REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	4.Aug.03	THESIS

4. TITLE AND SUBTITLE
"MATERNAL PERIODONTAL DISEASE AND PRETERM, LOW BIRTH WEIHGT INFANTS IN AN AIR FORCE POPULATION"

5. FUNDING NUMBERS

6. AUTHOR(S)
COL BARTOLONI JOSEPH A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
UNIVERSITY OF TEXAS HSC HOUSTON (SAN ANTONIO)

8. PERFORMING ORGANIZATION REPORT NUMBER
CI02-1215

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
THE DEPARTMENT OF THE AIR FORCE
AFIT/CIA, BLDG 125
2950 P STREET
WPAFB OH 45433

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION AVAILABILITY STATEMENT
Unlimited distribution
In Accordance With AFI 35-205/AFIT Sup 1

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

20030812 049

14. SUBJECT TERMS	15. NUMBER OF PAGES
	51
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT

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MATERNAL PERIODONTAL DISEASE AND PRETERM, LOW BIRTH WEIGHT INFANTS IN AN AIR FORCE POPULATION

By

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THESIS

Presented to the Faculty of the University of Texas

Health Science Center at Houston

School of Public Health

in Partial Fulfillment

of the Requirements

for the Degree of

MASTER OF PUBLIC HEALTH

THE UNIVERSITY OF TEXAS HEALTH SCIENCE CENTER AT HOUSTON
SCHOOL OF PUBLIC HEALTH
Houston, Texas
May, 2003

ACKNOWLEDGMENTS

I would like to express my sincere thanks and appreciation to my thesis committee, Dr. Teshia G. Arambula-Solomon and Dr. William D. Spears for their guidance, and assistance with this project. I would like to also acknowledge the staff of the Office of Prevention and Health Services Assessment at Brooks Air Force Base, San Antonio, Texas for providing me with the data for this thesis. Finally, I want to thank my dear wife for her continuous love and support. Her constant encouragement and strength have aided me during this endeavor and throughout my career. I am sincerely grateful for her presence.

Thesis submitted to the M.P.H. Committee on March 31, 2003.

MATERNAL PERIODONTAL DISEASE AND PRETERM, LOW BIRTH WEIGHT INFANTS IN AN AIR FORCE POPULATION

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In the United States, preterm, low birth weight (PLBW) infant deliveries are the leading cause of perinatal complication, and are the greatest single determinant of perinatal/neonatal morbidity and mortality. Several recent studies have indicated an association between maternal periodontal (gum) disease and adverse pregnancy outcomes, in particular, PLBW. The suggested mechanism for this phenomenon includes: translocation of periodontal pathogens to the fetoplacental unit, action of a periodontal reservoir of lipopolysaccharides on the fetoplacental unit, or action of a periodontal reservoir of inflammatory mediators on the fetoplacental unit. The purpose of this study was to examine the relationship between maternal periodontal disease (PD) and PLBW infants in a United States Air Force (USAF) female population. A retrospective population-based study was used utilizing analytic observation methods. The study sample included all active duty females in the USAF between the ages of 18-34 giving birth to a single infant between January 2001-June 2002, extracted from existing data sets (containing no identifiers) from Brooks Air Force Base, San Antonio, TX. PLBW was defined as less than 37 weeks gestation and/or less than 2,500 grams. Normal birth weight (NBW) was defined as greater than 37 weeks gestation and greater than 2,500 grams. PD was defined as one or

more sextants with a Periodontal Screening and Recording (PSR) score of 4. PLBW and NBW mothers were identified from existing data sets and cross-checked for periodontal disease. Data analysis included descriptive statistics, chi-square test, univariate/multivariate logistic regression analyses and odds ratio with 95% confidence intervals. Based on the data available in this study, an association between the clinical measurement of maternal PD using the PSR system and PLBW was not found. However, this investigation did show an association between race and PLBW, even after controlling for multiple risk factors.

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STUDY AIM

The purpose of this study was to determine if there was an association between maternal periodontal (gum) disease and the delivery of preterm, low birth weight infants in a selected United States Air Force (USAF) female population. The independent (outcome) variable "preterm, low birth weight (PLBW)" was defined as an infant delivered live that weighed less than 2,500 grams and/or had a gestation period less than 37 weeks. The dependent (exposure) variable "periodontal disease (PD)" was defined as a Periodontal Screening and Recording (PSR) score of 4. The following variables were statistically controlled in this study: age, race, and history of smoking. The null hypothesis was that there were no significant differences in the prevalence of PLBW infants in women with PD compared with periodontally healthy women.

BACKGROUND

Preterm, low birth weight

In the United States, preterm birth accounts for 11 percent of all pregnancies, and is responsible for the majority of neonatal deaths and approximately one half of all cases of congenital neurologic disability (McCormick, 1985). Seventy percent of neonatal and infant deaths can be attributed to preterm births (Pschirrer, 2000). Despite large-scale public health and medical advances, no measurable improvement in preterm births has occurred during the past decade (Ventura, 1996; Goldenberg, 1998a). Preterm birth is defined as a gestational age of less than 37 weeks (World Health Organization, 1977), which may result in low birth weight (LBW) defined as a birth weight less than 2500 grams (World Health Organization, 1984). Infants who are small or are born early have increased morbidity and mortality, and the more extremely early or small they are, the higher the risk (Wilcox, 1992). Shapiro (1980) found that low birth weight infants are much more likely to die in the first year and represent the majority of all infant deaths.

Epidemiologic and clinical studies of pregnancy often consider a variety of related, overlapping outcome measures with the magnitude strongly dependent on the severity of prematurity and size. Using the criteria for preterm and LBW, Savitz (2000) found that 69.2 percent of all LBW infants are preterm and 49.8 percent of preterm infants are also LBW. Using a hybrid index called preterm low birth weight (PLBW), combining shortened gestation with small size, Savitz (2000) found that PLBW represented 67.7 percent of all LBW infants, and 49.8 percent of all preterm infants.

PLBW infants are 40 times more likely to die during the first four weeks after birth (Shapiro, 1980). It is estimated that $5 billion is spent annually for infant intensive care in the treatment of PLBW (National Center for Health Statistics, 1982). Petrou (2001) revealed that PLBW can result in substantial costs to the health sector following the infants initial discharge from the hospital, even among non-disabled survivors. They can also impose a substantial burden on special education and social services, on families and caretakers of the infants, and on society in general. Surviving PLBW infants have a higher rate of severe neurodevelopmental disturbances (Bryrne, 1993; Fitzharding, 1976), health problems (such as asthma, upper and lower respiratory infections, and ear infections) (Hack, 1983; McCormick 1993), congenital anomalies (Christianson, 1981) and behavioral problems (Breslau, 1996; McCormick, 1990; Brandt, 1992).

Risk factors for PLBW include: maternal age; older (>34 years) and younger (<17 years); African-American ancestry; low socioeconomic status; inadequate prenatal care; drug, alcohol, and tobacco use; hypertension; genitourinary tract infections; diabetes mellitus; and multiple pregnancies. Approximately 25 percent of PLBW deliveries occur with unknown etiology. (Committee to Study the Prevention of Low Birthweight, 1985).

Preterm delivery is usually due to: premature labor and/or preterm rupture of the membranes (80% occurrence), or maternal/fetal complications (20% occurrence) (Main, 1988). Both preterm labor and premature rupture of the membranes are closely associated. It is quite common for preterm labor to result in rupture of the membranes, and most patients with rupture of the membranes proceed quickly to preterm labor (Blanco, 2000). Also, if an unfavorable intrauterine environment for the fetus or a dangerous environment

for the mother is found, the fetus is intentionally delivered early to prevent morbidity or mortality of the mother and fetus.

The rate of PLBW has not decreased in this country primarily due to a poor understanding of the antenatal factors that contribute to this health problem. Due to the impact of the high public health costs associated with PLBW, and significant increases in morbidity and mortality, a better understanding of the predisposing factors and causes of PLBW are indicated. Multiple studies have shown five common clinical findings associated with preterm labor including: normal physiological processes happening early, hemorrhage, placental ischemia/stress, inflammation, and infection (Lockwood, 1995).

The association between infection and PLBW

Evidence from several sources support a link between subclinical infection and prematurity (Gibbs, 2001). Uterine bacterial infections can occur between maternal tissues and fetal membranes (choriodecidual space), within the fetal membranes (amnion and chorion), within the placenta, within the amniotic fluid, or within the umbilical cord of the fetus (Goldenburg, 2000). Supporting evidence can be categorized as follows: the prevalence of histologic chorioamnionitis is increased in preterm birth (Hillier, 1988; Williams, 2000); clinically evident infection is increased in mothers and newborns after preterm birth (Daikoku, 1981; Seo, 1992); there are significant associations of some lower genital tract organisms/infections with preterm birth or preterm rupture of the membranes (Martin, 1982; Hardy, 1984; Minkoff, 1984; Gibbs, 1992; Hillier, 1995; French, 1999); positive cultures of the amniotic fluid or membranes are common in some patients with preterm labor/birth (Duff, 1987; Watts, 1992); there are numerous biochemical markers of

infection in preterm birth (Romero, 1987; Bennett, 1987); bacteria or their products induce preterm birth in animal models (Dombroski, 1990; Romero, 1991); and some antibiotic trials have shown a lower rate of preterm birth or have prolonged gestation (Cohen, 1990; Ryan, 1990; French, 1999).

In a normal birth, intra-amniotic levels of prostaglandin E2 (naturally occurring hydroxy fatty acid) and tissue necrosis factor alpha (naturally occurring immunity byproduct) rise throughout pregnancy until reaching a critical threshold level. This then results in labor, cervical dilation, and delivery. With infection, the biological mechanism involves bacterial-induced activation of cell-mediated immunity leading to cytokine production and synthesis and release of prostaglandins. These events appear to trigger preterm labor. Elevated levels of cytokines (interleukin-l alpha and interleukin-1 beta), and tumor necrosis factor alpha have been found in the amniotic fluid of patients in preterm labor with amniotic fluid infection. These cytokines are potent inducers of both prostaglandin synthesis and labor. Higher amniotic fluid prostaglandins also occur among patients in preterm labor with amniotic infection (Goldenberg, 2000).

