, it stays for a lifetime without fluctuation and provides employment opportunity. When correlation between insurance type (Medicaid vs. private insurance) and income was tested, the correlation was significant with a Rho value of 0.65. Women enrolled in Medicaid were

assumed to have low income, from 21% to 221% of the federal poverty level, depending on the state, to be eligible for Medicaid (163). A model was built with an income-insurance combined variable, but this did not address the research question on the Medicaid-enrolled population during pregnancy. In addition, a J-shape relationship was found in the unadjusted bivariate analysis between income and dental visits for cleaning during pregnancy, where women with lowest income category and women in the higher income category had a higher dental visit rate during pregnancy compared to women with income level between these two groups. While income information is based on the past year, Medicaid enrollment eligibility encompassed multiple factors, such as current assets, current employment, and other federal assistance. Therefore, mother's education levels and insurance types were included in the analysis, but the mother's income variable was not included in the study design.

With mounting evidence of persisting disparities in dental service utilization during pregnancy, both public and private perinatal programs and policymakers should design oral health programs that address specific barriers that pregnant women perceive, especially for women from socially disadvantaged backgrounds (203, 204). It is time to recognize the importance of oral health as integral to total body health and create a meaningful and sensible oral health care system as an integral part of primary and perinatal care. This study highlighted important factors in the silent epidemic of oral diseases, especially among women from disadvantaged backgrounds. Future research should integrate perceived oral health beliefs of women into the analyses to help advance the integration of oral health and health of women during pregnancy.

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EDUCATION

University of Maryland B.S. in Psychology, 2006

Harvard School of Dental Medicine, Doctor in Dental Medicine, 2010

Johns Hopkins Bloomberg School of Public Health, Master in Public Health, 2013

AcademyHealth Delivery System Science Fellowship, Health Service Research, 2018

Johns Hopkins Bloomberg School of Public Health, Doctor in Public Health in Health Policy and Management (expected graduation in Aug 2020)

CURRENT POSITIONS

Assistant Clinical Professor, Mount Sinai Hospital Adolescent Health Center & Icahn School of Medicine

Dec 2018 – Present

- Perform health service research on nationally representing maternal health database
- Develop integrative prenatal programs in Mount Sinai Health System
- Teach residents in health service research and design, clinical skills, treatment planning, patient management, and health education program development
- Mentor MS MPH student for capstone project.
- Consult Tanzania prenatal oral health study design and policy development consulting with the Ministry of Health, Tanzania

Quality Indicator Advisory Team, Center for Oral Health Systems Integration and Improvement (COHSII),

Sept 2017-Present

- COHSII is a consortium led by the National Maternal and Child Oral Health Resource Center at Georgetown University (GU) and is supported by a cooperative agreement from the Maternal and Child Health Bureau of the Health Resources and Services Administration.
- Develop health outcomes measures for children and maternal populations in collaboration with CMS, HRSA/MCHB, and other national professional entities.

Co-Chair of the Executive Oral Health Workgroup Member, World Federation of Public Health Association (WFPHA) Oral Health Committee

Feb 2015 - Present

The WFPHA is an international, nongovernmental organization representing around 1 million public health professionals worldwide. WFPHA is accredited as an NGO in official relations with the World Health Organization

- Develop oral health policy resolutions with international oral health experts for national public health association to adopt
- Develop strategic collaboration to integrate oral health into public health at a national level in various countries.

Executive Director, Mtree Inc

Aug 2012 - Present

- Full-time, 30 hours/week
- Directly supervise 7 directors and contractors in planning and operation.
- Develop health and education program for children and youth in rural Kenya
- Develop strategic collaboration in implementing program with more than 250 volunteers
- Analyze the program outcomes and develop strategic partnerships
- Advise to Tanzania Ministry of Health in program development and evaluation tool design.

PREVIOUS POSITIONS

**HEALTH RESOURCES AND SERVICES ADMINISTRATION (HRSA),
DEPARTMENT OF HEALTH AND HUMAN SERVICES (HHS), ROCKVILLE, MD
Public Health Analyst (GS-12)**

U.S. Public Health Service Commissioned Corps Officer

October 2010 – May 2014

Publication of a National Guideline: Oral Health during Pregnancy (2010-2012)

- Served as a subject matter expert and program manager for the National Consensus: Oral Health during Pregnancy in collaboration with HRSA, National Institutes of Health, Centers for Diseases Control and Prevention, American Dental Association, American Academy of Obstetrics and Gynecology, and other national organization.
- Manage health center oral health program consultation and technical assistance that demonstrated an understanding of both health center needs and program policy

Dental Consulting and Technical Assistance

- Managed health center oral health program consultation and technical assistance that demonstrated an understanding of both health center needs and program policy
- Co-coordinated BPHC Oral Health Policy discussion
- Performed a literature review and policy analysis to develop a scope of dental services cross-walk document.

Health Center Dental Program Analysis

- Performed gap analysis for health center oral health program data to improve quality of care and data integrity.
- Developed an oral health quality measure summary document outlining current oral health measures efforts by Dental Quality Alliance, the Office of the National Coordinator, the Center for Medicare & Medicaid Services, National Quality Forum, and others.

