

*This article has been peer reviewed.*

# Review of the Oral Disease-Systemic Disease Link. Part II: Preterm Low Birth Weight Babies, Respiratory Disease

## Canadian Dental Hygienists Association Position Statements

### Preterm low birth weight babies

In light of the possible association between periodontal disease and preterm low birth weight (PT/LBW) babies, women who are considering pregnancy or who are pregnant should have access to oral health services (including oral health promotion, disease prevention, and treatment), regardless of their income. In addition, dental hygienists should consider incorporating the following strategies into their practices:

- Educate pregnant women and those planning pregnancy regarding the possible impact of periodontal infection on pregnancy outcomes and benefits of treatment.
- Consider periodontal examinations and as-needed periodontal therapy as a necessary part of prenatal care for all women who are pregnant or planning pregnancy.
- Provide preventive oral care as early in pregnancy as possible, and throughout the pregnancy.
- Consider consultation with the clients' health care professionals to advise them of the diagnosis and treatment considerations.
- Increase interprofessional collaboration and communication between dental hygienists and public health prenatal programs in order to formalize support for pregnant women. These new opportunities can focus on oral/general health assessments, leadership capacity, policy development, surveillance, program delivery and evaluation.

### Respiratory disease

In light of the clear association between periodontal disease and pneumonia in health-compromised seniors in intensive and long-term care, high-risk seniors should have access to oral health services (including oral health promotion, disease prevention- and treatment), regardless of their income. In addition, dental hygienists should consider incorporating the following dental hygiene diagnosis and treatment issues into their practices:

- Provide disease prevention and treatment services for individuals at high risk for pneumonia, who are in intensive care units and long-term care facilities.
- Provide in-service training on oral health education to intensive care unit and long-term care facility staff.
- Increase interprofessional collaboration and communication between dental hygienists and long-term care facilities, and critical care units of hospitals. These new opportunities can focus on oral/general health assessments, leadership capacity, policy development, surveillance, program delivery and evaluation.

**Keywords:** Infant, low birth weight; Meta-analysis; Oral hygiene; Periodontal diseases; Respiratory tract diseases; Review literature

## CDHA Position Paper

by Judy Lux, BA, MSW

### INTRODUCTION

IN 2004, CDHA PUBLISHED A PAPER TITLED "YOUR Mouth – Portal to Your Body. CDHA Position Paper on the Links between Oral Health and General Health."<sup>1</sup> The evidence from this paper, although preliminary, supports the conclusion that oral diseases may have an association with the occurrence and severity of the following conditions: diabetes mellitus, heart disease, preterm low birth weight babies, and lung disease. In addition, oral hygiene

treatment was found to improve diabetic control of type 2 diabetes and to reduce the risk of premature birth and low birth weight. Following the publication of the 2004 position paper, substantial new research on this topic has been published. This current position paper updates the 2004 paper with a growing body of research that supports a link between oral diseases and systemic diseases. This new position paper is divided into two sections; the first section covered heart disease and diabetes and was published in the November-December 2006 issue of this journal. The second section, in this issue of the journal, covers preterm low birth weight babies and respiratory disease.

Other oral health organizations have issued position papers on this topic that lend support to CDHA's position.

# Déclarations de l'Association canadienne des hygiénistes dentaires

## Bébés prématurés de poids insuffisant à la naissance

Compte tenu de l'association possible entre la maladie parodontale et les bébés prématurés de poids insuffisant à la naissance, les femmes qui songent à une grossesse ou celles qui sont enceintes devraient avoir accès à des services de santé buccodentaire (incluant la promotion de la santé buccodentaire, la prévention de la maladie et le traitement) peu importe leurs revenus. De plus, les hygiénistes dentaires devraient considérer l'intégration des stratégies suivantes dans leur pratique :