Goldenberg (2002) found that late spontaneous preterm births do not usually occur in association with infection, but rather at birth less than 30 weeks. The most common identified organisms in spontaneous labor are: *Ureaplasma urealyticum, Mycoplasma hominis, Gardnerella vaginalis, Peptostreptococci, and Bacteroides* spp (Hauth, 1998). New studies have shown that intrauterine exposure to bacteria is associated with long-term neonatal complications, including cerebral palsy, bronchopulmonary dysplasia, and respiratory distress syndrome. This results from intrauterine exposure of the fetus to

infection leading to fetal production of cytokines, resulting in fetal cellular change to the brain and lung (Gibbs, 2001).

The suspected link between subclinical infection and preterm birth is that microorganisms or their byproducts pass into the uterine cavity during pregnancy by ascending from the lower genital tract or via the bloodstream from a non-genital source. The microorganisms or their byproducts then interact in the decidua or the membranes leading to prostaglandin production or directly to uterine muscle contractions, via the cytokine cascade. This results in cervical dilation and premature birth. Potentially, cytokines produced at a remote site of infection may enter the uterine cavity stimulating prostaglandin synthesis.

Periodontal disease

Periodontal disease (PD) is a chronic bacterial infection that causes a local and systemic response (resulting from a bacteremia). PD includes gingivitis (nondestructive form) and periodontitis, and is initially caused by bacteria found in plaque (sticky, colorless film that forms on teeth). Gingivitis, the mildest form of PD, results in reddened, swollen gingiva (gums) that bleeds easily and is often caused by inadequate oral hygiene. This condition is reversible with professional treatment and sound oral home care. If untreated, gingivitis can lead to periodontitis. In periodontitis, chronic plaque accumulation results in bacteria that produce toxins further irritating the gingiva. The toxins stimulate a chronic inflammatory response, which results in the destruction of the supporting structures of the teeth including the periodontal ligament, bone and soft tissues. This results in apical migration of the gingiva along the root surface or clinical attachment loss, deepened

pockets, and crestal bone loss that affects the gingiva and bone supporting the teeth. The results of periodontitis are irreversible, but professional treatment can halt further tissue destruction in most cases. If untreated, periodontal disease can result in tooth loss.

Epidemiologic studies show that gingivitis is ubiquitous both in children and adults (Albandar, 2002). Albandar (1996) found that 82.1 percent of adolescents and about half of U.S. adults had gingival bleeding (Albandar, 1999a). In spite of the widespread occurrence of gingival inflammation, most children and adolescents do not develop periodontitis, which is seen in only a subset of the population (about 35 percent of adults in the U.S.) (Albandar, 1999b).

The following risk factors are most directly associated with increases in prevalence and severity of PD: (1) gender, men experience greater prevalence levels and severity than women; (2) socioeconomic status, a higher education and greater income predicts lower levels; (3) number of teeth, more teeth per person experience greater severity; (4) smoking, heavy smokers have greater severity; and (5) age, older adults exhibit more loss of attachment than younger adults. Recently, diabetes mellitus has been found to be a risk factor (Douglass, 1996).

The pathogenesis of periodontitis involves five principles (Kornman, 1996).

1. Bacterial plaque is essential for the initiation of periodontitis.
2. The principal clinical signs of disease are the result of an activated inflammatory and immune response rather than direct effects of bacteria.
3. The quantity of bacterial plaque and the types found in plaque do not by themselves appear to explain the severity of the clinical disease.

4. The host factors responsible for clinical signs of disease appear to be influenced by both genetic factors and acquired factors that exert prolonged stress on the host.

5. Because different host responses may translate the bacterial challenge in different ways, the response to therapies focusing on reduction of bacterial challenge may produce different results in different individuals.

The pathogenic processes of PD are largely the result of the host response to microbially induced tissue destruction. These destructive processes are initiated by bacteria but are propagated by hosts cells. Thus, it is the host response that results in the destruction. The host produces enzymes that break down tissue (Kinane, 2001).

About 300 to 400 bacterial species have been found in the oral cavity. Of that number, approximately 10-20 species may play a role in the pathogenesis of destructive PD (Socransky, 1994). The oral microbes involved in periodontal disease are largely gram-negative anaerobic bacilli with some anaerobic cocci, and a large quantity of anaerobic spirochetes. The main microorganisms linked with destructive periodontal lesions are *Porphyromonas gingivalis, Prevotella intermedia, Bacteroides forsythus, Actinobacillus actiniomycetemcomitans and Treponema denticola* (Zambon, 1996).

Dental plaque serves as the environment for bacteria to coexist and interact in a biofilm. The biofilm exposes the host to bacterial cell surface components such as lipopolysaccharides (LPS) that are shed within the gingival sulcus (naturally occurring space between the teeth and gingival). These bacterial products attack and penetrate tissues coming in contact with a variety of host cells including monocytes and macrophages. Monocytes and macrophages bind to LPS resulting in the release of inflammatory

mediators like arachidonic metabolites (prostaglandin E2), and cytokines (interleukin-1 beta, and tumor necrosis factor alpha) (Paquette, 1999). These biochemical and cellular reactions begin the onset of periodontitis, which culminate in periodontal tissue destruction (pocket formation, clinical attachment loss, and alveolar bone loss) (Page, 1997). These processes provide access to the blood circulation via the ulcerated epithelium. This can allow the spread of bacteria and their byproducts throughout the body resulting in systemic infections.

Pregnancy and maternal PD

It is well recognized that pregnancy is associated with maternal PD. Studies have shown that elevated ovarian hormones (i.e., estrogen and progesterone) that accompany pregnancy are associated with an increased incidence and severity of gingival inflammation (Loe, 1963). This inflammation may range from mild inflammation with redness, to erythemic and edematous gingival tissues, which easily bleeds, to hyperplastic changes including a tumor-like growth known as a "pregnancy tumor" (Jensen, 1981). This entire phenomenon has been designated as "pregnancy gingivitis," and occurs in 30-100 percent of all pregnancies. (Hansen, 1986). This type of gingivitis may occur without changes in plaque levels (Kornman, 1980). Plausible explanations for this increase in gingivitis include: alteration in the subgingival plaque composition, changes in maternal immunoresponse, and increases in sex hormone concentrations (Otomo-Corgel, 2002a)

The association between maternal PD and PLBW

Recently, several authors have reported that maternal PD may increase the risk for systemic disorders, particularly for PLBW (Loesche, 1997; Zachariasen, 1998; Li, 2000;

Rivera-Hidalgo, 2001; Fowler, 2001; Garcia, 2001; McGaw, 2002; Teng, 2002; John, 2002; Krejei, 2002; Otomo-Corgel, 2002b). The hypothesis that oral conditions, such as PD, may be either risk factors or indicators for important medical outcomes represents a paradigm shift in thinking about causality and directionality of oral and systemic association (Page, 1998). This paradigm shift has resulted in the new term "periodontal medicine" (Offenbacher, 1998a) referring to the relationship between systemic health and oral health.

The idea that oral infections can affect systemic health was proposed over a century ago when Miller (1891) described the mouth as a "focus of infection" where oral microbes or their byproducts enter other body locations adjacent or remote from the mouth. The idea was reaffirmed by Hunter (1900), and led to the prophylactic extraction of many teeth for several decades to cure diseases remote from the oral cavity. However, Cecil (1938) and an editorial written in the Journal of the American Medical Association (1952) determined that patients' symptoms did not improve from full-mouth extractions and the theory was dispelled. A breakthrough report by Mattila (1989) reintroduced this concept by examining the role of chronic bacterial infections as a risk factor for coronary heart disease. He evaluated the association between poor dental health and acute myocardial infarction in two separate case-control studies, and found that dental health was significantly worse in patients with acute myocardial infarction than in controls. This was followed by a major study by Offenbacher (1996) showing that maternal PD was a potential risk factor for PLBW infants.

Today, most researchers working in the field of "periodontal medicine" believe that infection remote from the fetal-placental unit may influence PLBW infants with an

increased focus on the potential role of chronic bacterial infections in the body. PD is a remote chronic gram-negative infection, which results in local and systemic increases of proinflammatory prostaglandins and cytokines. Studies have shown that oral microbes can enter the circulation including periodontal pathogens. Hence, maternal PD may influence PLBW through mechanisms involving inflammatory mediators or a direct bacterial assault on the amnion (Teng, 2002).

Two theories have been proposed to explain the transfer from the oral cavity to the placenta. First, oral bacteria may migrate through the vagina (ascending route) after cunnilingus eventually reaching the amniotic fluid, causing an infection, resulting in preterm labor and/or premature rupture of the membranes, preterm birth and other perinatal infectious complications. Second, oral bacteria from a mother with PD may travel through the blood (oral-hematogenous route) reaching the amniotic fluid causing an infection, resulting in preterm labor and/or premature rupture of the membranes and preterm birth (Hill, 1998). It has been theorized that chronic maternal PD could mediate this systemic effect through one or more of the following mechanisms: translocation of periodontal pathogens to the fetoplacental unit; action of a periodontal reservoir of LPS on the fetoplacental unit; or action of a periodontal reservoir of inflammatory mediators (interleukin-1, interleukin-6, tissue necrosis factor alpha, prostaglandin E2) on the fetoplacental unit (McGaw, 2002).

