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Periodontal Disease during Pregnancy and Low Birth Weight of Newborns at Chris Hani District of Eastern Cape

by

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DECLARATION

I hereby declare that every aspect of this dissertation entitled *Periodontal disease during pregnancy and low birth weight of newborns at Chris Hani district of Eastern Cape* was undertaken by me. It has not been submitted for any degree or examination in any university, and all the resource materials used and/or quoted have been duly acknowledged.

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DEDICATION

This dissertation is dedicated to the memory of my parents;
Mr J.A. Agbeniyi and Mrs E.O. Agbeniyi,
in deep gratitude for giving me
a formal, moral and spiritual education.

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Finally, I would like to thank Dr Bukola Olutola for her time and support during my studies.

ABSTRACT

Objective: This study sought to determine the association between periodontal disease in pregnancy and the delivery of low birth weight newborns in a rural population of South African women.

Methods: This case-control study involved 348 new mothers. All subjects were recruited post-delivery from three public hospitals in the rural Eastern Cape of South Africa. The cases (n=119) were mothers who delivered through normal delivery and whose babies at the time of delivery weighed <2.5 kg. Age-matched controls (n=229) were mothers who delivered ≥2.5 kg babies. Potential risk factors for periodontal disease and low birth weight were collected by means of a structured questionnaire and maternity record review. Using the WHO's community periodontal index, a trained dental clinician blinded to participants' birth-outcomes recorded the periodontal health status of each participant (intra-examiner reliability; kappa = 0.95). Mothers who presented with a probing depth ≥4 mm on more than four index teeth without the presence of gingival overgrowth were deemed to present with periodontal disease. Data analysis included conditional logistic regression analysis.

Results: Periodontal disease was diagnosed in 37.9% (n=45) of the case group and 9.2% (n=21) of the control group. Low birth weight was also significantly more common among those who were unemployed, those who reported fewer than three antenatal visits and drinking on five or more days per week during pregnancy. After controlling for potential confounders, mothers presenting with a probing depth of ≥ 4 mm on four teeth (OR = 4.12; 95% CI = 1.78 - 9.50) or more than four teeth (OR = 4.95; 95% CI: 1.52 – 15.81) were found to be significantly more likely to have low birth weight babies.

Conclusions: The study findings suggest that there is a significant dose-dependent positive association between periodontal disease and low birth weight, independent of other risk factors measured in this study.

Keywords: Periodontal disease, Low birth weight, Pregnancy, South Africa, Case, Control, Probing depth, Maternity record, Questionnaire, Community periodontal index.

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LIST OF ABBREVIATIONS

CI	Confidence interval
CPI	Community periodontal index
DNA	Deoxyribonucleic acid
DOH	Department of Health
GCF	Gingival crevicular fluid
HIV/AIDS	Human immunodeficiency virus/Acquired immunodeficiency syndrome
IVH	Intravascular haemorrhage (bleeding in the brain)
MCH	Maternal and child health
MDG	Millennium development goal
MMP	Matrix metalloproteinase
NEC	Necrotizing enterocolitis
OR	Odds ratio
PD	Periodontal disease
PDA	Patent ductus arteriosus
PGE_2	Prostaglandin E_2
RDS	Respiratory distress syndrome
ROP	Retinopathy of prematurity
TNF	Tumour necrotic factors
WHO	World Health Organization

CHAPTER 1:
INTRODUCTION

1.1 BACKGROUND

Low birth weight is a leading perinatal problem world-wide, and may account for a sizable percentage of perinatal morbidity and mortality.[1] The World Health Organization (WHO) defines the condition as a baby born with a birth weight lower than 2.5 kg, due to either a short gestational period or to intrauterine growth delay.[1] Low birth weight is not synonymous with preterm deliveries. Low birth weight refers to infants weighing less than 2.5 kg, whereas preterm infants are infants born before 37 weeks of pregnancy have been completed. Thus, a low birth weight infant could be born preterm or could be born at a normal gestation period following a period of poor intrauterine fetal growth.

Babies with low birth weight look much smaller than babies of normal birth weight. A low birth weight baby's head may appear to be bigger than the rest of the body and the baby often looks thin, with little body fat (see Figure 1, overleaf).

Compared to normal weight newborns, babies with this condition face a higher risk of serious health problems, lasting disabilities and even death during the neonatal period.[2] Medical problems that are common in low birth weight babies include respiratory distress syndrome (RDS), intravascular haemorrhage (IVH),

patent ductus arteriosus (PDA), necrotizing enterocolitis (NEC) and retinopathy of prematurity (ROP).[3] They also demonstrate more behavioural abnormalities as preschoolers.[3]

Figure 1: A low birth weight baby

Factors that may contribute to fetal growth restriction include the following:[3]

- chronic health problems in the mother;
- smoking by the mother (active and passive);
- alcohol and illicit drug use by the mother;
- infections in the mother, particularly of the genitourinary tract;
- infections in the uterus;
- placenta problems such as abnormal placenta;
- inadequate maternal weight gain; and
- socio-economic factors such as unfavourable socio-economic conditions.

Low birth weight presents any community with several challenges. Increased susceptibility to infections and a range of medical complications, together with the added infrastructural, financial and human resources required to reduce mortality in such newborns, have generated interest in this condition in recent times.[3]

The low birth weight incidence rate has been used as an indicator for the socio-economic and general health status of women and the community at large.[3] The South African low birth weight rate is on a par with the global rate of 15%.[3] However, a much lower incidence of 4% in Sweden, 6% in Switzerland, and 8% in the United Kingdom[3] illustrates the need for improvement, especially in the upstream factors required to decrease low birth weight rates in South Africa. The difference between low birth weight incidence rates in these developed countries and South Africa may be a reflection of the lower socio-economic and general health status of women and the larger community in South Africa compared to that of women in such developed countries.

Several scientific reports have implicated various factors as predisposing mothers to delivering low birth weight babies. However, medical professionals remain unable to predict the occurrence of low birth weight with absolute certainty and medical interventions are still unable to prevent this condition in many cases. This has led many health workers to hypothesize the presence of some as yet unidentified contributing factors, including periodontal disease during pregnancy[4-5] that may be linked to an increased risk of low birth weight.

Periodontal disease (see Figure 2, overleaf) is an oral disease characterized by a Gram-negative bacterial infection that progresses from affecting the gingival

tissue to reaching the tooth-supporting structure. Although periodontal disease starts as a localized inflammatory condition in the oral cavity, it may present a risk factor for health problems and an inflammatory challenge at a systemic level.[5] In the dental literature, periodontal diseases are generally classified into two groups, namely gingivitis (inflammation of the gingivae/gums) and periodontitis (a more severe inflammatory condition that progressively damages the tissues that support the teeth beneath the gum).[5]

Figure 2: Periodontal disease

Periodontal diseases are considered one of the most widespread diseases amongst humans. They are caused by the activity of bacteria that are present in dental plaque and that accumulate as a result of inadequate oral hygiene practices. Recently, the impact of periodontal disease in terms of adverse pregnancy outcomes, especially low birth weight, has received considerable attention.[4,5] Since 1996, a number of studies have investigated the potential relationship between periodontal disease and low birth weight.[6,7] The initial

results have been inconsistent,[8] but more scientific evidence is beginning to emerge in support of a positive association between periodontal disease in pregnancy and the occurrence of low birth weight in new-borns.[9] Most of the studies on this subject have been conducted in high-income countries, so that only limited information is available on the association between periodontal disease and low birth weight in low-income and middle-income countries, where both poor oral health and adverse reproductive outcomes are more prevalent.[4]

In South Africa, the prevalence of periodontal disease is high.[10] Fewer than 2% of younger adults (between 35 and 44 years)[10] and children younger than 15 years[11] in South Africa have healthy gums. Experiencing 'bleeding gum' when brushing the teeth gently and painful gums are the most common symptoms of periodontal diseases.[12] Periodontal disease is also an infectious disease, affecting more than 23% of women between the ages of 30 and 54 years.[13]

Once diagnosed, most periodontal diseases can be treated successfully. The therapeutic goals in periodontal therapy are threefold. The first aim is to alter or eliminate the origin of the microbes, as well as contributing risk factors, thereby preventing the progression of the disease and preserving the healthy state of the periodontium. The second goal is to prevent the recurrence of periodontal disease. Finally, in severe cases, regeneration of the periodontal attachments must be attempted.[14]

The paucity of studies from developing countries warrants more studies from this part of the world so that associations between low birth weight and periodontal disease can be considered from a developing country perspective. It is this gap that the current study attempts to address.

1.2 LITERATURE REVIEW

Periodontal disease is recognized as the second most prevalent oral disease after dental caries.[15] It represents an important individual and public health problem, not only because of its relatively high prevalence, but also because of the way in which its effects go beyond the oral region.