- Éduquer les femmes enceintes et celles qui planifient une grossesse concernant les répercussions possibles d'une infection parodontale sur les résultats de la grossesse et sur les avantages du traitement.
- Considérer les examens parodontaux et, au besoin, le traitement parodontal comme un élément nécessaire des soins prénatals pour toutes les femmes qui sont enceintes ou qui planifient une grossesse.
- Prodiguer des soins buccodentaires préventifs aussitôt que possible dans la grossesse et tout au long de celle-ci.
- Considérer une consultation avec les professionnels en soins de santé des clientes afin de les informer du diagnostic et des traitements envisagés.
- Augmenter la collaboration et la communication interprofessionnelles entre les hygiénistes dentaires et les programmes prénatals des services de santé publique afin d'officialiser le soutien apporté aux femmes enceintes. Ces nouvelles possibilités d'action peuvent englober les évaluations de l'état de santé générale et de l'état de santé buccodentaire, la capacité de leadership, le développement de politiques, la surveillance, la mise en œuvre de programmes et l'évaluation.

## Maladies respiratoires

Compte tenu de l'association évidente entre la maladie parodontale et la pneumonie chez les personnes âgées fragilisées admises dans les unités de soins intensifs et de soins de longue durée, les personnes âgées à haut risque devraient avoir accès à des services de santé buccodentaire (incluant la promotion de la santé buccodentaire, la prévention de la maladie et le traitement) peu importe leurs revenus. De plus, les hygiénistes dentaires devraient considérer l'intégration des stratégies suivantes de diagnostic et de traitement en hygiène dentaire dans leur pratique :

- Offrir des services de prévention et de traitement de la maladie aux personnes à haut risque pour la pneumonie qui se trouvent les unités de soins intensifs et dans les établissements de soins de longue durée.
- Offrir de la formation interne portant sur l'éducation en santé buccodentaire au personnel des unités de soins intensifs et des établissements de soins de longue durée.
- Augmenter la collaboration et la communication interprofessionnelles entre les hygiénistes dentaires et les établissements de soins de longue durée et les unités de soins intensifs des hôpitaux. Ces nouvelles possibilités d'action peuvent englober les évaluations de l'état de santé générale et l'état de santé buccodentaire, la capacité de leadership, le développement de politiques, la surveillance, la mise en œuvre de programmes et l'évaluation.

These specific positions are identified in more detail in the separate sections of this paper.

The year following CDHA's first position paper on this topic, the Canadian Dental Association (CDA) issued a statement that takes a reserved, somewhat cautious approach to the topic. Although the CDA notes that the U.S. Surgeon General highlights a bi-directional interaction between oral and systemic health, CDA recommends that "further emphasis should be placed on research and educating dentists, physicians, students, residents, other healthcare professionals and most importantly patients regarding the importance of these possible relationships."<sup>2</sup>

Periodontal disease is considered the most prevalent chronic disease affecting children, adolescents, adults, and the elderly.<sup>3</sup> In addition, periodontal disease is an infectious disease that may be transmitted from one person to another. In the United States, there are recent national statistics indicating the prevalence of periodontal disease is

between 3.8% and 12.3% of the population.<sup>4</sup> Similar recent Canada-wide information is not available; however, 35 years ago, 15% of Canadians aged 19 years and over had periodontal pockets.<sup>5</sup>

A more recent but partial picture of Canadian data comes from several provincial studies. In 1986, a Saskatchewan study indicated that of those aged 30 to 44 years, 34% had 4 or 5 mm periodontal pockets and 15% had periodontal pockets ( $\geq$ ) 6 mm.<sup>6</sup> In addition, a 2001 Quebec study indicates that people with low family income, men, and persons living in metropolitan areas are at higher risk of having at least one tooth with a pocket ( $\geq$ ) 6 mm.<sup>7</sup> New developments indicate that Canada is beginning to address some of the oral health data gaps. Dr. Peter Cooney, Canada's Chief Dental Officer, has developed an oral health component of the Canadian Health Measures Survey. The statistics gathered will not only provide us with national prevalence rates but will also assist in

determining the extent of the relationship between oral health and systemic health.