Interestingly a few studies have shown the presence of common oral microbes in the utero/fetal environment. Ernest (1985) was the first to report that *Capnocytophaga*, an oral microorganism, was found in the uterus in association with preterm labor and

chorioamnionitis. Hill (1998) found that *Fusobacterium nucleatum*, a common oral species, is the most frequently isolated species from amniotic fluid cultures among women with preterm labor and intact membranes. The species and subspecies of fusobacteria identified from amniotic fluid most closely match those reported from healthy and diseased subgingival (gum) sites, namely *F. nucleatum subspecies vincentii*, and *F. nucleatum* subspecies nucleatum, compared to strains identified from the lower genital tract. The normal location of *F. nucleatum* and *Capnocytophaga* suggest the possibility of a transient bacteremia originating from the mouth and hematogenous spread with infection of amniotic fluid through the placenta as alternative to an ascending route from the vagina.

Animal studies using the pregnant hamster model suggest that remote reservoirs of gram-negative microorganisms and their byproducts may have a negative impact on pregnancy outcome. *Porphyromonas gingivalis* was inoculated into the subcutaneous tissue chamber on the 8th day of gestation in a group of animals to determine the effects on fetal weight, viability, and resorption. The localized subcutaneous infection resulted in significant increases in prostaglandin E2 and tissue necrosis factor alpha producing significant increases in fetal death and a decrease in fetal birth weight for survivors, when compared to uninoculated control animals (Collins, 1994a). This suggests that a remote infection with *P. gingivalis* may result in abnormal pregnancy outcomes in this model. Collins (1994b) also showed that inoculating the hamster with *P. gingivalis* LPS on day 8 of pregnancy produced dose-dependent effect on fetal growth retardation, fetal death, and fetal resorption. This demonstrated that LPS from oral bacteria could cause adverse pregnancy outcomes. Offenbacher (1998b) produced *P. gingivalis* experimental

periodontitis in hamsters resulting in decreased fetal birth weight and increased levels of prostaglandin E2 and tumor necrosis alpha. This provided direct evidence that periodontal infection can affect the fetal environment and pregnancy outcome in hamsters.

These animal studies were expanded to include examining the potential effects of maternal PD on pregnancy outcomes in humans. In a case-control study of 124 women, Offenbacher (1996) found that women having PLBW infants had significantly worse PD than the respective normal birth weight (NBW) controls. Controlling for other risk factors and covariates, using multivariate logistic regression models, Offenbacher found that mothers with PD had a 7.5-fold increased risk of having a PLBW infant. This study indicated a strong association between maternal PD and adverse pregnancy outcomes. This was the first study showing that maternal PD was a clinically important risk factor for PLBW in humans.

Dasanayake (1998) conducted a matched case-control study of 55 women evaluating the hypothesis that poor oral health of pregnant women is a risk factor for low birth weight (LBW). Case (LBW) mothers had statistically fewer healthy gingival sextants, more bleeding sextants, and more sextants with calculus (mineralized deposits sometimes found on teeth, usually due to inadequate oral hygiene). On average, control-group (NBW) infants were about 700 grams heavier than case-group infants. The author concluded that poor maternal periodontal health is a potential independent risk factor for low birth weight.

In a subsequent study using 48 case-control subjects, Offenbacher (1998b) found that gingival crevicular fluid (normal body fluid secreted from gingiva, increased with inflammation) levels of prostaglandin E2 were significantly higher in PLBW mothers as

compared to normal birth weight controls (131.4 ± 21.8 vs 62.6 ± 10.3 [mean ± SE ng/ml], respectively at P = 0.02). Furthermore, within primiparous PLBW mothers, there was a significant inverse association between birth weight (as well as gestational age) and gingival crevicular fluid levels of prostaglandin E2 (P = 0.023). This suggests a dose-response relationship for increasing gingival crevicular fluid prostaglandin E2 as a marker of current periodontal disease activity and decreasing birth weight. The authors also found that four organisms associated with mature plaque and progressing periodontitis (*Bacteroides forsythus, Porphyromonas gingivalis, Actinobacillus actinomycetemcomitans, Treponema denticola*) were detected at higher levels in PLBW mothers as compared to normal birth weight controls. This suggests that biochemical measures of maternal periodontal status and oral microbial burden are associated with current PLBW.

Mitchell-Lewis (2001) initiated a study evaluating the association between periodontal infections and adverse birth outcomes in a cohort of young minority women of low socioeconomic status in New York. The author's findings revealed that PLBW mothers harbored significantly increased levels of periodontal pathogens (*Bacteroides forsythus*, *Camplyobacter rectus*), and the incidence of PLBW in women who received basic periodontal therapy during pregnancy was substantially reduced (28.6 percent). This was the first study reporting the effects of periodontal interventions on the incidence of adverse birth outcomes.

Jeffcoat (2001a) designed a prospective study to correlate the presence of periodontitis in pregnant women assessed at 21 to 24 weeks gestation with the presence and severity of subsequent preterm births in 1,313 women. The risk of preterm birth in subjects with

generalized periodontitis was from 4.5 to 7.1 times higher than that in periodontally healthy women with the adjusted odds ratio rising with increasing prematurity. The study found that preexisting PD in the second trimester of pregnancy increased the risk of preterm birth. In a follow-up study by Jeffcoat (2001b), results showed that overall adjusted odds ratio was 2.83 (95 percent confidence interval [CI] 1.79 to 4.47) for patients with mild to moderate PD, and 4.18 (95 percent [CI] 1.41 to 12.42) for patients with severe PD. This study showed that patients with the most severe PD had the greatest risk for preterm birth even after adjusting for known risk factors.

In another prospective study by Dasanayake (2001), 448 women were recruited during their second trimester of their first pregnancy from two study centers. Using 17 PLBW cases and 63 randomly selected controls (NBW) from the same cohort, the periodontal pathogen-specific maternal serum IgG (antibody) levels during the second trimester of pregnancy was measured in relation to infant birth weight while controlling for known risk factors for low birth weight. Results showed that *Porphyromonas gingivalis* specific maternal serum IgG levels were higher in the LBW group (mean = 58.1, SE = 20.0 microg/ml) compared to normal birth weight (NBW) group (mean 13.5, SE = 3.9 microg/ml; P = 0.004). Women with higher levels of *P. gingivalis* specific IgG had higher odds of giving birth to LBW infants (odds ratio [OR] = 4.1; 95 percent confidence interval [CI] 1.3 to 12.8). This study was able to demonstrate that second trimester levels of serum antibody against *P. gingivalis* was related to LBW.

In a recent prospective study designed by Offenbacher (2001) to determine whether maternal PD contributes to the risk for prematurity and growth restriction in the presence of

traditional obstetric risk factors was conducted. Interim data from 814 deliveries demonstrated that maternal PD at antepartum and incidence/progression of PD were significantly associated with a higher prevalence rate of preterm births, and smaller birth weight for gestational age. The adjusted prevalence rates among gestational age outcomes were significantly different for mothers with mild PD (n=566) and moderate - severe PD (n=45) by pair-wise comparison to the periodontally healthy reference group (n=201) at P = 0.017 and P = 0.000 respectively. A similar pattern was seen for increased prevalence of LBW deliveries among mothers with antepartum PD. This study provides evidence that maternal PD and incident progression are significant contributors to obstetric risk for preterm delivery, LBW and low weight for gestational age.

Madianos (2001) analyzed maternal plaque and serum collected postpartum (within 48 hours of delivery), and fetal cord serum collected at delivery from 400 women. Results showed there was a 2.9-fold higher prevalence of IgM seropositivity for one or more periodontal pathogens among preterm births, as compared to term babies (19.9 percent, versus 6.9 percent, respectively, P=0.002, Chi square). Specifically, the prevalence of positive fetal IgM to *Campylobacter rectus* was significantly higher for preterm as compared to full-term neonates (20.0 percent versus 6.3 percent, P = 0.000), as well as *Prevotella intermedia* (8.8 percent versus 1.1 percent, P = 0.000). Also, lack of maternal IgG antibody to certain periodontal pathogens was associated with an increased rate of prematurity (odds ratio [OR] = 2.2; confidence interval [CI] 1.48 to 3.79), consistent with the concept that maternal antibodies protect the fetus from exposure and resultant prematurity. This data supports the concept that maternal PD in the absence of a protective

maternal antibody response is associated with systemic dissemination of oral organisms that translocate to the fetus resulting in prematurity. The high prevalence of elevated *C. rectus* among premature infants raises the possibility that this specific maternal oral pathogen may serve as a primary fetal infectious agent eliciting prematurity.

Lopez (2002a) investigated whether the maintenance of the mother's periodontal health after 28 weeks gestation reduces the risk of PLBW. Study results showed that the incidence of PLBW was 2.5 percent (10/406) in periodontally healthy women and 8.6 percent (20/233) (P = 0.001) in women with PD. The relative risk for a woman with PD having a PLBW was 3.5 (95 percent confidence interval [CI] 1.7 to 7.3; P = 0.004). The authors concluded that PD is an independent risk factor for PLBW and affords more than a three-fold increase in the risk for PLBW. A follow-up study (Lopez, 2002b) showed that the incidence of PLBW in the treatment group (periodontal therapy during pregnancy) was 1.8 percent (3/163) and 10.1 percent (19/188) in the control group (no periodontal treatment during pregnancy) (odds ratio [OR] 5.49, 95 percent confidence interval [CI] 1.65 to 18.22, P = 0.001). Multivariate logistic regression analysis showed that PD was the strongest factor related to PLBW (odds ratio [OR] 4.70, 95 percent confidence interval [CI] 1.29 to 17.13). The authors concluded that periodontal therapy during pregnancy significantly reduced the rates of PLBW in the population of women with PD.

To date, one published study (Davenport, 2002) contradicts the potential association between maternal PD and PLBW. A case-control study of 236 cases and 507 controls were examined. The risk for PLBW decreased with increasing pocket depth meaning more significant PD (odds ratio [OR] 0.78, 95 percent confidence interval [CI] 0.64 to 0.99). The

authors found no evidence for an association between PLBW and PD and felt no need to improve the periodontal health of pregnant women as a means of improving pregnancy outcomes.