The bacteria that form plaque also release toxins that stimulate the immune system to overproduce a powerful infection-fighting factor called cytokines. Ordinarily, cytokines, which are a hormone-like protein, are important for healing. In excess, however, they cause inflammation and tissue damage.[15] Two cytokines that are important in periodontal disease are known as tumour necrotic factor-alpha (TNF-alpha) and interleukin-1 beta.[15] In addition, white blood cells produced by the immune response to these bacteria also release a family of enzymes called matrix metalloproteinases (MMPs) which break down connective tissue. The integrity of the periodontium is thus broken by the activity of bacteria present in dental plaque.

Periodontal integrity can be maintained by means of the combined effects of host factors, adequate nutrition, adequate oral self-care and the absence of undermining systemic conditions.[15] Factors such as smoking, alcohol intake, poor nutrition, and immune-suppression associated with diseases (such as diabetes or HIV) have also been known to pose a risk for periodontal disease.[16]

Evidence has accumulated to indicate that there is a relationship between periodontal disease and low birth weight.[4-5,8] Other systemic conditions that have been associated with periodontal diseases include cardiovascular disease,

diabetes mellitus and osteoporosis.[9] In addition to the biological components that contribute to the association between periodontal disease and low birth weight, there are a number of, other factors that are also relevant to the causal process of this association, such as unfavourable socio-economic conditions, difficulty in accessing health services and lifestyle habits that have a bearing on health, such as smoking and alcohol use.[8]

The ability of periodontal pathogens and their virulence factors to disseminate and induce both local and systemic inflammatory responses in the host has led to the hypothesis that periodontal disease may have consequences beyond the periodontal tissues themselves. Interestingly, this concept was reported by Miller[16] as early as 1891, when he published the theory of 'focal infection'. On the basis of this theory, oral foci of infection are considered responsible for a number of local and systemic diseases such as tonsillitis, pneumonia, endocardiatis and septicaemia. However, because of a lack of scientific evidence, this theory was largely ignored, although Galloway[18] suggested in 1931 that periodontal disease has more than just an association with, and can actually contribute to a low birth weight. It was only in the early 1990s, about a 100 years after Miller made his proposition, that Colin and colleagues[17] hypothesized that an oral infection such as periodontitis could act as a source of bacteria and could be an inflammatory mediator that could disseminate systemically to the fetal-placental unit, via blood circulation, and induce complications in pregnancy.

In a series of landmark animal studies, Colin et al.[17] demonstrated that in a hamster chamber model, chronic exposure to *Porphymonas gingivalis* led to a

15% to 18% decrease in fetal weight, along with a local increase in prostaglandin E_2 (PGE_2) and tumour necrotic factors (TNFs) within the chamber fluid. Later they studied the association between infection and pregnancy by including periodontal disease in the hamster model. Four groups of animals were fed either control chow or plaque-promoting chow for an eight-week period to induce experimental periodontitis prior to mating. Two additional groups received exogenous *Porphymonas gingivalis* via oral lavage. On the day of sacrifice, animals receiving both plaque-promoting chow and exogenous *Porphymonas gingivalis* challenge demonstrated a significant 22.5% reduction in the mean fetal weight. These animal studies provided vital proof-of-principle experiments and suggested the possibility that low grade infections may indeed trigger maternal-fetal inflammation, resulting in adverse pregnancy events.

Periodontal disease is a Gram-negative infection and it may indeed have the potential to influence the outcome of a pregnancy. During pregnancy, the proportion of Gram-negative anaerobic bacteria in dental plaque increases compared to the proportion of aerobic bacteria.[19] In a study conducted by Li et al.,[20] *fusobactrium nucleatum* and other subspecies emanating from the oral flora were found in the amniotic fluid of women with low birth weight. Evidence of an increased rate of amniotic fluid infections, chorioamnion infection and chorioamnionitis support an association between low birth weight and infection during pregnancy.[20] Histologically, the chorioamnion is often inflamed, even in the absence of any bacterial infection in the vagina or cervical area. This suggests that distant sites of infection or sepsis may be targeting the placenta membranes. Some case-control studies[20-21] have demonstrated that women who have low birth weight infants as a consequence of either preterm labour or

premature rupture of membranes tend to have more severe periodontal disease than mothers with normal birth weight infants.

Another study conducted by Bostrom et al.[22] found that the Gram-negative bacteria associated with progressive disease can produce a variety of bioactive molecules that may affect the host directly. It was suggested in their study that the microbial component, lipopolysaccharides, can activate the macrophages and other cells to synthesize and secrete a wide spectrum of molecules, including cytokines IL, TNFs, PGE_2 and MMPs. It was further suggested that if these components travel via the bloodstream and cross the placental barrier, the physiological levels of PGE_2 and TNFs in the amniotic fluid may increase and induce a pre-term birth, resulting in low birth weight.[22]

In 2008, Marakoglu et al.[23] conducted a cross-sectional unmatched case-control study in Turkey. The aim of their study was to evaluate periodontal disease as a risk factor for low birth weight. The results indicated that periodontal disease was independent risk factor for low birth weight.

In 1996, Offenbacher et al.[24] conducted a case-control study in which they hypothesized that periodontal infection may be associated with low births. A case-control study of 124 pregnant or postpartum mothers was conducted, using mothers with normal birth weight babies as controls. The assessment included a broad range of known obstetric risk factors, such as tobacco and drug use, alcohol consumption, the level of prenatal care, parity, genitourinary infections and nutrition. Each subject received a periodontal examination to determine her clinical attachment level. Mothers of low birth weight infants and primiparous mothers of low birth infants had significantly worse periodontal

disease than the mothers of the normal birth weight infants. Multivariate logistic regression models used to control for other risk factors and covariates demonstrated that periodontal disease was a statistically significant risk factor for low birth weight, with adjusted odds ratios of 7.9 and 7.5 for all low birth weight cases and primiparous low birth weight cases respectively. These observations indicate that periodontal disease represents a previously unrecognized and clinically significant risk factor for low birth weight as a consequence of either preterm labour or premature rupture of the membrane.

Offenbacher et al.[25] also conducted a more recent case-control study, in which the gingival crevicular fluid (GCF) levels of PGE_2 and interleukin of 48 case-control subjects were measured to determine whether mediator levels are related to current pregnancy outcomes. In addition, the levels of four periodontal pathogens were measured by using microbe-specific DNA probes. The results indicated that the GCF PGE_2 levels were significantly higher in mothers of low birth weight infants than in mothers of normal birth weight infants (the control). Furthermore, among the primiparous mothers of pre-term low birth weight infants, there is a significant inverse association between birth weight and the GCF PGE_2 level. This study also suggested a dose-response relationship for increased GCF PGE_2 as a marker of current periodontal disease activity and decreasing birth weight. Four organisms associated with mature plaque and progressing periodontitis, namely *Acteroides forsythus*, *Porphymonas gingivalis*, *Acteroides actinomycetemcomitans and Treponema denticola*, were detected and displayed higher levels in the mothers of pre-term low birth weight infants in the study than in the mothers in the control. These observations, taken together, suggest that biochemical measures of maternal periodontal status and an

elevated oral microbial burden are associated with preterm birth and low birth weight. Offenbacher et al. [25] concluded that 18.2% of the incidence of preterm low birth weight may result from periodontal disease.

Jeffcoat et al.[26] conducted a prospective cohort study among women between the ages of 20 and 30 years; 83% of the subjects were African Americans and the remaining 17% were Caucasians. Their study reported that maternal periodontal disease represents a significant risk factor for low birth weight. The adjusted prevalence of moderate to severe periodontal disease increased with reducing gestational age. It was concluded that the average newborn's weight and gestational age was inversely proportional to maternal periodontitis status. Xiong et al.[27] report that it has already been proven that periodontal disease is a major inflammatory precursor to adverse pregnancy outcomes and may be implicated in up to 50% of cases.

In 2002, Madianos et al.[28] analysed three studies published on the association between periodontal disease and an increased risk of coronary heart disease and preterm and/or low birth weight deliveries. Two out of the three eligible studies found a significant association between periodontitis and adverse pregnancy outcomes. The third study did not find any association. A study by Moreu et al.[29] also reports inconsistent results, concluding that periodontal disease was a significant risk factor for low birth weight, but not for pre-term delivery. Recently, in 2010, Rajn et al.[30] concluded that periodontal disease appears to be an independent risk factor for preterm low birth weight and that there is a need to expand preventive measures for pregnant women in

harmonization with the gynaecological and dental profession, and to provide professional oral hygiene measurement during pregnancy.

Since the pioneering study in 1996 by Offenbacher et al.[24] there has been increased interest in identifying the potential association between periodontal disease and pregnancy outcomes. Some intervention studies[31-40] have shown that providing periodontal treatment to pregnant women with periodontal disease improved pregnancy outcomes, buttressing the link between periodontal disease and adverse pregnancy outcomes.