## METHODOLOGY

The methodological approach in this paper is a comprehensive review of systematic reviews, meta-analysis, literature reviews, and clinical trials on the connection between periodontal diseases and systemic diseases, specifically preterm/low birth weight babies, and respiratory disease. The research question was: What is the relationship between periodontal disease and preterm low birth weight babies and respiratory disease? This question was used to develop the following search terms: periodontal disease, periodontal diseases, periodontitis, preterm birth, preterm births, low birth weight, low birth weights, pregnancy and pregnancy outcomes, respiratory disease, respiratory diseases, and chronic obstructive pulmonary disease, pneumonia, lung disease, and respiratory tract infections.

### *The research question was: What is the relationship between periodontal disease and preterm low birth weight babies and respiratory disease?*

The literature was limited to English language human studies in MedLine, Cochrane controlled trials register, and Google Scholar from 2003 to March 2006. The database search retrieved four articles pertaining to PT/LBW and four articles pertaining to respiratory disease; all of these articles were included in this review as they met quality standards. The search also included reference lists of published review papers to identify additional articles. The search also included “gray” literature—information not reported in the scientific periodical literature—and web sites known to contain publications on this topic. Consultation with two recognized topic experts, Salme Lavigne and Dr. Howard Tenenbaum, took place at a number of developmental stages and a consultation on the draft paper took place with CDHA members and other topic experts.

## PRETERM LOW BIRTH WEIGHT BABIES

### Literature Review

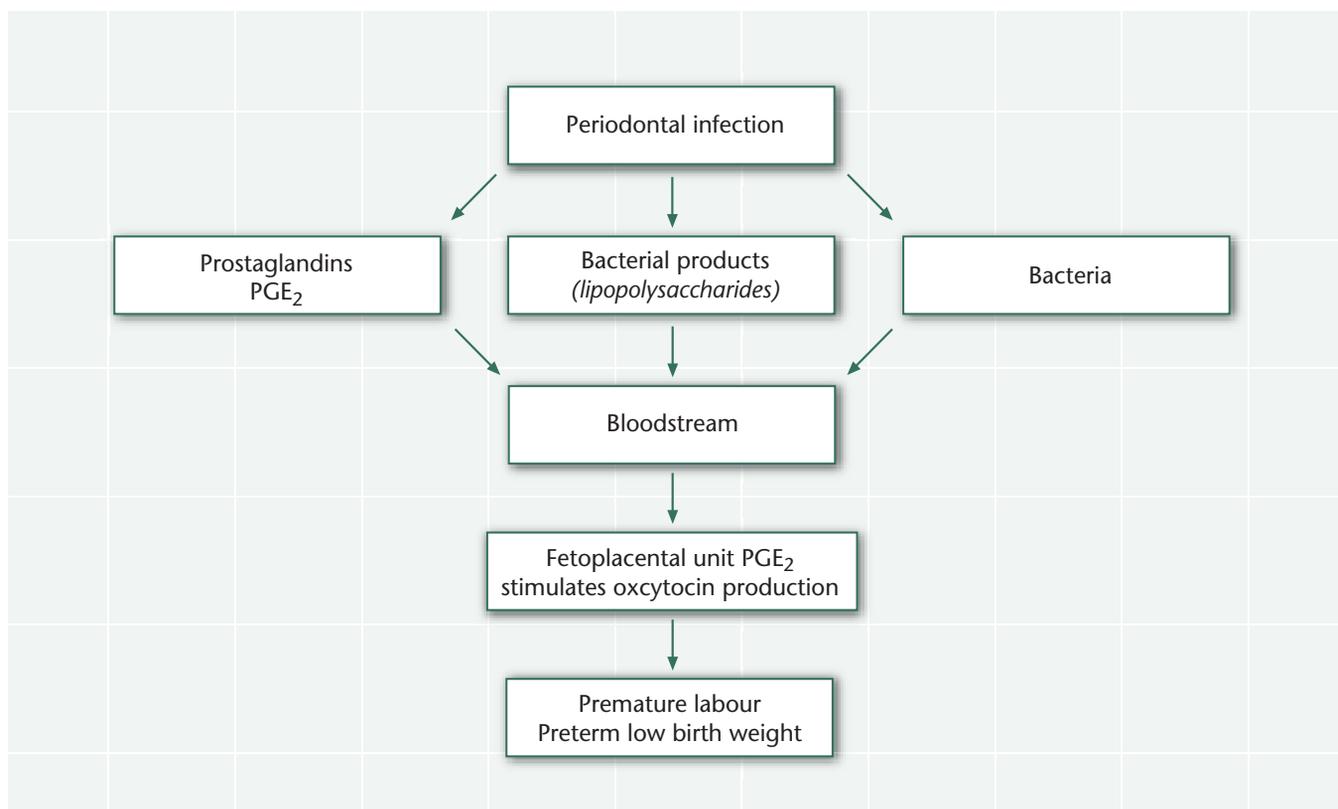
The World Health Organization defines preterm birth as birth prior to 37 weeks of gestation and low birth weight as babies born under 2500 grams.<sup>8</sup> In Canada, the preterm birth rate has been increasing recently. In 2000, the preterm birth rate was 7.6 per 100 live births, compared with 6.6 per 100 live births in 1991.<sup>9</sup> There is regional variation in this rate, with a low of 5.8 in Prince Edward Island to a high of 10.4 in Nunavut.<sup>9</sup> There has also been a recent rise in the incidence of low birth weight, which may be explained by a decline in infant mortality rate and an increase in multiple births. Low birth weight rates in Canada in 1996 ranged from a low of 4% in the Yukon to a high of 9% in Newfoundland.<sup>10</sup>