Summary

Based on a majority of the data supporting biologically plausible interactive mechanisms in humans, and animal studies showing adverse effects of experimental periodontitis on the fetus; the evidence strongly suggests that PD may have significant negative impact on pregnancy outcomes in some women requiring further evaluation.

This study evaluated the potential association between maternal PD and PLBW in a selected population of women in the United States Air Force. The null hypothesis tested by this study is: that there is no significant difference in the number of PLBW infants in mothers with PD compared to mothers without PD. The alternative hypothesis tested by this study is: that there is a significant difference in the number of PLBW infants in mothers with PD compared to mothers without PD.

MATERIALS AND METHODS

This study was based on an analysis of a secondary data set collected by the Office of Prevention and Health Services Assessment (OPHSA) division of the Population Health Support Office (PHSO) located at Brooks Air Force Base, San Antonio, Texas. This organization approved the use of this data set and no personal identifiers were included.

A population-based study was employed using analytic observation methods to explore the association between maternal PD and PLBW. The study population was active duty females in the United States Air Force (USAF) between the ages of 18 - 34. The study sample was active duty females in the USAF who gave birth to a single infant between January 2001 and June 2002 determined from computerized data systems.

The following computerized data systems were used to ascertain the information for the outcome variable (PLBW) and normal birth weight (NBW): Standard Inpatient Data Record (SIDR), Standard Ambulatory Data Record (SADR) and All Regional Server (ARS). The SIDR and SADR provided coded patient encounter data from any military healthcare facility. The ARS provided information on coded encounter data from both institutional and non-institutional facilities. These databases were capable of tracking all participant use of the system allowing for a 100 percent match. Patient records were linked using their sponsor's social security number and date of birth as identifiers. Study participants' individual computerized medical records (both inpatient and outpatient), dating from January 1, 2001 to June 30, 2002, were queried to identify those with a history of PLBW diagnoses.

PLBW was defined as a female (18-34) who gave birth to single live infant between January 2001 and June 2002 whose infant had a birth weight of less than 2,500 grams and/or a gestational age less than 37 weeks. A diagnosis of preterm labor or premature rupture of membranes was also included due to its association with PLBW. NBW was defined as a female (18-34) who gave birth to a single live infant between January 2001 and June 2002 with a diagnosis of normal birth weight ($\geq$ 2500 grams) and a gestation period greater than 37 weeks. A diagnosis of PLBW, NBW, preterm labor or premature rupture of membranes was identified from the computerized data system mentioned using International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes. The following codes were utilized: 644.2 - Early Onset of Delivery; 656.5 - Poor Fetal Growth; 658.1 - Premature Rupture of Membranes; 765.0 - Extreme Immaturity; 765.1 - Other Preterm Infants.

The variables age, race and history of smoking were adjusted using the logistic regression model. This data was identified from the following computerized data systems: Military Personal Data System (age, race) and Dental Data System (history of smoking).

The exposure variable PD was defined as a Periodontal Screening and Recording (PSR) score of 4 (ascertained from the Dental Data System). PD can range from simple gingivitis to severe periodontitis. Early detection and diagnosis are key elements in the prevention of oral pathology. PD in a population commonly involves measuring clinical attachment loss via probing with a periodontal probe. PSR is a rapid and cost effective method to screen patients for periodontal disease (Lo Frisco, 1993; Charles, 1994; Khocht, 1995; Corbet,

1998; Landry, 2002). PSR scores have shown a significant association between probing depths and attachment levels (Khocht, 1996).

The PSR system was adopted for use in the USAF in 1996 as part of the annual dental examination. All USAF patients are examined for PD using the PSR system. Each tooth is probed at six sites with a special color coded PSR probe. This probe consists of a 0.5 mm balled end probe, which has a color band extending from the 3.5 to the 5.5 mm area. The colored band allows a quick estimate to be made of pocket depth (deepened space between tooth and gingiva) and the degree of gingival recession. The probe is designed to rapidly differentiate "normal" from "abnormal" status to provide an estimate of the patient's treatment needs. PSR guidelines set three criteria for scoring: probe reading, bleeding on probing and presence of calculus or other irritants. The deepest probing depth of each sextant is charted. The code for charting is determined by how much of the colored band on a PSR probe is visible when inserted into the gingival sulcus. Only six scores (one per sextant) are recorded. Only the highest score is recorded in each sextant. One of five possible codes (0, 1, 2, 3, 4) is assigned to each sextant. Based on the patient's scores from the coding system, as well as clinical judgment, the dental health care provider is able to determine the need for further periodontal charting, evaluation, home care, possible periodontal therapy and/or consultation with a periodontist. A PSR score of 4 indicates that the colored area of the PSR probe completely disappears in the gingival sulcus, indicating a probing depth greater than 5.5 mm (signifying potential pathology). A PSR score of 4 indicates that the patient requires a comprehensive periodontal examination and charting to determine a treatment plan, and need for improved personal plaque control.

Minitab, version 13 (Minitab, Inc.) was used for statistical analysis. Descriptive statistics were used to characterize the population. Chi-square analysis was used to test group differences in categorical variables, and the student's t-test was used to test group differences in continuous variables. Also, univariate/multivariate analysis was performed using conditional logistic regression analysis. The exposure variable (PD) and outcome variable (PLBW) was presented in a two-by-two or contingency table. An odds ratio (OR) with 95% confidence interval was calculated to express the rate of developing the PLBW given the presence of the potential risk factor PD relative to its absence. Statistical significance was defined as $P < 0.05$. Assuming a probability of PLBW of 10 percent in the general population (Branum, 2002) and a probability of seven percent in the USAF population (Herbold, 1998), a sample size of 750 women was necessary to detect a significant difference between groups ($P<0.05$) with a power of 80 percent.

RESULTS

Descriptive statistics

The demographic characteristics of the study sample appear in Table 1. There were 7,659 births during this observational period. The mean age of the study sample was 24.9 $\pm$ 4.1 (s.d.). The total prevalence of PLBW and PD was 6.4 percent, and 2.3 percent, respectively. Approximately two-thirds of the cases of PD (93/136), and PLBW (328/492) were in the younger age group 18-26. PD was most prevalent in African-Americans at 4.4 percent, followed by the combined ethnic categories of Asian/Pacific Islander, American Indian/Alaskan Native, and Other at 3.6 percent, and whites at 1.0 percent. PLBW was most prevalent in African-Americans at 9.0 percent, followed by the combined ethnic categories at 7.8 percent, and whites at 5.1 percent. Tobacco use was highest in whites at 15.4 percent, followed by the combined ethnic categories at 11.0 percent, and African-Americans at 8.3 percent. Only 6.0 percent of smokers had a PLBW outcome, and 2.1 percent of smokers had PD. Over 80 percent of the smokers were in the 18-26 age group.

The mean age of mothers with PLBW outcomes was 24.7 $\pm$ 4.3 (s.d.), and the mean age of mothers with NBW outcomes was 24.9 $\pm$ 4.1 (s.d.). Using the t-test, no significant difference in age was found in these two groups of women (95 percent confidence interval [CI] -0.59 to 0.20, P = 0.329). PD was slightly more common in the NBW group at 2.3 percent compared to the PLBW group at 1.8 percent. However, no significant difference was found between the two groups ($\chi^2 = 0.354$, P = 0.552). Approximately the same percentage of women smoked in both groups (12.9 percent for NBW, 12.1 percent for

PLBW). No significant difference was found between the two groups ($\chi^2 = 0.203$, P = 0.652). Of the seven cases of PD in the PLBW group, six were of African-American or the combined ethnic races. In the NBW group, PD was most common in African-Americans at 4.4 percent, followed by the combined ethnic categories at 3.4 percent, and whites at 1.2 percent. The only significant difference found between the PLBW and NBW groups was race (χ^2 =35.27, P= 0.000). A larger percentage of African-Americans were found in the PLBW group (38.0 percent) compared to the NBW group (26.6 percent).

The strength of association between PD and PLBW is displayed by the 2 x 2 contingency table (Table 2). The odds ratio was calculated from this table, and was determined to be 0.79 (95 percent confidence interval [CI] 0.37 to 1.71; P = 0.553). This indicates there was no evidence of an association between PD and PLBW in this study sample.

Inferential statistics

Logistic regression analysis was conducted to estimate the probability associated with PLBW for the various explanatory variables. In the univariate logistic regression analysis for PLBW, a significant association was found for race (African-American, P = 0.000, Combined, P = 0.018, referent group was white). No other significant association was found for the variables PD, age and tobacco use. Table 3 contains the results of this analysis.

Since all the above variables have been cited in the literature as potential risk factors for PLBW, they all were included in the preliminary model in the multivariate logistic regression analysis. The final model included the variables: periodontal disease, tobacco

use, and race, while age was deleted (Table 4). The full model that included the outcome variable and the explanatory variables yielded a Hosmer and Lemeshow goodness-of-fit P-value of 0.992, indicating that the model effectively describes the outcome variable. Using the full model, African-Americans were 1.65 times more likely to experience PLBW, while the combined ethnic categories were 1.26 times more likely to experience PLBW.

DISCUSSION

The study method used in this investigation attempted to determine if there was an association between maternal PD and PLBW, while controlling for several known risk factors for PLBW. Women aged 18 to 34 years of age were selected because maternal age less than 18 and greater than 34 has been found to be a risk factor for PLBW (Committee to Study the Prevention of Low Birthweight, 1985). Only mothers with a singleton gestation were included due to the relationship between multiple gestation and preterm low birth weight (Berkowitz, 1993). Women were selected from a central data source based on medical diagnoses using the ICD-9-CM codes. The time period of 18 months was chosen based on the available data, and to maximize the sample size. Mothers in this study were found to be relatively homogenous in relation to age, history of tobacco use, and prevalence of PD.