Mitchell-Lewis et al.[32] investigated the relationship between periodontal infections and low birth weight in a cohort of young, minority, pregnant and post-partum women. Periodontal treatment was provided to 74 pregnant women and the incidence of low birth weight was compared to that among 90 women studied after the birth of their babies. Although the incidence of adverse pregnancy outcomes was higher in women who had received no periodontal treatment, this difference was not statistically significant, due to the small sample size. However, the study did show that low birth weight mothers had significant levels of *Tannerella forsythensis* and *Campylobacter rectus.*[32] Similarly, Lopez et al.[33] found a reduction in the rate of preterm births and/or low birth weight in women who received periodontal treatment before the 28th gestational week, compared to the rate among women who had not received any such treatment. This reduction was significant for women with both gingivitis and periodontal disease.[33-35]

Jeffcoat et al.[36] did a pilot study in which they enrolled 366 women with periodontitis between the 21st and 25th gestation weeks in three intervention

groups. In Group 1, the intervention consisted of dental prophylaxis plus a placebo capsule; in Group 2, it consisted of scaling and root planing plus a placebo capsule; and in Group 3, it consisted of scaling and root planing plus a metronidazole capsule. The researchers concluded that performing scaling and root planing in pregnant women with periodontitis may reduce low birth weight in that population, but that adjunctive metronidazole therapy did not improve pregnancy outcomes.

In 2009, Sha et al.[37] conducted a study in China which found that oral health instruction and periodontal treatment may decrease infection by periodontal pathogens and reduce the risk of low birth weight. They concluded that the best advice for a woman who is contemplating pregnancy is effective brushing two times per day and regular periodontal treatment. In Brazil, in a study to evaluate whether periodontal therapy among pregnant women would reduce the incidence of low birth weight, Cruz et al.[38] demonstrated that the frequency of low birth weight among women who had periodontal disease but who were treated was 9.22%, while it was 13.10% in the group without treatment for periodontal disease. This suggests that periodontal therapy is a protective factor against low birth weight.[38] In 2011, Sant'Ana et al.[39] also reported on another study conducted in Brazil which showed that performing periodontal treatment during the second trimester of gestation would decrease the risk that adverse pregnancy outcomes would develop. Their finding could imply that periodontal disease can be considered a risk factor for adverse pregnancy outcomes, especially preterm birth and/or low birth weight.

In a 1:1 matched case-control study (55 pairs), Dasanayake[40] tested the hypothesis that poor oral health in a pregnant woman is a risk factor for low birth weight. The effect of the periodontal and dental caries status of each mother on the birth weight of her infant was evaluated at the time of delivery by conditional logistic regression analysis, while controlling for known risk factors for low birth weight. Mothers of low birth weight infants were shorter, were less educated, and were married to men of lower occupational class, had fewer areas of healthy gingiva and more areas with bleeding and calculus (tartar), and gained less weight during pregnancy. Conditional logistic regression analysis indicated that mothers with more healthy gingival areas (odds ratio [OR] =0.3, 95% confidence interval [CI]=0.12 to 0.72) and those who were taller (OR=0.86, 95% CI=0.75 to 0.98) have a lower risk of giving birth to low birth weight infants. It was concluded that poor periodontal health is a potential independent risk factor for low birth weight.

Although the number of studies showing a positive correlation in terms of a possible link between periodontal disease and low birth weight is growing, some studies have demonstrated contrary findings. Davenport et al.[41] found no association between maternal periodontal disease and a risk of preterm low birth weight. In another study, Michalowicz et al.[42] suggested that periodontal progression is not associated with an increased risk for delivering a preterm or a low birth weight infant. The distribution of gestational age at the end of pregnancy and mean birth weight in Michalowicz et al.'s[42] study did not differ significantly between women with and without periodontal disease progression. Gestational age and birth weight were not associated with a change from the baseline in the percentage of tooth sites with periodontal disease.

Interestingly, a few studies have also queried the role of periodontal therapy in reducing low birth weight. In 2009, Michalowicz et al.[43] studied the effect of scaling and root planing before the 21st gestational week, plus monthly tooth polishing, in 823 pregnant women in Minnesota in the USA. They did not find a significant difference between the treatment and the control groups with regard to the birth weight or in the rate of delivery of infants that were small for their gestational age. In 2010, an observational study by Calabrasse et al.[45] was also unable to provide evidence of an association between periodontal disease and pre-term low birth weight. In 2011, a meta-analysis of randomized controlled trials by Baccaglini[44] showed no evidence that periodontal treatment during pregnancy could prevent adverse pregnancy outcomes. Another study in 2011 by Chambrone et al.[46] also reported that maternal periodontal disease treatment did not decrease the risk of preterm birth or of low birth weight.

In conclusion, while the review of the literature suggests that the evidence appears to be weighted in favour of a significant association between periodontal disease and preterm delivery and/or low birth weight delivery,[7,8,47] the evidence is not unequivocal. Furthermore, most studies on this subject have been conducted using a relatively small sample size and/or have been conducted mostly in developed countries. Therefore, only limited information is available on the association between periodontal disease and low birth weight in low-income and middle-income countries, where both poor oral health and adverse reproductive outcomes are more prevalent.

1.3 SIGNIFICANCE AND RELEVANCE OF THE STUDY

In the light of the controversial results of previous investigations, and especially the possibility that a combination of biological and environmental factors may promote an association between periodontal disease and low birth weight, without a clear cause-effect relationship,[43] it is imperative to continue to investigate this question in order to expand our understanding of the relationship between oral health and pregnancy outcomes. This is particularly important considering that to the best of the researcher's knowledge, this is the first study to examine this relationship in a South African population.

Conducting this study is relevant to public health, because low birth weight is one of the dominant factors causing child morbidity and mortality worldwide, and the frequency of its occurrence has not been satisfactorily reduced, even in developed countries.[48] Reducing child mortality and morbidity remains one of the critical millennium development goals (MDGs).[48-50] The results of this study will therefore inform the content of potential educational interventions for promoting oral health at mother and child health (MCH) clinics as envisaged in the South African oral health promotion framework (DOH, 2010),[49] and will contribute to the achievement of the health-related MDG goals in South Africa.

This study may also allow some insight into the utilization rate of dental services and the prevalence of oral health-related risk behaviour among a population of South African pregnant women.

In view of these observations, and with the aim of expanding the body of evidence on this matter, the proposed study has the objective of evaluating

whether or not there is an association between maternal periodontal disease and low birth weight.

1.4 OUTLINE OF THE STUDY

The introductory chapter has presented the background to the study, as well as a literature review of prior studies on the possible association between low birth weight and periodontal disease. The significance and relevance of the study have also been discussed. The remainder of the study is organised as follows:

- Chapter 2 sets out the aim and objectives of the study, and the research question and null hypothesis;
- Chapter 3 discusses the methodology used in the study (including the study design, study population, sample, subjects, control, data collection, data analysis, and ethical considerations);
- Chapter 4 presents the results;
- Chapter 5 discusses the results; and
- Chapter 6 contains the conclusions, and a recommendation is made.

CHAPTER 2:
AIM AND OBJECTIVES OF THE STUDY

2.1 AIM OF STUDY

The aim of this study is to explore the association between periodontal disease among pregnant women and adverse reproductive outcomes in a rural population of South African women. This may inform policy aimed at improving pregnancy outcomes.

2.2 SPECIFIC OBJECTIVES

The specific objectives of this study are the following:

- to examine the association, if any, between periodontal disease in pregnant women and the delivery of low birth weight newborns;
- to determine the prevalence of oral health-related risk behaviours among pregnant women; and
- to determine the utilization rates for dental services among pregnant women in the Chris Hani District of the Eastern Cape.

2.3 RESEARCH QUESTION

The study attempts to answer the following question:

Is periodontal disease associated with a significantly increased risk for the delivery of low birth weight newborns?

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2.4 HYPOTHESIS

The null hypothesis in this study is the following:

> There are no significant differences in the incidence of low birth weight among women with periodontal disease compared to the incidence among periodontally healthy women.

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CHAPTER 3:
METHODOLOGY

3.1 STUDY DESIGN

The study is a matched case-control study conducted in the rural Chris Hani District in the Eastern Cape, South Africa, from May to November 2010.

3.2 STUDY POPULATION

The participants were mothers of the black South African race group whose deliveries took place at one of the three public hospitals (the Frontier, Glen Grey and Cala Hospitals) in the rural Chris Hani District of the Eastern Cape. This selection was based on the availability of matching participants of the same socio-economic status and age and taking into consideration the significant association between socio-economic status and race in South Africa.[49]

3.3 STUDY SUBJECTS

3.3.1 Case

A case was defined as a mother who delivered a newborn through normal delivery and whose baby at the time of delivery weighed <2.5 kg, as recorded in the medical records at the hospital concerned.

3.3.2 Control

A control was defined as a mother who delivered a newborn through normal delivery and whose baby at the time of delivery weighed ≥2.5 kg.