HHS Oral Health Strategic Plan Development

- Analyzed HHS oral health activities with a HHS Oral Health Strategic Plan
- Participated in publication of the HHS Oral Health Strategic Plan

Dental Consulting and Agency-wide oral health program coordination

- Supported the Office of Administrator in HRSA cross-cutting oral health related activities.
- Performed data research, prepare oral health reports, and reviews documents that may pertain to access, oral health service delivery, compensation, and workforce development.
- Analyzed the agency's need for use in the management and direction of the agency's programs.
- Provided technical assistance to HRSA staff in development, maintenance, analysis, and distribution of oral health resources and programs.
- Served as a planning committee member for the Interprofessional Oral Health Core Clinical Competencies meetings to develop core domains of oral health training for non-dental primary care providers.

Collaboration with other Departmental and Federal agencies to promote oral health by building public-private partnerships

- Collaborated with the National Migrant and Seasonal Head Start Collaboration Office and the HRSA Data Warehouse to develop an online interactive map tool for migrant populations to assist in finding community health centers in close proximity to migrant head start sites.

- Served as the HRSA coordinator for Healthy People 2020 oral health objectives and provide oral health expertise to Healthy People 2020 Federal Interagency Workgroup including the review of Healthy People 2010 oral health chapter.

Assessment of the impact of quality initiatives in the community, especially for the uninsured, underserved, and special needs populations.

- Collaborated with the National Quality Forum and Dental Quality Alliance to identify oral health performance measures to be tested.

Project Officer for the National Cooperative Agreement (NCA) between HRSA and the National Network for Oral Health Access (NNOHA)

- Managed the NCA to achieve its goals and objectives to advance oral health care for safety-net populations by providing training and technical assistance to HRSA grantees, including the Interprofessional Oral Health Core Clinical Competencies demonstration project.

Healthy People 2020 Oral Health Objective Federal Interagency Workgroup Co-coordinator

Jun 2011 – May 2014

- Reviewed Healthy People 2010 Oral Health Chapter.
- Coordinated health center oral health data reporting to the workgroup.
- Participated in various Healthy People 2020 activities that meet the Healthy People 2020 oral health goals.

Prenatal Oral Health Program “Smile for Two!” developed and implemented through CenteringPregnancy program in East Harlem and Bronx, New York

Jun 2014 – May 2016

- Developed a set of modules for oral health education integrated into CenteringPregnancy prenatal model
- Evaluated the effect of in-person integrated oral health module to dental service utilization among low-income pregnant women
- Trained care providers in family medicine and OB/GYN in providing core oral health messages and preventive intervention for young children.
- Trained oral health providers and administrative staff at the Institute of Family Health based on the National Consensus: Oral Health during Pregnancy to provide best practice care to pregnant patients referred by primary care providers

Visiting Researcher

Sept 2016- Jun 2017

- Analyzed health disparities in Marriage-Immigrant women in South Korea
- Evaluated a public-private partnership initiative on Marriage-Immigrant women from 2010 to 2016 and published the program outcomes

AcademyHealth, Delivery System Science Fellow

Sept 2017- Dec 2018

- Analyzed 13 state Medicaid claim data and studied racial/ethnic disparity studies in maternal and child health focusing on preterm birth
- Presented at AcademyHealth annual conferences, Dissemination & Implementation annual conferment, and National Health Policy Conference.

AWARDS & CERTIFICATION OF APPRECIATION

- U.S. Public Health Service, Ernest Eugene Buell Dental Award – Distinguished dental award for junior officers
- Achievement Medal, U.S. Public Health Service, for the contribution to develop a National Consensus Statement, Oral Health Care During Pregnancy
- HRSA Honor Awards, Administrator’s Citation for Outstanding Group Performance with the Advancing Oral Health Care Quality Measurement
- HRSA Team Award for being a member of the Office of Special Health Affairs
- Jimmy Carter Academic-Service Entrepreneur Award

PUBLICATIONS & PRESENTATIONS

- **Lee H, Okunev I, Tranby E, Monopoli M. (2020)** “Different levels of associations between medical co-morbidities and preterm birth outcomes among racial/ethnic women enrolled in Medicaid 2014-2015: Retrospective Analysis.” *BMC Pregnancy and Childbirth* Jan 13;20(1):33. doi: 10.1186/s12884-020-2722-8.
- **Lee H, Seo S, Kang R, Kim Y, Hyun HK. (2019)** "Increasing Access to Oral Health Care for Marriage-Immigrant Women in South Korea: Program Design to Policy Recommendation" *International Dental Journal*. Oct;69(5):354-460
- Center for Oral Health Systems Integration and Improvement Quality Indicator Advisory Team (**QIAT**), National Maternal and Child Oral Health Resource Center, Dental Quality Alliance. 2018. *Oral Health Quality Improvement for the Maternal and Child Health Population: Identifying a Set of Quality Indicators*. Washington, DC: National Maternal and Child Oral Health Resource Center, and Chicago, IL: Dental Quality Alliance.
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