This study sample was well suited for this investigation since several potential confounding social risk factors had minimal impact due to adequate access to health care and the minimal costs associated with it. Women in this study had free access to prenatal care as part of their health benefits as active duty members of the military. The association between the use of prenatal care and positive birth outcomes is well established (Peoples, 1983).

The prevalence of PD and PLBW in this study was found to be lower than the national average (PD = 11.9 percent, PLBW = 8.65 percent) for all ages in the United States (Borrell, 2002; MacDorman, 2002). This is likely due to active duty population of the

USAF who tend to be young and healthy individuals with few medical conditions, and extensive free medical/dental care access.

The sample size (492 women) was smaller than an anticipated sample size of 750 women based on national averages. A smaller sample size may have decreased statistical power reducing the ability to detect an important existing effect. A larger sample size would have reduced the standard error of the estimate leading to increased precision and study power.

The study design included restricting the age interval from 18 to 34 to reduce confounding. Results showed no association between age and PLBW which was confirmed in the logistic regression model. The final results verified the intent of the study design.

There is evidence that maternal smoking is associated with PLBW and periodontal disease (Shiono, 1986; MacDonald, 1992). In this study, the proportion of smokers was similar in both groups, and smoking did not show an association with PLBW. This lack of association may be due to health education and anti-smoking counseling provided during prenatal care visits, and to the lower level of prevalence of smoking in the study sample (approximately 12 percent) compared to the national average (24.2 percent) (Schoenborn, 2003).

This study found no evidence that maternal periodontal disease is associated with an increased risk for PLBW births. After controlling for other variables, only race (African-American, combined ethnic category) showed a significant association with PLBW. This association was consistently maintained without substantial changes even after adjusting for other risk factors. The results coincide with those of past studies evaluating prematurity

rates in Air Force active duty women (Buttemiller, 1984; Herbold, 1998). This suggests that race is an independent risk factor for PLBW.

African-Americans, in particular, had the highest rate of PLBW. Several studies have shown that low birth weight and preterm delivery are higher among African-Americans (Kessel, 1988; Taylor, 2000). Several studies have shown that black/white differences persist event in the military with universal employment and health coverage though disparities were reduced (Adams, 1993; Alexander, 1993; Barfield, 1996). This continues to result in persistent black-white disparities in infant mortality (MMWR, 2002). It is disturbing the lack of information regarding factors that may explain the identified racial discrepancies in PLBW. Potential explanations based on traditional risk factors, including differences in age, parity, educational attainment, marital status, prenatal care, nutrition, smoking, and substance abuse do not appear to be the answers (Kleinman, 1987).

Both biological and social factors have been proposed to explain this disparity though. Goldenberg (1996a) found that black women had higher levels of hypertension and diabetes, which may contribute to this difference in health status. Other studies have proposed that a greater prevalence of bacterial vaginosis among black women may explain the higher rate (Goldenberg, 1998b; Hauth 1995). A few studies have linked bacterial vaginosis to PLBW among African-Americans. The Vaginal Infections in Pregnancy Study found organisms associated with bacterial vaginosis more often in black women even when differences in health behaviors were controlled (Goldenberg, 1996b). The preterm Prediction Study revealed that the relationship between PLBW, black race, and bacterial vaginosis were mediated by elevated fibronectin levels (Goldenberg, 1998b). This material

is a glycoprotein produced by a variety of cell types that plays a role in intercellular adhesion in relation to implantation. Hogue (1995) showed that stress-associated behavioral risks were associated with higher PLBW in African-American communities. Blackmore (1993) found that cultural and environmental factors that vary between the races, but not between the different socioeconomic levels within a race, may account for some of the unexplained ethnic differences. Geronimus (1992) proposed that different life circumstances either undermine or promote health through a cascade of advantages or disadvantages throughout the course of life. He described this as the "weathering hypothesis" to explain life course differences in birth outcomes between black and white women. This theory was suggested to help explain the ethnic disparities in health at birth by showing that black and white women "weather" at different rates. Another approach to explaining the differences in birth outcomes looks at racial segregation and discrimination as potential contributing factors (Williams, 1996).

Because PLBW is poorly understood in general, new studies should focus not only on biological mechanisms, but on the social, cultural, and political context of African-American women and environmental stressors and the physiological responses and protective mechanisms associated with stress. Due to the major public health implications of PLBW and its association with race, there is a continued need to search for the risk factors that are amenable to prevention.

Also, in this study sample, African-Americans had the highest level of PD, which concurs with the findings from the Third National Health and Nutrition Examination Survey (National Center for Health Statistics, 1996). Studies have shown that African-

Americans have increased prevalence and severity of destructive periodontal diseases, in comparison to white populations (Beck, 1990; Beck, 1995; Beck 1997; Dolan, 1997; Drake, 1995). It is possible that PD, in part, may provide the biological explanation for the apparent disparities in prevalence for PLBW among races. Studies have found differences in subgingival microbial species and host immune response among several American minority populations (Schenkein, 1993; Beck, 1992; Umeda, 1998; Gunsolley, 1991; Lu, 1994). Other studies have shown that elevated serum IgG antibody to *P. gingivalis* may be considered a risk factor for disease progression in minority populations (Craig, 2002; Dasanayake, 2003). The higher prevalence of PD in African-Americans may represent a potentially modifiable risk factor that could be an underlying component of the disparities with regard to PLBW.

Also, socioeconomic indicators such as education, income, and occupation have been consistently associated with low birth weight, preterm birth and infant mortality (Savitz, 1996; Rutter, 1990). It has been suggested that the health of reproductive-age women may be shaped beginning with their health at birth and continuing through childhood and adolescence with conditions that develop prior to becoming pregnant (Power, 1998). A marked socioeconomic gradient in low birth weight for white and black groups have been shown with lower socioeconomic women at greater risk for illness and conditions that complicate pregnancy (Pamuk, 1998). In this study, socioeconomic indicators were not measured for the following reasons: education and occupational information was not available, using rank/pay grade as an indicator has not been validated

in past studies, no information was available on whether the spouse was employed, and access to healthcare was equally available for all individuals.

In any study, the validity of the results must be examined in regard to potential bias and confounders. The limitations to this study included: misclassification bias due to measurement error, over/under- diagnosis bias of PD due to multiple examiners, potential confounding by other variables not measured, and potential for interaction resulting from potentially more than one association. Due to the nature of this study only potential risk factors examined could be adjusted statistically.

This investigation was conducted among a well-defined population using a central database for diagnosis for PLBW, minimizing selection bias and information bias. Unfortunately, there was potential for measurement error leading to misclassification bias for PD. This may have resulted in the low prevalence in PD in both the PLBW and NBW groups. In determining the degree of PD, there are several measures of disease activity available (e.g., full periodontal examination, radiographs, gingival crevicular activity, chromosomal DNA probes, and screening examination). The PSR system, a screening examination, was chosen by the USAF to provide the most appropriate screening tool for the chosen setting. However, a full periodontal examination might have resulted in a higher prevalence of PD in this study sample, which in turn, would have produced a higher odds ratio for PLBW. Also, if PSR 3 scores (pocket depths 4-5.5 mm) were available and combined with PSR 4 scores, an increased odds ratio might have resulted.

The observed relationship between PD and PLBW in this study contradicts the previous literature that measured PD using a full periodontal examination (Offenbacher,

1996; Jeffcoat, 2001a; Lopez, 2002a; Lopez, 2002b; Mitchell-Lewis, 2001; Offenbacher, 2001). Differences between this investigation and that of other evaluators is probably due to measurement error from the PSR screening examination compared to a full periodontal charting. Attachment level losses measured during a full periodontal examination would be the most accurate measure of previous destructive disease experience, which was not accomplished in this study. This lack of good clinical measure of PD is a major limitation of the study resulting in nondifferential misclassification. Therefore, we were less likely to detect an association between PD and PLBW. In addition, the inability to demonstrate an association between maternal PD and PLBW using the PSR system was also found in one other study (Dasanyake, 2001).

Also, the severity of PD may be underestimated resulting in increased false negative results when utilizing the PSR system. A major shortcoming of this screening exam is that it does not fully measure epithelial attachment loss. This is an approximation of the destruction of the connective tissue attachment to the root surface. Changes in epithelial attachment loss are considered the "gold standard" for measuring PD progression (Armitage, 1996). The PSR system uses the probing depth to approximate attachment loss. One study found that the PSR system could over or underestimate the extent of PD (Khocht 1995). Khocht (1995) found that additional abnormalities like furcation involvement, tooth mobility and gingival recession were poorly detected, and that the percent agreement between actual PSR scores versus a conventional periodontal examination was 58.8 percent overall. Also, the PSR probe design (i.e., 0.5 mm balled shape) may make it difficult to

probe accurately around calculus on root surfaces as compared to a regular probe resulting in an underestimation of disease severity.

The USAF Dental Corps environment may also contribute to underestimation of PD severity. The Dental Corps consists of approximately 1100 dentists with different dental backgrounds. The examination room tends to be a very busy area with multiple examinations scheduled every 10-15 minutes. Due to the tight time schedule, the multiple dental providers may not have been as precise and accurate when using the PSR system as during a full periodontal examination. Also, there is no standardized training for the PSR system in the USAF, and there is no calibration among examiners. Both of these issues could result in measurement error.

Given the low prevalence of PD in this study sample, no association was found between PD and PLBW. Thus we failed to reject our null hypothesis of no significant differences in the prevalence of PLBW infants in women with PD compared to periodontally healthy women. This study sample consisted of a healthy population that had both excellent medical and dental care. In all likelihood, the issues that contribute to PLBW may not be present in this population.

In this study sample, the identification of race as a potential risk factor for PLBW requires further investigation. Understanding the different patterns in birth outcomes among African-American and white infants is necessary to develop effective interventions designed to decrease racial disparities. Also, additional research is warranted to determine whether maternal PD is associated with PLBW. To date, based on existing case-control studies and prospective and uncontrolled intervention studies, there is minimal evidence

that treatment of PD will reduce the risk of PLBW. It remains to be seen whether or not large prospective studies can validate the link between PD and PLBW, and if so, can periodontal therapy reduce the rate of PLBW. Future studies should include a randomized, placebo-controlled, double blind intervention trial to establish a causal link between PD and PLBW.