Control mothers were matched with cases by age, and socio-economic status. Age matching was done in five-year band and the level of educational attainment was used as proxy measure for socio-economic status, as these are known to influence both dental care and low birth weight delivery.[50-51]

3.3.3 Sample size determination

In line with a prior study by Cruz et al.,[8] the sample size determinant was based on the assumption of a periodontal disease prevalence of 15% among normal weight delivery[41] and a prevalence (30%) about double (that is OR=2.3)[6] among women with low birth weight deliveries. Considering the rarity of low birth weight (<10%), in order to ensure sampling efficiency and adequate statistical power, two controls were recruited for each case. It was calculated that for a 5% significance level and 80% power, at a non-disease to disease ratio of two to one, 300 participants (200 controls and 100 cases) were required. However, in order to accommodate possible incomplete or missing responses, an additional 10% of the required sample was targeted, resulting in an eventual sample size of 348 (229 controls and 119 cases).

3.3.4 Exclusion criteria

Mothers who presented with cardiac disease, diabetes, HIV and/or AIDS or who were on antibiotic prophylaxis were excluded. The exclusion criteria were applied by the attending nursing Sister-in-charge without the knowledge of the

researcher. This exclusion was done primarily in the interests of the patient's safety, but also to eliminate a potential source of bias in the interpretation of the study results.

3.4 DATA COLLECTION

Data were collected using a structured questionnaire and measuring the subjects' periodontal status. These data collection methods are discussed in more detail below.

3.4.1 Structured questionnaire

Candidates were approached and the study was explained to them. They were asked to give written consent to participate. After each study participant had given her informed consent, she was invited to complete a self-administered pre-validated structured questionnaire adapted from those used in prior studies reported in previous published papers.[8,51,52] The questionnaire was translated into Xhosa and back-translated into English to ensure consistency of meaning.

The information elicited by the questionnaire included socio-demographic data on each participant's employment status, area of residence and educational level; oral health care practices; current and previous gestational history; and health risk behaviour (such as active and passive smoking and alcohol use). The living conditions of the mothers were expressed as crowding (inhabitants per room), which was derived from responses to questions on how many rooms were present in the household and how many people resided in a respondent's household. Information was also requested on the frequency of antenatal visits and any experience of obstetric complications such as pre-eclampsia and

antepartum haemorrhage during pregnancy or any maternal characteristics such as parity and gravidity that may be a risk for the delivery of low birth weight babies.

The data related to the newborn weight were collected from the newborn's medical card. A newborn is usually weighed within an hour after delivery (in other words, before postnatal weight loss occurs). A trained maternity nurse completed a separate section of the questionnaire which requires information from the participant's maternity record, including the weight of the newborn. The clinical examination form was a stand-alone form that carried only a matching study number assigned to each participant by the attending nurse who recruited the participants from the ward. This was done to ensure that the oral examiner was blinded to the birth outcome status of the participating mothers and to ensure the confidentiality of other records in the mother's file.

3.4.2 Measurement of periodontal status

After each consenting participant had completed the self-administered questionnaire, she was invited to participate in a clinical oral examination. This was typically done two to four days after delivery. Systematic oral examination was carried out in the hospital's dental consulting room by a trained dentist who examined the patients who were referred to him from the maternity ward with an examination form.

Periodontal status was recorded using the WHO's Community Periodontal Index (CPI).[53,54] Calibrated periodontal probes (Williams probes) were used. The examiner was blinded to the newborn's weight, as the participants only

reported to the dentist's room with a numbered examination form. The nursing sister that assisted during the self-administration of the questionnaire assigned a number to each questionnaire and the accompanying examination form, but only sent the participant to the dentist with the detached examination form without the correspondingly numbered completed questionnaire.

3.4.3 Criteria for the diagnosis of periodontal disease

During the dental examination, the sulcus/pocket probing depth, presence or absence of any calculus deposit, and gum bleeding on probing were recorded. The relevant codes were used in line with the WHO survey methods for the CPI.[54] This involved recording the periodontal status of six index teeth, namely teeth 11,16/17, 26/27, 31, 36/37, and 46/47. The presence and extent of any sign of gingival overgrowth were also recorded. Index teeth with gingival overgrowth were not recorded. Similar to the definition used by Cruz et al.,[8] mothers who presented with at least four indexed teeth with one or more sites showing a probing depth ≥4 mm (in other words, with CPI codes 3 or 4) without gingival overgrowth were considered to have periodontitis. Those who showed signs of bleeding on probing only were considered to have gingivitis. Anyone with either periodontitis or gingivitis was considered to have periodontal disease.

3.5 QUALITY ASSURANCE

The universal infection control protocol was employed throughout the study. In particular, in order to ensure effective sterility, a hypochlorite solution was used to disinfect the examining probes before autoclave sterilization.

The clinical examiner was trained by an experienced periodontist using a series of standardized procedures and one-on-one tutorials in the periodontal clinic at the University of Pretoria. The study examiner was calibrated against the experienced periodontist examiner, and the level of agreement with this examiner was determined using kappa statistics. Training was continuous until the clinical examiner reached at least a kappa of 0.70 with the specialist examiner.

In order to limit the problem of inter-examiner variation, only one examiner examined all 348 study participants in this study. In order to determine intra-examiner reliability, 10% of the participants in this study were randomly recalled for a duplicate examination (intra-examiner reliability; kappa=0.95).

3.6 DATA ANALYSIS

The analysis procedures included a series of stratified analyses, followed by conditional logistic regression. To describe the study sample, the distributions of the principal independent variable (periodontal disease) and all the covariables considered were explored.

Group differences were tested using the Chi-square (or Fischer's exact test when the expected cell count was <5) and the t-test for categorical variables and for continuous variables respectively. All statistical tests were two-tailed and the level of significance was set at $p<0.05$.

The confounding effect of potential covariates which had previously been identified in the literature and which were significantly associated with periodontal disease in the bivariate analysis were controlled for in a logistic

regression model using backward stepwise procedures. Adjusted odds ratios (ORs) with their 95% CI were calculated to estimate effect sizes.

To measure potential dose-response relation, periodontal disease was further divided to moderate (four teeth with a (PD) ≥4 mm) and severe periodontal disease (more than four teeth with PD≥4 mm). To test the role of preterm delivery as a potential mediator of the effect of periodontal disease, gestational period was entered into the regression model last and any changes in the effect size of periodontal status were noted.

All data analyses were conducted using V.10 statistical software.

3.7 ETHICAL CONSIDERATIONS

The questionnaire survey was anonymous and information was kept confidential. Permission to conduct the study was obtained from the managements of the respective hospitals.

Only individuals who provided written informed consent were included in the study.

The study protocol was further subjected to review and was approved by the School of Dentistry Research Committee University of Pretoria, as well as the Research Ethics Committee of Faculty of Health Sciences of the University of Pretoria (Approval Number: S147/2010).

3.7.1 Benefits for participants

All the study participants who needed treatment were referred for treatment, which consisted of plaque control instructions and supra- and subgingival scaling and polishing. They were also all informed of how to care for their teeth and those of their baby.

3.7.2 Potential risk

In general, the probing could cause some discomfort. However, the oral examination protocol used was similar to that of any oral examination the participants would in any case have been subjected to in the course of routine dental care, thus no particular risk was posed by participating in this study.

CHAPTER 4:
RESULTS

4.1 SOCIO-ECONOMIC STATUS OF THE STUDIED POPULATION

There was no difference between the education levels of the cases and controls. Of the study participants, among the cases, the proportions of those in the case group were as follows: those who had less than a high school education made up 47.5% (n=57), those with a high school education made up 35.8% (n=43), and those with a post-high school education made up 16.7% (n=20). These figures were not statistically significantly different from those of the control group (p=0.78) (see Table 1).

The number of unemployed case participants, however, was significantly higher than the number of unemployed controls. Of the mothers in the case group, 38.3% (n=46) were unemployed, compared to 23.7% (n=54) of the control group (see Table 1).

4.2 OBSTETRIC RISK FACTORS AND MATERNAL CHARACTERISTICS OF CASES AND CONTROLS

As Table 1 shows, of the study respondents, 34.5% (n=119) were cases, while 65.5% (n=229) were controls. Compared to the controls, the cases were significantly more likely to have been diagnosed with at least one known obstetric risk factor for a low birth weight baby (1.3% vs 6.8%; p=0.01). The

most common obstetric problem reported during pregnancy was pre-eclampsia (45.5%), followed by antepartum haemorrhage (27.7%). Compared to the controls, the cases had a significantly lower gestational age (39.7 weeks vs 36.7 weeks; <0.01) (see Table 2). There were no statistically significant differences in marital status (see Table 1) or age, or the living conditions (crowding) of the participants in the two groups (see Table 2). Compared to those in the control group, a greater proportion of mothers in the case group reported three or fewer antenatal care visits (79.8vs 68%; p=0.02) (see Table 1).

4.3 TOBACCO USE AND ALCOHOL INTAKE DURING PREGNANCY

As compared to the controls, the cases tended to be more likely to have been exposed to second-hand smoke during pregnancy (21.9% vs 36.7%; p=0.01) and were more likely to report drinking at least one glass of alcohol on five or more days per week during pregnancy (10.8% vs 4.0%; p=0.03).

Although compared to the controls, the cases were significantly more likely to report exposure to second-hand smoke, no statistically significant difference was found between the two groups with regard to current smoking, current snuff use and smoking during pregnancy (see Table 1).