As outlined earlier, the causes of PLBW and PD are multiple as are the variables associated with them including specific genetic and environmental factors. There remains the possibility that interactions between several variables may be involved in describing the possible biological mechanisms. Hopefully, design of future studies will provide a clearer understanding of these mechanisms.

CONCLUSION

Since infant mortality and morbidity increases as birth weight decreases (Shapiro, 1980), there is a continued need to search for risk factors for preterm, low birth weight that are amenable to prevention. The data presented in this study do not indicate a potentially damaging effect of maternal periodontal disease on the fetal-placental unit. The limited scope of this population-based study does not enable generalization about the potential public health impact of maternal periodontal disease and preterm, low birth weights. Caution must be exercised in interpreting the appropriateness of this data due to the limitations of the data of the study.

Even though this study did not find an association between maternal PD and PLBW infants, it is important for dental providers to promote excellent oral health for all their patients including expectant mothers. The results of this study, though, do not support specific efforts to ameliorate the periodontal health of pregnant women as a means of improving pregnancy outcome. Without definitive intervention data, the best guidance to give to a woman considering pregnancy is to prevent PD. This approach will minimize treatment when the expectant mother and fetus are most vulnerable.

Further studies in the field of "periodontal medicine" are also needed. It is essential that dental providers are cognizant of this data and other published studies to provide the most accurate and updated information to their expectant patients regarding PD and PLBW. Today, there is an increased urgency for both civilian and military medical/dental colleagues to consult with each other and share knowledge to insure that appropriate

diagnoses can be made and proper treatment can be provided to their patients. In the end, improving oral health care will promote masticatory function and prevent oral disease, while contributing to good general health and quality of life.

Table 1: STUDY SAMPLE DEMOGRAPHIC DATA

CHARACTERISTICS	PLBW (%) N=492	NBW (%) N= 7167	TOTAL (%) N= 7659
Race			
White	244 (49.6)	4476 (62.5)	4720 (61.6)
African American	187 (38.0)	1904 (26.6)	2091 (27.3)
Combined	61 (12.4)	787 (10.9)	848 (11.1)
Age			
18 - 26	328 (66.7)	4851 (67.6)	5179 (67.6)
27 - 34	164 (33.3)	2323 (32.4)	2487 (32.4)
Smoking			
Yes	46 (12.1)	718 (12.9)	764 (12.8)
No	335 (87.9)	4860 (87.1)	5195 (87.2)
PD	7 (1.8)	129 (2.3)	136 (2.3)

Table 2: ODDS RATIO DETERMINATION FOR PLBW COMPARED TO NBW

	PLBW	NBW
PD	7	129
No PD	377	5506

Odds ratio = 0.79 (7 x 5506/129 x 377)

Table 3: UNIVARIATE LOGISTIC REGRESSION MODEL FOR PLBW

VARIABLE	COEFFICIENT	STANDARD ERROR	P VALUE	ODDS RATIO	95% CI
PD	-0.2326	0.3917	0.553	0.79	(0.37, 1.71)
AGE	-0.01173	0.0115	0.307	0.99	(0.97, 1.01)
AFRICAN-AMERICAN	0.5887	0.1010	0.000	1.80	(1.48, 2.20)
COMBINED	0.3520	0.1483	0.018	1.42	(1.06, 1.90)
SMOKING	-0.0732	0.1622	0.652	0.93	(0.68, 1.28)

Table 4: MULTIVARIATE LOGISTIC REGRESSION MODEL FOR PLBW

VARIABLE	COEFFICIENT	STANDARD ERROR	P VALUE	ODDS RATIO	95% CI
PD	-0.3551	0.3937	0.367	0.70	(0.32, 1.52)
AFRICAN-AMERICAN	0.5017	0.1164	0.000	1.65	(1.31, 2.07)
COMBINED	0.2349	0.1726	0.173	1.26	(0.90, 1.77)
SMOKING	0.0083	0.1635	0.960	1.01	(0.73, 1.39)

Final model equation = -2.86093 -0.3551*PD + 0.5017*African-American + 0.2349*Combined + 0.0083*Smoking

REFERENCES

Adams MM, Read JA, Rawlings JS, Harlass FB, Sarno AP, Rhodes PH. Preterm delivery among black and white enlisted women in the United States Army. Obstet and Gynecol 1993;81:65-71.

Albandar JM, Brown LJ, Brunell JA, Loe H. Gingival state and dental calculus in early-onset periodontitis. J Periodontol 1996;67:953-959.

Albandar JM, Kingman A. Gingival recession, gingival bleeding, and dental calculus in adults, 30 years of age and older in the United States, 1988-1994. J Periodontol 1999a;70:30-43.

Albandar JM, Brunelle JA, Kingman A. Destructive periodontal disease in adults 30 years of age and older in the United States, 1988-1994. J Periodontol 1999b;70:13-29.

Albandar JM. Global risk factors and risk indicators for periodontal diseases. Periodontol 2000 2002;29;177-206.

Alexander GR, Baruffi G, Mor JM, Kieffer EC, Hulsey TC. Mutiethnic variations in the pregnancy outcomes of military dependents. Am J Public Health 1993;83:1721-1725.

Armitage GC. Manual periodontal probing in supportive periodontal treatment. Periodontol 2000 1996;12:33-39.

Barfield WD, Wise PH, Rust FP, Rust KJ, Gould JB, Gortmaker SL. Racial disparities in outcomes of military and civilian births in California. Arch Pediatr Adolesc Med 1996;150:1062-1067.

Beck JD, Sharp T, Koch GG. A study of attachment loss patterns in survivor teeth at 18 months, 36 months and 5 years in community-dwelling older adults. J Periodontol Res 1997;32:497-505.

Beck JD, Koch GC, Offenbacher S. Incidence of attachment loss over 3 years in older adults-new and progressing lesions. Community Dent Oral Epidemiol 1995;23:291-296.

Beck JD, Koch GG, Zambon JJ, Genco RJ, Tudor GE. Evaluation of oral bacteria as risk indicators for periodontitis in older adults. J Periodontol 1992;63:93-99.

Beck JD, Koch GG, Rosier RG, Tudor GE. Prevalence and risk indicators for periodontal attachment loss in a population of older community-dwelling Blacks and Whites. J Periodontol 1990;61:521-528.

Bennett PR, Rose MP, Myatt L, Elder MG. Preterm labor: stimulation of arachidonic acid metabolism in human amnion cells by bacterial products. Am J Obstet Gynecol 1987 Mar;156(3):649-655.

Berkowitz GS, Papiernik E. Epidemiology of preterm birth. Epidemiol Rev 1993;15:414-443.

Blackmore CA, Ferre CD, Rowley DL, Hogue CJ, Gaiter J, Atrash H. Is race a risk factor or a risk marker for preterm delivery. Ethn Dis 1993;3(4):372-377.

Blanco JD. Clinical Problem of Preterm Labor. Clin Obstet Gynecol 2000 Dec;43(4):713-716.

Borrell LN, Burt BA, Gillespie BW, Lynch J, Neighbors H. Periodontitis in the United States: beyond black and white. J Public Health Dent 2002 Spring;62(2):92-101.

Brandt P, Magyary D, Hammond M, Barnard K. Learning and behavioral-emotional problems of children born preterm at second grade. J Pediatric Psychol 1992 Jun;17(3):291-311.

Breslau N, Brown GG, DelDotto JE, Kumar S, Ezhuthachan S, Andreski P, Hufnagle KG. Psychiatric sequelae of low birth weight at 6 years of age. J Abnorm Child Psychol 1996 Jun;24(3):385-400.

Buttemiller R. Prematurity among United States Air Force active-duty gravidas. Military Medicine 1984;149:665-668.

Byrne J, Ellsworth C, Bowering E, Vincer M. Language development in low birth weight infants: the first two years of life. J Dev Behav Pediatr 1993 Feb;14 (1):21-27.

Cecil RL, Angevine DM. Clinical and experimental observations on focal infection with an analysis of 200 cases of rheumatoid arthritis. Ann Intern Med 1938;12:577-584.

Charles CJ, Charles AH. Periodontal screening and recording. J Calif Dent Assoc 1994 Feb;22(2):43-46.

Christianson RE, van den Berg BJ, Milkovich L, Oechsli FW. Incidence of congenital anomalies among white and black live births with long-term follow-up. Am J Public Health 1981 Dec;71(12):1333-1341.

Cohen I, Veille JC, Calkins BM. Improved pregnancy outcome following successful treatment of chlamydial infection. JAMA 1990 Jun 20;263(23):3160-3163.

Collins JG, Windley HW, Arnold RR, Offenbacher S. Effects of Porphyromonas gingivalis infection on inflammatory mediator response and pregnancy outcome in hamsters. Infect Immun 1994a;62:4356-4361.

Collins JG, Smith MA, Arnold RR, Offenbacher S. Effects of Escherichia coli and Porphyromonas gingivalis lipopolysaccharide on pregnancy outcome in the golden hamster. Infect Immun 1994b;62:4652-4655.

Committee to Study the Prevention of Low Birthweight, Divisions of Health Promotion and Disease Prevention, Institute of Medicine: Preventing Low Birthweight. Washington, DC, National Academy Press; 1985.

Corbet EF. Practical periodontal screening and diagnosis. Int Dent J 1998 Jun;48(3 Suppl 1):268-274.

Craig RG, Boylan JY, Mijares D, Imam M, Socransky SS, Taubman MA, Haffajee AD. Serum IgG antibody response to periodontal pathogens in minority populations: relationship to periodontal disease status and progression. J Periodontol Res 2002;37:132-46.