4.4 ORAL HEALTH BEHAVIOURS AND ORAL HEALTH OF THE STUDIED POPULATION

Compared to the controls, the cases were no more likely to rate their oral health as poor (22.5% vs 21.5%; p=0.83). Those categorized as cases, compared to controls, were not only more likely to report frequent bleeding gums when

brushing, but were also more likely to be diagnosed with periodontitis (37.9% vs 9.2%; p=0.001).

No significantly different dental visit patterns were observed between the cases and the controls during the period of pregnancy or in general. Only 14.2% of the cases and 15.8% of the controls reported a visit to a dental clinic during pregnancy. Notably, 85.3% of the study participants had never visited a dentist before (see Figure 3).

Although the proportion of mothers in the case group who reported brushing at least once daily was higher than that proportion in the control group, the frequency of bleeding gums while brushing was more common among the cases than among the controls (16.0% vs 7.4%; p=0.02) (see Table 1).

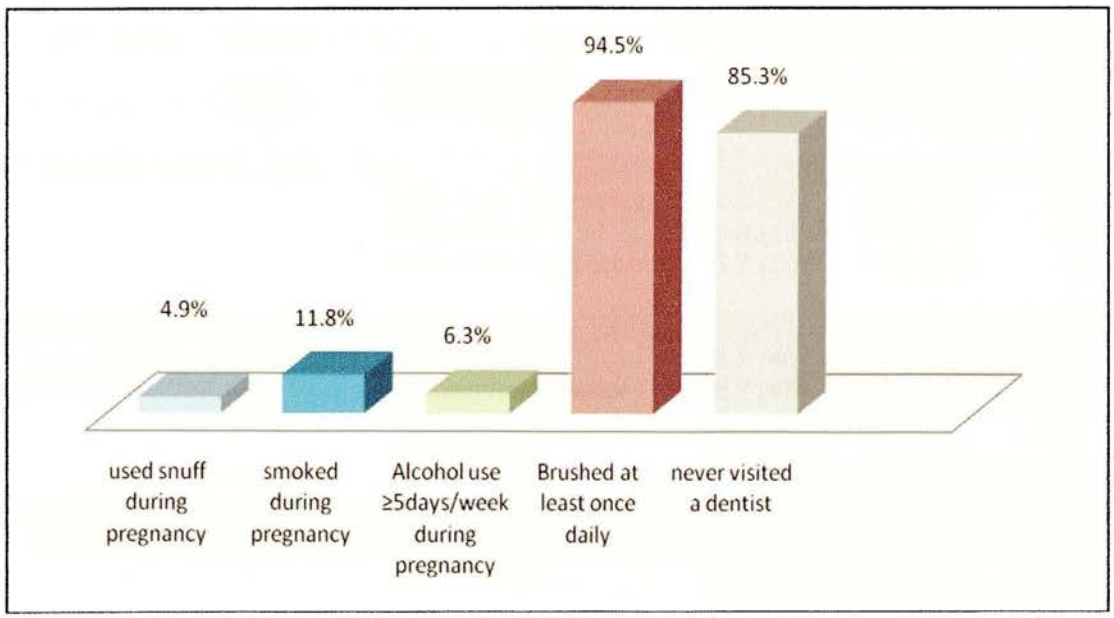

Figure 3: Distribution of oral health-related risk behaviour among the study population

4.5 UTILIZATION OF DENTAL SERVICES AMONG PREGNANT WOMEN

Only 14.7% (n=51) of the study participants had ever visited a dentist before. Of those who had ever visited a dentist, most (82.4%) had visited one mostly only when in pain (symptomatic visits). Those who reported past dental visits tended to be employed, but were significantly more likely to have reported that they were currently smoking, and/or that they frequently had bleeding gums on brushing and to present with a periodontal pocket of ≥4 mm on more than three teeth at the time of the oral examination (see Table 3). Other factors associated with past dental visits are displayed in Table 3.

Table 1: Socio-demographic, obstetric and behavioural characteristics of control and case mothers

Characteristics	Category	Cases %(n)	Controls %(n)	p-value
Marital status				0.20
	Never married	66.7 (80)	73.3 (167)	
	Ever married	33.3 (40)	26.8 (61)	
Education level				0.78
	Less than high school	47.5 (57)	45.6 (104)	
	High school	35.8 (43)	39.5 (90)	
	More than high school	16.7 (20)	14.9 (34)	
Employment status				<0.001
	Unemployed	38.3 (46)	23.7 (54)	
	Student/housewife/ on a grant	38.3 (46)	58.3 (133)	
	Employed	23.3 (28)	18.0 (41)	
Obstetric complications during pregnancy				0.01
	No	93.2 (110)	98.7(226)	
	Yes	12.6 (15)	2.6 (6)	
Number of antenatal visits				0.02
	≤ 3 visits	79.7 (94)	68.1 (156)	
	> 3 visits	6.8 (8)	1.3 (3)	
Parity (previous children)				0.24
	None	18.3 (22)	16.7 (38)	
	1-3 children	72.5 (87)	78.5 (179)	

Characteristics	Category	Cases %(n)	Controls %(n)	p-value
Smoking during pregnancy				0.49
	No	87.5 (105)	89.9 (205)	
	Yes	12.5 (15)	10.1 (23)	
Exposure to second-hand smoking				0.01
	No exposure	63.3 (76)	78.1 (178)	
	Exposure at home or at work	30.8 (37)	20.2 (46)	
	Exposure at home and at work	5.8 (7)	1.8 (4)	
Alcohol use frequency in pregnancy				0.03
	None	70.6 (84)	72.9 (167)	
	1-4 days per week	18.5 (22)	23.1 (53)	
	≥ 5 days per week	10.9 (13)	3.9 (9)	
Reason for past dental visits				0.39
	Never visited a dentist	83.3 (100)	86.4 (197)	
	Symptomatic	12.5 (15)	11.8 (27)	
	Preventive	4.2 (5)	1.8 (4)	
Dental visits in pregnancy				0.75
	Never	85.8 (103)	84.2 (192)	
	0-26 weeks	11.7 (14)	14.0 (32)	
	≥ 26 weeks	2.5 (3)	1.8 (4)	
Frequency of tooth-brushing				0.02
	Non-daily	1.7 (2)	7.5 (17)	
	At least once daily	98.3 (118)	92.5 (211)	
Gum bleeding on brushing				0.01
	Never/rarely	84.0 (100)	92.6 (212)	
	Very often/always	16.0 (19)	7.4 (17)	
Periodontal status				<0.001
	≤ 3 teeth with a periodontal pocket of ≥4 mm	62.2 (74)	90.8 (208)	
	4 teeth with a periodontal pocket of ≥ 4 mm	24.4 (29)	7.0 (16)	
	5 to 6 teeth with a periodontal pocket of ≥ 4 mm	13.5 (16)	2.2 (5)	

Table 2: Mothers' socio-demographic and pregnancy outcome characteristics, comparing cases with controls

Characteristics	Cases: Mean (SD)	Controls: Mean (SD)	p-value
Age of mother (years)	25.3 (4.9)	24.6 (3.7)	0.17
Baby weight (kg)	2.0 (0.4)	3.3 (0.5)	<0.001
Baby height (cm)	42.1 (5.7)	48.7 (4.2)	<0.001
Gestational age (weeks)	36.7 (3.6)	39.7 (2.3)	<0.001
Crowding	0.7 (0.8)	0.6 (0.2)	0.07

Table 3: Oral health-related behaviour and the use of dental services among the study population

Characteristics			Ever visited dentist % (n)	p-value
Pregnancy-related factors				
	Obstetric problem			0.67
		No	14.6 (49)	
		Yes	18.2 (3)	
	Frequency of antenatal visits			0.35
		< 3 times	13.6 (34)	
		>3 times	17.5 (17)	
	Parity			0.04
		None	5.1 (3)	
		1-3 children	16.2 (43)	
		>3 children	21.7 (5)	
Socio-demographics				
	Marital status			0.29
		Never	13.4 (33)	
		Ever married	17.8 (18)	
	Educational level			0.13
		<High school	10.6 (17)	
		High school	18.8 (25)	
		> High school	16.7 (9)	
	Employment			0.06
		Unemployed	9.0 (9)	
		Employed	16.9 (42)	
	Residential			0.03
		Urban	17.8 (16)	
		Rural	13.6 (35)	

Characteristics			Ever visited dentist % (n)	p-value
Oral health-related factor				
	Self-reported gum bleeding			0.02
		Never/rare	13.1 (41)	
		Very often/always	44.4 (4)	
	Self-rated oral health			0.05
		Very good/good	17.1 (13)	
		Very poor/poor/ don't know	14.0 (38)	
	Frequency of tooth brushing			0.25
		Once or less daily	13.0 (29)	
		Twice or more daily	17.6 (22)	
	Current smoking			0.04
		No	13.4 (42)	
		Yes	26.5 (9)	
	Current snuff use			0.13
		No	14.2 (48)	
		Yes	33.3 (3)	
	Exposure to second-hand smoking in pregnancy			0.01
		Exposure	11.8 (30)	
		No exposure	22.3 (21)	
	Alcohol use during pregnancy			0.00
		None	10.8 (27)	
		<weekly	26.7 (20)	
		>weekly	18.2 (4)	
Periodontal disease				0.04
		≤ 3 teeth with a periodontal pocket of ≥4 mm	12.8 (36)	
		More than 3 teeth with a periodontal pocket of ≥4 mm	22.7 (15)	

4.6 CONDITIONAL LOGISTIC REGRESSION MODEL PREDICTING LOW BIRTH WEIGHT

After controlling for potential confounders and other known risk factors for low birth weight, mothers presenting with a probing depth of ≥4 mm on four teeth (OR=4.12; 95% CI =1.78-9.50) or more than four indexed teeth (OR=4.91; 95% CI:1.52-15.81) were significantly more likely to have low birth weight babies, compared to mothers with three teeth or fewer with periodontal pockets. These effects were stronger before controlling for gestational age, with ORs of 5.33 and 7.47 respectively. Obstetric complications also became non-significant after controlling for gestational age.