Daikoku NH, Kaltreider DF, Johnson TR, Johnson JW, Simmons MA. Premature rupture of membranes and preterm labor: neonatal infection and perinatal mortality risks. Obstet Gynecol 1981 Oct;58(4):417-425.

Dasanayake AP. Poor periodontal health of the pregnant woman as a risk factor for low birth weight. Ann Periodontol 1998 Jul;3(1):206-212.

Dasanayake AP, Boyd D, Madianos PN, Offenbacher S, Hills E. The association between Porphyromonas gingivalis-specific maternal serum IgG and low birth weight. J Periodontol 2001 Nov;72(11):1491-1497.

Dasanayake AP, Russell S, Boyd D, Madianos PN, Forster T, Hill E. Preterm low birth weight and periodontal disease among African Americans. Dent Clin North Am 2003;47(1):115-25.

Davenport ES, Williams CE, Sterne JA, Murad S, Sivapathasundram V, Curtis MA. Maternal periodontal disease and preterm low birthweight: case-control study. J Dent Res 2002 May;81(5):313-318.

Dolan TA, Gilbert GH, Ringelberg ML. Behavioral risk indicators of attachment loss in adult Floridians. J Clin Periodontol 1997;24:223-232.

Dombroski RA, Woodard DS, Harper MJ, Gibbs RS. A rabbit model for bacteria-induced preterm pregnancy loss. Am J Obstet Gynecol 1990 Dec;163(6 Pt 1):1938-1943.

Douglass GW. The epidemiology of periodontal disease. In: Wilson TG, Kornman KS (eds): Fundamentals of Periodontics, Chicago, Quintessence, 1996.

Drake CW, Hunt RJ, Koch GG. Three-year tooth loss among Black and White older adults in North Carolina. J Dent Res 1995;74:675-680.

Duff P, Kopelman JN. Subclinical intra-amniotic infection in asymptomatic patients with refractory preterm labor. Obstet Gynecol 1987 May;69(5):756-759.

Editorial. JAMA 1952;150:490.

Ernest JM, Wasilauskas B. Capnocytophaga in the amniotic fluid of a woman in preterm labor with intact membranes. Am J Obstet Gynecol 1985 Nov;153(6):648-649.

Fitzharding PM. Follow-up studies on the low birth weight infant. Clin Perinatol 1976; 3(2):503-516.

Fowler EB, Breault LG, Cuenin MF. Periodontal disease and its association with systemic disease. Mil Med 2001 Jan:166(1):85-89.

French JI, McGregor JA, Draper D, Parker R, McFee J. Gestational bleeding, bacterial vaginosis, and common reproductive tract infections: risk for preterm birth and benefit of treatment. Obstet Gynecol 1999 May; 93(5 Pt 1):715-724.

Garcia RI, Heashaw MM, Krall EA. Relationship between periodontal disease and systemic health. Periodontal 2000 2001;25:21-36.

Geronimus AT. The weathering hypothesis and the health of African-American women and infants: evidence and speculation. Ethn Dis 1992;2:207-221.

Gibbs RS. The relationship between infections and adverse pregnancy outcomes: an overview. Ann Periodontol 2001 Dec;6(1):153-163.

Gibbs RS, Romero R, Hillier SL, Eschenbach DA, Sweet RL. A review of premature birth and subclinical infection. Am J Obstet Gynecol 1992 May;166:1515-1528.

Goldenberg RL, Andrews WW, Hauth JC. Choriodecidual infection and preterm birth. Nutr Rev 2002 May;60(5 Pt 2):S19-25.

Goldenberg RL, Hauth JC, Andrews WW. Intrauterine infection and preterm delivery. N Engl J Med 2000 May 18;342(20):1500-1507.

Goldenberg RL, Rouse DJ. The prevention of premature birth. N Eng J Med 1998a;339: 313-320.

Goldenberg RL, Iams JD, Mercer BM. The preterm prediction study: the value of new vs. standard risk factors in predicting early and all spontaneous preterm birth. Am J Public Health 1998b;88:233-238.

Goldenberg RL, Cliver SP, Mulvihill FX, Hickey CA, Hoffman HJ, Klerman LV, Johnson MJ. Medical, psychosocial, and behavioral risk factors do not explain the increased risk for low birth weight among black women. Am J Obstet Gynecol 1996a;175(5):1317-1324.

Goldenberg RL, Klebanoff MA, Nugent R. Vaginal Infection Pregnancy Study Group: bacterial colonization of the vagina in four ethnic groups. Am J Obstet Gynecol 1996b;174:1618-1623.

Gunsolley JC, Tew JG, Connor T, Burmeister JA, Schenkein HA. Relationship between race and antibody reactive with periodontitis-associated bacteria. J Periodontol Res 1991;26:59-63.

Hack M, Caron B, Rivers A, Fanaroff AA. The very low birth weight infant: the broader spectrum of morbidity during infancy and early childhood. J Dev Behav Pediatr 1983 Dec;4 (4):243-249.

Hansen L, Sobol SM, Abelson TI. Otolaryngologic manifestations of pregnancy. J Fam Pract 1986;23:151-155.

Hardy PH, Hardy JB, Nell EE, Graham DA, Spence MR, Rosenbaum RC. Prevalence of six sexually transmitted disease agents among pregnant inner-city adolescents and pregnancy outcome. Lancet 1984 Aug 11;2(8398):333-337.

Hauth JC, Andrews WW, Goldenberg RL. Infection-related risk factors predictive of spontaneous labor and birth. Prenat Neonat Med 1998;3:86-90.

Hauth JC, Goldenberg RL, Andrews WW. Reduced incidence of preterm delivery with metronidazole and erythromycin in women with bacterial vaginosis. N Engl J Med 1995;333:1732-1736.

Herbold J, Grayson K. An investigation of reproductive health outcomes and potential risk factors in Air Force women, Phase 1: Technical Report, Sept 1998.

Hill GB. Preterm birth: associations with genital and possibly oral microflora. Ann Periodontal 1998;3:222-232.

Hillier SL, Nugent RP, Eschenbach DA. Association between bacterial vaginosis and preterm delivery of a low-birthweight infant. N Engl J Med 1995 Dec 28;333(26):1337-1342.

Hillier SL, Martius J, Krohn M, Kiviat N, Holmes KK, Eschenbach DA. A case-control study of chorioamnionic infection and histologic chorioamnionitis in prematurity. N Eng J Med 1988 Oct 13;319(15):972-978.

Hogue CJ, Hargraves MA. Preterm birth in the African-American community. Semin Perinatol 1995;19(4):255-262.

Hunter W. Oral sepsis as a cause of disease. Br Med J 1900;1:215-216.

Jeffcoat MK, Geurs NC, Reddy MS, Cliver SP, Goldenberg RL, Hauth JC. Periodontal infection and preterm birth: results of a prospective study. J Am Dent Assoc 2001a July;132:875-880.

Jeffcoat MK, Geurs NC, Reddy MS, Goldenberg RL, Hauth JC. Current evidence regarding periodontal disease as a risk factor in preterm birth. Ann Periodontol 2001b Dec;6(1):183-188.

Jensen J, Lilejemark W, Bloomquist C. The effect of female sex hormones on subgingival plaque. J Periodontol 1981;52:599-602.

John W, Kin SJ. Periodontal disease and systemic disease: clinical information for the practicing dentist. J Indiana Dent Assoc 2002;81(2):15-18.

Kessel SS, Kleinman JC, Koontz AM, Hogue CJ, Berendes HW. Racial differences in pregnancy outcomes. Clin Perinatol 1988;15(4):745-754.

Khocht A, Zohn H, Deasy M, Chang KM. Assessment of periodontal status with PSR and traditional periodontal examination. J Am Dent Assoc 1995 Dec;126(12):1658-1665.

Khocht A, Zohn H, Deasy M, Chang KM. Screening for periodontal disease: radiographic vs. PSR. J Am Dent Assoc 1996 June;127(6):749-756.

Kinane DF. Causation and pathogenesis of periodontal disease. Periodontol 2000 2001;25:8-20.

Kleinman JC, Kessel SS. Racial differences in low birth weight: trends and risk factors. N Engl J Med 1987;317:749-753.

Kornman KS, Loesche WJ. The subgingival microbial flora during pregnancy. Periodontol Res 1980;15:111-122.

Kornman KS. The pathogenesis of periodontal diseases: an overview. In: Wilson TG, Kornman KS (eds): Fundamentals of Periodontics, Chicago, Quintessence, 1996.

Krejci CB, Bissada NF. Women's health issues and their relationship to periodontitis. J Am Dent Assoc 2002 Mar;133:323-329.

Landry RG, Jean M. Periodontal screening and recording (PSR) index: precursors, utility and limitations in a clinical setting. Int Den J 2002 Feb;52(1):35-40.

Li X, Kolltveit KM, Tronstad L, Olsen I. Systemic diseases caused by oral infection. Clin Micro Rev 2000 Oct;13(4):547-558.

Lockwood CJ. The diagnosis of preterm labor and the prediction of preterm delivery. Clin Obstet Gynecol 1995 Dec;38(4):675-687.

Loe H, Silness J. Periodontal disease in pregnancy: prevalence and severity. Acta Odont Scand 1963;21:533-551.

Loesche WJ. Association of the oral flora with important medical diseases. Curr Opin Periodontol 1997;4:21-28.

Lo Frisco C, Cutler R, Branson JB. Periodontal screening and recording: perceptions and effects on practice. J Am Dent Assoc 1993 Jul;124(7):226-232.

Lopez NJ, Smith PC, Gutierrez J. Higher risk of preterm birth and low birth weight in women with periodontal disease. J Dent Res 2002a Jan;81(1):58-63.

Lopez NJ, Smith PC, Gutierrez J. Periodontal therapy may reduce the risk of preterm low birth weight in women with periodontal disease; a randomized controlled trial. J Periodontol 2002b Aug;73(8):911-924.