The mothers who consumed alcohol on five or more days weekly during pregnancy were four times more likely to have low birth weight babies than those who did not drink at all (see Table 3, above). Low birth weight was also significantly more common among those who were unemployed and those who reported fewer than three antenatal visits. It was also observed that compared to those with no known obstetric risk factors, mothers with any obstetric risk factors were more likely to have children with a low birth weight (OR 3.98; 95% CI: 1.29-12.27).

Table 4: Final logistic regression model of factors associated with low birth weight

Characteristics		Odds ratio	95% CI
Periodontal status			
	≤ 3 teeth with a periodontal pocket of ≥4 mm	1.0	
	4 teeth with a periodontal pocket of ≥4 mm	4.12	1.78 - 9.50
	5 to 6 teeth with a periodontal pocket of ≥4 mm	4.91	1.52 - 15.81
Alcohol use in pregnancy			
	None	1.0	
	1-4 days per week	0.93	0.44 - 1.97
	≥5 days per week	6.51	2.15 - 19.75
Employment status			
	Employed/Student/housewife/ on a grant	1.0	
	Unemployed/no grants	2.75	1.44 - 5.27
Frequency of antenatal visits			
	≤ 3 times	1.0	
	> 3 times	0.31	0.14 - 0.65
Self-reported gum bleeding			
	Never/rarely	1.0	
	Very often/always	3.61	1.39 - 9.37
Gestational age	(per week increase)	0.67	0.58 - 0.76
Model $R^2 = 0.32$			

CHAPTER 5
DISCUSSION

5.1 INTRODUCTION

The primary objective of this study was to examine the association if any, between periodontal disease in pregnant women and the delivery of low birth weight babies. In addition, the study sought to determine the prevalence of oral health-related risk behaviour among pregnant women, and the utilization of dental services among pregnant women in the Chris Hani District of the Eastern Cape.

The results from this study show that there was a positive dose-dependent association between periodontal disease and low birth weight. Some of the known risk factors for low birth weight such as low socio-economic status and alcohol use were also confirmed in this study.

The findings from this study point in the same direction as data published by Cruz et al.[8.] They are also consistent with the findings of most other authors who have investigated the hypothesized association, using different diagnostic criteria for periodontal disease.[5-6,9] This study's findings, as with other studies, are supported by biological plausibility, namely that infection in the periodontium may promote an inflammatory reaction, which may induce preterm delivery

and/or may restrict the blood supply to the fetus and consequently retard fetal growth.[8,9,23,34,55]

5.2 GENDER OF THE BABY AND LOW BIRTH WEIGHT

No significant difference was found in this study between male and female newborns and their weight at birth. This is in contrast to findings from a study in Australia by Phung et al.,[62] which found that female babies had a significantly lower birth weight than male babies. The same observation on gender differences was also reported in a study conducted by Oni.[63] The sample sizes in these two studies were in the thousands. The relatively smaller sample size of the current study may explain why this study failed to detect a gender difference in relation to low birth weight. The present study was not statistically powered to detect gender differences in relation to low birth weight, and this was not a focus of this study.

5.3 OBSTETRIC FACTORS AND LOW BIRTH WEIGHT

Consistent with findings reported in the literature,[62] in the current study, obstetric problems during pregnancy were associated with low birth weight. Fetal growth and consequently birth weight are influenced by a variety of factors, along with specific medical conditions that may be present during pregnancy. Obstetric problems recorded in this study include antepartum haemorrhage, pre-eclampsia and other unspecified problems. A number of studies have indeed established that pregnancy-induced pre-eclampsia and antepartum haemorrhage are among the most common risk factors leading to low birth weight.[67-69]

5.4 MARITAL STATUS AND LOW BIRTH WEIGHT

In the present study, marital status was not found to be related to low birth weight. Marital status has been shown to be associated with birth weight in some prior studies.[64-65] It has been suggested that marital status may serve as a marker for the 'wantedness' of the child, and the economic status of the mother, all of which are factors that may influence the health of the mother and infant. About two thirds of the participants in this study have never been married, compared to mothers in the other studies[64-65] in which many participants were married. The fact that the majority of the participants in the current study have never been married suggests that marital status may not be a marker for 'wantedness' of a child in South Africa. It may partly explain the differences in the findings between the current study and those in other settings where being unmarried is not a norm. Furthermore, given that maternity services in public hospitals are free of charge, marital status may have limited relevance to the economic status of the mother with regard to posing a significant risk for low birth weight.

5.5 EDUCATION LEVEL AND LOW BIRTH WEIGHT

In this study educational level was not found to be related to birth weight. This is contrary to findings from a similar study by Cruz et al.,[8] which found that mothers with very low schooling levels who had periodontal disease had more than twice as large a chance of having a child with a low birth weight than those with a high school level. Considering the past inequality in access to education in South Africa, and the introduction of black economic empowerment that aims to economically empower those previously disadvantaged (which may include

those with no educational opportunities), it is likely that education has become a weaker proxy of socio-economic status in the South African population, compared to other settings where the prior studies referred to above were conducted. This may explain the differences in the observations in this study compared to those in others.

5.6 EMPLOYMENT STATUS AND LOW BIRTH WEIGHT

Employment status is more likely to be a proximal determinant of the socio-economic status of mothers. It was therefore not surprising that employment status was significantly associated with low birth weight delivery. Unemployed and thus poor women might have a lower caloric intake, which has been shown to impair fetal growth and result in low birth weight. The association between poverty and low birth weight has indeed been demonstrated in several studies.[22,36,69]

5.7 FREQUENCY OF ANTENATAL VISITS AND LOW BIRTH WEIGHT

Mothers that attended fewer than three ante-natal visits over the duration of the pregnancy were more likely to deliver low birth weight newborns. This observation is consistent with what has been reported in previous studies[69-72] that have linked inadequate prenatal care (including infrequent attendance) to low birth weight. Conceivably, regular utilization of prenatal services would be associated with improved birth outcomes, as any threatening condition would be picked up and addressed early.

5.8 PARITY AND LOW BIRTH WEIGHT

In this study, there was no association between parity and low birth weight. The explanation for this could be that no history of previous low birth deliveries was taken from the participants. Some studies[73-79] have given a possible explanation for this relationship, including the fact that mothers who have given birth to low birth weight infants in the past are more likely to deliver low birth weight babies subsequently.

5.9 SELF-REPORTED ORAL HEALTH

Most mothers in this study reported their oral health to be good. The mothers may have provided what they believed to be socially desirable responses. A lack of knowledge about oral and dental health has been strongly linked to women with lower educational achievements and lower socio-economic backgrounds.[75-83]

5.10 TOBACCO USE AND LOW BIRTH WEIGHT

There is convincing evidence from the previous studies that maternal smoking is associated with low birth weight.[74-76,84-86,96-98] However, in this study, current smoking (and current snuff use) was not associated with low birth weight. The failure to detect a statistically significant association may be due to the small sample size and the low proportion of participants who used tobacco. Historically, the prevalence of smoking among black women in South Africa is very low, in part because of strong cultural constraints against women's using tobacco. However, the finding in the current study of no association between

snuff use and low birth weight is consistent with that of Steyn et al.[99] Moreover, in the current study, exposure to second-hand smoking, which was very prevalent in the studied population, was significantly associated with low birth weight in the bivariate analysis, but not after controlling for other factors. Hence, there is a need for further studies to elucidate the role of exposure to tobacco smoke and low birth weight delivery among black women in South Africa.

5.11 ALCOHOL USE AND LOW BIRTH WEIGHT

In this study, mothers who reported drinking alcohol five days or more per week during pregnancy period had a four-fold increase in the odds of delivering a low birth weight baby when compared to those that did not consume alcohol during the pregnancy. This finding is in line with observations in some similar studies[84-90] which reported an association between alcohol intake during the early and late pregnancy term and the delivery of low birth newborns.