Lu H, Wang M, Gunsolley JC, Schenkein HA, Tew JG. Serum immunoglobulin G subclass concentrations in periodontally healthy and diseased individuals. Infect Immun 1994;62:1677-1682.

MacDonald AD, Armstrong BG, Sloan M. Cigarettes, alcohol, and coffee consumption and prematurity. Am J Public Health 1992;82:87-90.

MacDorman MF, Minino AM, Strobino DM, Guyer B. Annual summary of vital statistics-2001. Pediatrics 2002;110(6):1037-52.

Madianos PN, Leiff S, Murtha AP, Boggess KA, Auten RL, Beck JD, Offenbacher S. Maternal periodontitis and prematurity. Part II: maternal infection and fetal exposure. Ann Periodontol 2001;6(1):175-182.

Main MD. The epidemiology of preterm birth. Clin Obstet Gynecol 1988;31:521-532.

Martin DH, Koutsky L, Eschenbach DA. Prematurity and perinatal mortality in pregnancies complicated by maternal Chlamydia trachomatis infections. JAMA 1982 Mar 19; 247(11):1585-1588.

Mattila KJ, Neiminen MS, Valtonen VV. Association between dental health and acute myocardial infarction. Br Med J 1989 Mar 25;298(6676):779-781.

McCormick MC. The contribution of low birth weight to infant mortality and childhood morbidity. N Engl J Med 1985 Jan 10;312(2):82-90.

McCormick MC, Gortmaker SL, Sobol AM. Very low birth weight children: behavior problems and school difficulty in a national sample. J Pediatr 1990 Nov;117(5):687-693.

McCormick MC, Workman-Daniels K, Brooks-Gunn J, Peckham GJ. Hospitalization of very low birth weight children at school age. J Pediatr 1993 Mar;122(3):360-365.

McGaw T. Periodontal disease and preterm delivery of low-birth-weight infants. J Can Dent Assoc 2002 Mar;68(3):165-169.

Miller WD. The human mouth as a focus of infection. Dental Cosmos 1891;33:689-713.

Minkoff H, Grunebaum AN, Schwarz RH. Risk factors for prematurity and premature rupture of membranes: a prospective study of the vaginal flora in pregnancy. Am J Obstet Gynecol 1984 Dec;150(8):965-972.

Mitchell-Lewis D, Engebretson SP, Chen J, Lamster IB, Papapanou PN. Periodontal infections and pre-term birth: early finding from a cohort of young minority women in New York. Eur J Oral Sci 2001 Feb;109(1):34-39.

MMWR Morb Mortal Wkly Rep 2002 Jul 12;51(27):589-592.

National Center for Health Statistics: Health, United States, 1982, DHHS, publication (PHS) 83 - 1232. Washington DC, US Government Printing Office, December 1982.

National Center for Health Statistics. Third National Health and Nutrition Examination Survey reference manuals and reports. Hyattsville MD, 1996.

Offenbacher S, Katz V, Fertik G. Periodontol infection as a possible risk factor for preterm low birth weight. J Periodontol 1996;67(10):1103-1103

Offenbacher S, Beck JD, Lieff S, Slade G. Role of periodontitis in systemic health: spontaneous preterm birth. J Dent Educ 1998a;62(10):852-858.

Offenbacher S, Jared HL, O'Reilly PG, Wells SR, Salvi GE, Lawrence HP, Socransky SS, Beck JD. Potential pathogenic mechanisms of periodontitis-associated pregnancy complications. An Periodontol 1998b;3(1):233-250.

Offenbacher S, Lieff S, Boggess KA, Murtha AP, Madianos PN, Champagne CM, McKaig RG, Jared HL, Mauriello SM, Auten RL, Herber WN, Beck JD. Maternal periodontitis and prematurity. Part I: obstetric outcome of prematurity and growth restriction. Ann Periodontol 2001 Dec:6(1):164-174.

Otomo-Corgel J. Periodontal therapy in the female patient (puberty, menses, pregnancy, and menopause). In: Newman MG, Takei HH, Carranza FA, eds. Carranza's Clinical Periodontology. 9th ed. Philadelphia: WB Saunders, 2002a:516-518.

Otomo-Corgel J, Merin RL. Periodontal disease and systemic health-what you and your patients need to know. Can Dent Assoc J 2002b Apr;30(4):307-311.

Page RC, Offenbacher S, Schroeder HE. Advances in the pathogenesis of periodontitis: summary of developments, clinical implications and future directions. Periodontol 2000 1997;14:216-248.

Page RC. Periodontal diseases: a new paradigm. J Dent Educ 1998 Oct;62(10):812-821.

Pamuk E, MakucD, Heck K, Reuben C, Lochner K. Socioeconomic status and health chartbook: Health, United States, 1998. Hyattsville, MD: National Center for Health Statistics, U. S. Department of Health and Human Services.

Paquette DW, Madianos P, Offenbacher S, Beck JD, Williams RC. The concept of "risk" and the emerging discipline of periodontal medicine. J Contemp Dent Pract 1999 Nov;15(1):1-18.

Peoples MD, Siegal E. Measuring the impact of programs for mothers and infants on prenatal care and low birthweight: the value of refined analysis. Med Care 1983;21:586-588.

Petrou S, Sach T, Davidson L. The long-term costs of preterm birth and low birth weight: results of a systematic review. Child Care Health Dev 2001 Mar;27(2):97-115.

Power C, Matthews S, Manor O. Inequalities in self-rated health: explanations from different stages of life. Lancet 1998;351:1009-1014.

Pschirrer ER, Monga M. Risk factors for preterm labor. Clin Obstet Gynecol 2000 Dec;43 (4):727-734.

Rivera-Hidalgo F. Systemic disease and periodontal disease. Texas Dent J 2001 Oct;118(10):944-953.

Romero R, Emamian M, Wan M, Quintero R, Hobbins JC, Mitchell MD. Prostaglandin concentrations in amniotic fluid of women with intra-amniotic infection and preterm labor. Am J Obstet Gynecol 1987 Dec;157(6):1461-1467.

Romero R, Mazor M, Tartakovsky B. Systemic administration of interleukin-1 induces preterm parturition in mice. Am J Obstet Gynecol 1991 Oct;165(4 Pt 1):969-971.

Rutter DR, Quine L. Inequalities in pregnancy outcome: a review of psychosocial and behavioural mediators. Soc Sci Med 1990;30:553-568.

Ryan GM, Abdella TN, McNeeley SG, Baselski VS, Drummond DE. Chlamydia trachomatis infection in pregnancy and effect of treatment as outcome. Am J Obstet Gynecol 1990 Jan;162(1):34-39.

Savitz DA, Olshan AF, Gallagher K. Maternal occupation and pregnancy outcome. Epidemiology 1996;7:269-274.

Savitz DA, Ananth CV, Berkowitz GS, Lapinski R. Concordance among measures of pregnancy outcome based on fetal size and duration of gestation. Am J Epidemiol 2000 Mar 15;151(6):627-633.

Schenkein HA, Burmeister JA, Koetre. The influence of race and gender on periodontal microflora. J Periodontol 1993;64:292-296.

Schoenborn C, Vickerie, JL, Barnes PM. Cigarette smoking behavior of adults: United States, 1997-98. Vital and Health Statistics; no 331. Hyattsville, MD: National Center for Health Statistics, 2003.

Seo K, McGregor JA, French JI. Preterm birth is associated with increased risk of maternal and neonatal infection. Obstet Gynecol 1992 Jan;79(1):75-80.

Shapiro S, McCormick MC, Starfield BH, Krischer JP, Bross D. Relevance of correlates of infant deaths for significant morbidity at 1 year of age. Am J Obstet Gynecol 1980 Feb 1; 136(3):363-373.

Shiono PH, Klebanoff MA, Rhoads GG. Smoking and drinking during pregnancy: their effects on preterm birth. JAMA 1986;255:82-84.

Socransky S, Haffajee A. Evidence of bacterial aetiology: a historical perspective. Periodontol 2000 1994;5:7-25.

Taylor D. State-specific changes in singleton preterm births among black and white women-United States, 1990 and 1997. MMWR 2000;49:837-840.

Teng YTA, Taylor GW, Scannapieco F, Kinane DF, Curtis M, Beck JD, Kogon S. Periodontal health and systemic disorders. J Can Dent Assoc 2002 Mar;68(3):188-192.

Umeda M, Chen C, Bakker I, Contreras A, Morrison JL, Slots J. Risk indicators for harboring periodontal pathogens. J Periodontol 1998;69:1111-1118.

Ventura SJ, Martin JA, Mathews TJ, Clarke SC. Advance report of final natality statistics, 1994. Mon Vital Stat Rep 1996;44(suppl 11):75.

Watts DH, Krohn MA, Hillier SL, Eschenbach DA. The association of occult amniotic fluid infection with gestational age and neonatal outcome among women in preterm labor. Obstet Gynecol 1992 Mar;79(3):351-357.

Wilcox AJ, Skjaerven R. Birth weight and perinatal mortality: the effect of gestational age. Am J Public Health 1992 Mar;82(3):378-382.

Williams DR. Racism and health: a research agenda. Ethn Dis 1996;6:1-8.

Williams MC, O'Brien WF, Nelson RN, Spellacy WN. Histologic chorioamnionitis is associated with fetal growth restriction in term and preterm infants. Am J Obstet Gynecol 2000 Nov;183(5):1094-1099.

World Health Organization. International Classification of Diseases. 1975 revision. Volume 1. Geneva: WHO, 1977.

World Health Organization. The incidence of low birth weight: an update. Weekly Epidemiol Rec 1984;59:205-211.

Zachariasen RD, Dennison DK. Periodontal disease and preterm low birth weight deliveries. J Greater Houston Dent Soc 1998 Nov:70(4):16-19.

Zambon JJ. Periodontal diseases: microbial factors. Ann Periodontol 1996 Nov;1(1):879-925.

VITA

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