5.12 PERIODONTAL DISEASE AND LOW BIRTH WEIGHT

Periodontal disease was strongly associated with low birth weight in this study. Mothers who had a periodontal pocket of >4 mm on four teeth or more were about ten times more likely to deliver an infant with a low birth weight than those who had such a pocket on fewer than four teeth.

Previous human case-control studies have demonstrated that women who have low birth weight infants tend to have more periodontal disease than mothers with normal birth weight infants.[19,23-25] This association was indeed independent of other known risk factors in the current study. Other studies[82-83] has also reported the observation that bleeding gums are common among pregnant

women. However, the current study also observed an independent association between reporting gum bleeding during pregnancy and low birth weight, which suggests that the mother's periodontal condition during pregnancy, independent of clinical pocketing at the time of birth, may be an indicator of low birth weight outcome.

5.13 UTILIZATION OF DENTAL SERVICES

Another objective of this study was to determine the utilization rates for dental services among pregnant women in the Chris Hani District of the Eastern Cape. The results from this study showed that the majority of pregnant women in this area do not seek dental care during their pregnancy. This raises serious concerns about dental care seeking behaviours, as most of these women would have been due for their recommended routine six-month dental visits at some point during the nine-month period of pregnancy. Moreover, pregnant women may even need extra periodontal care, which is not reflected by their utilization of dental services in this study.

Poor attendance for dental treatment by pregnant women is a worldwide phenomenon as reported in other studies.[83,100-103] The explanation for the particularly low utilization in this study may be that in South Africa, one must have medical aid/health insurance, or be prepared to pay to cover private dental treatment, or be placed on a waiting list to seek free treatment in the public system in some open government facilities, especially in rural areas.

Another possible explanation could be that women seem to rate their general health significantly better than their oral health and some of the women with

dental problems would rather postpone seeking dental treatment until after the pregnancy. The low utilization may also be related to the perception that professional dental care was not needed, given that the majority of the mothers surveyed perceived their oral health to be good, despite the fact that many had periodontal disease.

The policy implication of this low utilization of dental services among those in need is that there is urgent need for public education on the need for pregnant women to make at least one visit to an oral health professional during pregnancy as part of an integrated approach to primary health care.

5.14 LIMITATIONS OF THE STUDY

The findings in this study need to be interpreted with caution. One limitation of the current study was that it has only demonstrated an association between periodontal disease in pregnancy and low birth weight, but has not necessarily established causality, even though the dose-response association supports a possible causal relationship.

Also, some of the mothers who had periodontal disease during pregnancy and had it treated might not have had periodontal disease at the time of delivery. This could have led to misclassification bias. However, such misclassification is more likely to cause a bias towards the null hypothesis, in other words, reduce the strength of the association reported in this study. Furthermore, given that the clinical examination occurred during the period immediately after delivery and also there was no significant difference between the cases and controls in the use of dental services during pregnancy, it is likely that the observed clinical

status closely approximates the situation at least during the latter part of the pregnancy.

In studies of clinical periodontal disease, varying measures of disease severity have been used. The choice of periodontal measurement used in the current study was essentially determined by the need to carry out the clinical examination in the dentist's room of the three public hospitals with limited resources, while also ensuring that the study could be easily replicated using large population surveys.

Using only PD ≥4 mm to identify periodontal cases might also have increased the possibility of a false positive diagnosis. However, in their analysis, Nabet et al.[51] did not find a significant difference in the strength in the association between periodontal disease and preterm delivery, based on the different criteria used in diagnosing periodontal disease, including using only PD ≥ 4 mm on four teeth or more, as was done in the current study.

There may also have been under-reporting of tobacco and alcohol use by the mothers, because of the widely known harmful effects of these on pregnancy. However, measurements that were used in similar studies were applied, thus making the results comparable. Covariates that were self-reported and needed to be recalled could have caused recall bias.[15] This is not likely to have made a change in the results obtained in this study, since such recall bias would have occurred randomly, in other words, it would not necessarily have occurred more or less among those diagnosed as cases compared to among those diagnosed as controls.

The participants were not interviewed about the history of their previous low birth weight newborns, maternal height or maternal weight, all of which have previously been associated with low birth weight in prior studies.[22,30,96-97]

Despite these limitations, the study has produced for the first time some information that can be used to inform appropriate health promotion interventions among pregnant women in South Africa.

CHAPTER 6:
CONCLUSIONS AND RECOMMENDATION

6.1 CONCLUSIONS

To the best of the researcher's knowledge, this study is the first in South Africa to demonstrate a positive association between periodontal disease and low birth weight.

- Prevalence of low birth weight was highest among mothers who had four or more teeth with a periodontal pocket of ≥4 mm. This association was independent of potential confounding factors such as employment status and excessive alcohol use during pregnancy. However, it was observed that the effect of periodontal disease remained independently associated with low birth weight delivery, although it was partly mediated through increasing the risk for preterm birth,

- A significant proportion of mothers of newborns reported known risk behaviours for poor oral health during pregnancy, namely smoking and excessive alcohol use.

- There was poor utilization of dental services during pregnancy by most participants, especially those who were unemployed and in rural areas, even though observation showed that they needed such services. A significant

proportion of the women studied presented with poor periodontal health, including frequent bleeding gums and periodontal pocketing.

6.2 RECOMMENDATION

This study's findings highlight the need to prioritize periodontal care as part of an effort to improve birth outcomes in the studied population and therefore to contribute to the achievement of the health-related MDGs in South Africa. In particular, considering the low utilization of dental services among the studied population, it is recommended that primary oral care services be integrated with maternal and child health programmes in order to improve access to oral care, particularly among vulnerable women (especially the unemployed). There is also a need for greater public health awareness of the importance of oral care, particularly before and during pregnancy. It must be kept in mind that not only one factor is involved in the healthy development of a fetus. The parent's basic health, including oral health, medical history, lifestyle, the mother's diet, outside pollutants, tobacco and drug use during pregnancy, and other socio-economic factors all have an impact.

There is an urgent need to adopt proven measures to prevent and control excessive alcohol consumption among pregnant women. Pregnant women should also be a priority population for tobacco control efforts, because passive smoking poses serious risks to fetal and maternal health during pregnancy, including the delivery of babies with low birth weight.

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APPENDICES

APPENDIX A:

PARTICIPANT'S INFORMATION LEAFLET &

INFORMED CONSENT FOR ANONYMOUS QUESTIONNAIRES

Researcher's name: Dr O.C. Agbeniyi

Student Number: 26104921

Department of Community Dentistry, University of Pretoria.

Dear Participant,

THE ASSOCIATION BETWEEN PERIODONTAL DISEASE DURING PREGNANCY AND LOW BIRTH WEIGHT OF NEWBORNS IN THE CHRIS HANI DISTRICT OF THE EASTERN CAPE

I am a Postgraduate Master's student in the Department of Community Dentistry at the University of Pretoria, and a dentist at Cala hospital, Chris Hani District. You are invited to volunteer to participate in our research project on the above title.

This letter gives information to help you to decide if you want to take part in this study. Before you agree, you should fully understand what is involved. If you do not understand the information or have any other questions, do not hesitate to ask the Sister-in-charge. You should not agree to take part unless you are completely happy about what we expect of you.

The purpose of the study is to investigate if there might be an association between a particular mouth condition and the weight of the new born baby. This study would also inform us of oral health conditions experienced during pregnancy and access to care, and thus help us design appropriate strategies to improve the situation.

We would like you to complete a questionnaire. This may take about ten minutes. The Sister-in-charge will collect the questionnaire from you and then you will be invited to the dental clinic for an oral examination. This will be carried out by me. The questionnaire will be kept in a safe place to ensure confidentiality. Please do not write your name on the questionnaire. We will also request access to your maternity record to get the gender and weight of your newborn at birth, duration of your pregnancy and any associated pregnancy related problems.

This study will enable you to get information on how to care for your teeth and those of the newborn. Furthermore, you benefit directly from the free oral/dental examination. This may allow early detection of any oral problems and referral for early treatment thereof.

No particular risk is posed by participating in this study. In general, the probing may cause some discomfort, but this is usually no problem. The oral

examination is similar to any oral examination you would have during the course of routine dental care or check-up.

The Research Ethics Committee of the University of Pretoria, Faculty of Health Sciences, has granted written approval for this study.

Your participation in this study is voluntary. You can refuse to participate or stop at any time without giving any reason. As you do not write your name on the questionnaire, you give us the information anonymously (that is, without us knowing who you are). Therefore, once you have given the questionnaire back to us, you cannot recall your consent. We will not be able to trace your information. Therefore, you will also not be identified as a participant in any publication that comes from the study.

If you have any questions concerning this study, contact me on 0478770129.

We sincerely appreciate your help.

Yours truly,

Dr O C Agbeniyi

CONSENT TO PARTICIPATE IN THIS STUDY

I have read (or had read to me) in a language that I understand the above information before signing this consent form. The content and meaning of this information have been explained to me. I understand that if I do not consent, there will be no repercussions for me in any way. I understand that treatment will not be performed on me and I am at liberty to go for treatment at a clinic/dentist of my choice. I hereby consent to participate in this study.

.....	.....
Participant's signature	Date
.....	.....
Researcher's signature	Date
.....	.....
Witness's signature	Date

APPENDIX B:

QUESTIONNAIRE: ORAL HEALTH IN PREGNANCY

SECTION A

INFORMATION FROM THE PARTICIPANT'S MATERNITY RECORD

1. Height of baby as on record/Ubude

	cm

2. Weight of baby/Ubunzima bomntwana

	kg

3. Sex of baby/Isini Somntwana

	Male/Yinkwenkwe
	Female/Yintombazana

4. Gestational age/Inyanga Zokukhulelwa

	Weeks/iiveki

5. Obstetric factors/Izigulo zomama (mark all that applies)

1.		Antepartum Haemorrhage
2.		Pre-eclampsia
3.		Parity
4.		Gravidity
5.		Others (specify)
6		No problems

SECTION B

QUESTIONNAIRE: ORAL HEALTH IN PREGNANCY

Please answer every question to the extent possible by marking the appropriate response./

Phendula yonke imibuzo ngokukhetha impendulo eyiyo.

6. Age/ Iminyaka

	Years/Iminyaka

7. Marital status/imo yomtshato

1.		Never married/ Zange watshata
2.		Divorced/Separated/ Waqhawula umtshato
3.		Widowed/Umhlolokazi
4.		Married/Utshatile

8. What is the highest school you completed?/
Ngawaphi amabanga emfundo ephezulu owagqibileyo?

1.		Completed primary school or less/ Uwenzile amabanga aphantsi/nangezantsi
2.		Did some high school/ Uwenzile amabanga aphakamileyo
3.		Completed high school/ Uphumelele amabanga aphakamileyo
4.		Did some university/technikon/ Uyile eyuniversity/technikon
5.		Completed university/technikon/ Ugqibile eyuniversity technikon
6.		Post-graduate training after university/ Abantu abagqibileyo ukufunda eyunivesiti

9. How many people living in your home?/Bangapi abantu abahlala kowenu?

……..person(s)

10. How many rooms in your house?/Mangaphi amagumbi endlu yakho?

……..room(s)

11. What is your employment status?/Uyintoni emsebenzini?

1.		Paid employment /Uyabhatalwa
2.		Housewife/Umfazi ongaphangelile
3.		Student/Umfundi
4.		Unemployed/Awuphangeli
5.		Unemployed but on grant/ Onga sebenziyo kodwa ufumana isibonelelo kurhulumente

12. How many times did you visit antenatal clinic before delivery?
/Uye kangaphi ekliniki yokuhlukuhla pambi kokubeleka?

1.		None/Zange waya
2.		One/Kanye
3.		Two to three/Kabini ukuya kwisithathu
4.		Four to five/Kane ukuya kwisihlanu
5.		Six or more/Kathandathu nanga phezulu

13. How many children have you had?/Unabantwana abangaphi?

0.		None/Akakho
1.		One/Mnye
2.		Two/Ababini
3.		Three/Abathathu
4.		Four/Abane
5.		Five/Abahlanu
6.		More than five/Ngaphezu kwesihlanu
7		None

14. How would you describe the area where you currently reside?/
Uhlalla kweyiphi ilokishi ngoku?

1.		Urban/Edolophini
2.		Rural/Ezilalini

15. Oral Health/Imeko yomlomo

A. How often do you brush/clean your teeth?/
Uwahlamba kangaphi amazinyo?

1.		Not every day/Andiwahlambi qho
2.		Once a day/Kanye ngemini
3.		Twice a day/Kabini ngemini
4.		More than twice a day/Kaninzi

B. When and why do you usually visit a dentist?/
Uya xa kutheni kugqirha wamazinyo?

1.		I have never visited a dentist/ Zange ndiye kugqirha wamazinyo
2.		I have visited dentist mainly when in pain/ Xa ndisiva intlungu
3.		I have visited dentist mainly for routine checkup/cleaning/ Xa ndiyowacoca nowajonga

C. How would you rate your oral health status? /
Xa uzijonga umlomo wakho ucocekile?

1.		Very good/Kakuhle kakhulu
2.		Good/Kakuhle
3.		Poor/Kakubi
4.		Very poor/Kakubi kakhulu
5.		Do not know/can't' choose/ Andiqinisekanga/andazi

D. During your pregnancy, how often did it happen that your gums bled on brushing and/or you had painful gums? /
Ukhe uye kuvavanyo lwamazinyo ngexesha lokukhulewa?

1.		Never/Hayi
2.		Rarely/Iyenzeka
3.		Often/Ngamanye amaxesha
4.		Very often/Rhoqo
5.		Always/Roqo

E. Have you ever visited a dental clinic for dental treatment of bleeding gums during this pregnancy?/
Wakhe waya kwavanyo lwamazinyo ngexesha lokukhulwa?

1.		Never/Zange
2.		I did at least once during 0 to 13 weeks of pregnancy/ Ndiya kanye ukusuka 0 ukuya kwinyanga ezintathu ndikhulelwe
3.		I did at least once during the 14 to 26 weeks of pregnancy/ Ndiya kanye ukusuka kwinyanga ezintathu ukuya kwinyanga ezintantandathu ezineveki ezimbini
4		I did at least once only after 26 weeks of pregnancy/ Ndiya kanye nangaphezulu kwenyanga ezintandathu

16. Tobacco use/ Ukutshaya

A. In the past nine months, did you ever smoke a cigarette, even one puff?
Kwinyanga ezilithoba ezidlule, ukhe watshaya icuba nah?

1		Yes/Ewe
2		No/Hayi

B. Do you currently smoke cigarettes? /
Okwangoku ingaba uyatshaya nah?

1.		Yes every day/Ewe yonke imihla
2.		Yes, some days/Ewe ngentsuku ezithile
3.		No, I have completely stopped smoking/Hayi ndayeka
4.		I have never smoked before/ Andizange ndatshaya kwasekuqaleni

C. During the past nine months, on the days you smoked, how many cigarettes did you smoke per day?/
Kwezinyanga zilithoba utshaye izoli ezingaphi?

0.		Never/Zange
1.		Less than one cigarette per day/Ngaphantsi kwezoli enye
2.		One cigarette per day/Izoli enye ngosuku
3.		Two to five cigarettes per day/Ezimbini ukuya kwezintlanu
4.		Six to ten cigarettes per day/Ezintandathu ukuya kwezilishumi
5		More than ten cigarettes per day/Ngaphezu kweshumi

D. In the past nine months, did you ever use smokeless tobacco such as snuff or chewing tobacco?/
Kwezinyanga zilithoba zidlulileyo ubukhe walisebenzisa igwada okanye icuba elihlafunwayo?

1.		Yes/Ewe
2.		No/Hayi

E. Do you currently use any smokeless tobacco such as snuff or chewing tobacco? /
Uyalisebenzisa icuba elingaqhumiyo njenge-gwada okanye elihlafunwayo?

1.		Yes/Ewe
2.		No/Hayi

F. Do you currently use smokeless tobacco daily?/
Usebenzisa icuba elingaqhumiyo rhoqo?

1.		Yes/Ewe
2.		No/Hayi

G. On average how many times do you use each of the following items per day?/
Uzisebenzisa kangaphi ezi zinto ziladelayo ngemini?

0	0 times		Never/Zange
1.	1-5 times		Snuff by mouth/Ugwada kangaphi ngomlomo
2.	1-5 times		Snuff by nose/Ugwada kangaphi ngemini ngempumlo
3.	1-5 times		Chewing tobacco/Ulihlafuna kangaphi icuba ngemini

H. During the past nine months did you live in a house where other people smoke cigarettes daily?/
Kwezinyanga uhlala kwindlu apho kutshaywayo kuyo?

1.		Yes/Ewe
2.		No/Hayi

I. During the past nine months did you work in a job where other people smoke cigarettes around you? /
Kwezinyanga esebenza nabantu abatshayayo?

1.		Yes/Ewe
2.		No/Hayi

17. Alcohol Use/Utywala

A. Have you ever consumed drinks that contain alcohol such as beer, wine, spirit or sorghum beer? /
Ubukhe wasele isiselo esinxilisayo njenge-beer, iwayini okanye ispiriti?

1.		Yes/Ewe
2.		No/Hayi

B. Was this within the last nine months? /
Ubusele kwisithuba senyanga ezilithoba?

1.		Yes/Ewe
2.		No/Hayi

C. In the past nine months, how frequently have you had at least one drink?/
Kwezinyanga zilithoba ubusele kangakanani?

1.		5 or more days a week/ Kahlanu nangaphezulu ngeveki.
2.		1 to 4 days per week/ Kanye ukuya kwintsuka ezine ngeveki
3.		1 to 4 days per month/ Kanye ukuya kwintsuku ezine ngenyanga
4.		Less than once a month/ Ngaphantsi kwinyanga nokuba kukanye