The consequences of preterm birth (PTB) and PT/LBW babies are staggering. The infant morbidity and mortality<sup>11</sup> associated with PT/LBW create a significant economic drain on the health system, and social and emotional problems for the families involved who often manage long-term disabilities in their children. Preterm birth accounts for 75% to 85% of all perinatal mortality in Canada and is considered an important determinant of neonatal and infant morbidity, including neurodevelopmental handicaps, such as cerebral palsy; chronic respiratory problems; infections; and ophthalmological problems.<sup>12</sup>

Research as early as 1931 found that periodontal diseases in the mother may have harmful effects on the developing fetus.<sup>13</sup> CDHA's 2004 position paper reports on the results from case-controlled, prospective, and intervention studies and two randomized controlled trials. It concludes that there is a possible link or correlation between periodontal disease and PLBW and preterm birth and that women with periodontal disease may have a 4 to 7.9 odds ratio (OR) of having a preterm birth than women with good oral health.<sup>1</sup> These findings are consistent with former studies that indicate chronic infection plays an important role in PT/LBW, including bacterial vaginosis (BV),<sup>14,15</sup> genitourinary infections,<sup>16,17</sup> kidney infection and pneumonia.<sup>11</sup> The CDHA position paper also indicated that there is preliminary evidence that periodontal treatment during pregnancy may reduce the incidence of adverse pregnancy outcomes.<sup>1</sup> Other research not included in the CDHA position paper and conducted following the publication of the paper also support this conclusion.<sup>18,19</sup>

The American Academy of Periodontology issued a position statement in 2004, the same year as CDHA's first statement, recommending that “women who are pregnant or planning pregnancy undergo periodontal examinations...” and that “preventive oral care services should be provided as early in pregnancy as possible. However, women should be encouraged to achieve a high level of oral hygiene prior to becoming pregnant and throughout their pregnancies.”<sup>13</sup> Other groups approved the content of this statement, including the American College of Obstetricians and Gynecologists, the U.S. March of Dimes, and the U.S. National Nursing Association.<sup>20</sup> Furthermore, consumer groups are also taking a stand on this topic to demand better services for the public. In 2001, the U.S. National Healthy Mothers, Healthy Babies Coalition published the following position statement, “...oral health care during pregnancy is crucial and should be made available to all women, regardless of their income level.”<sup>21</sup>

Another measure of the growing importance of this topic in our society is the degree of emphasis that research centres place on this topic. At present, the U.S. National Institute of Dental and Craniofacial Research (NIDCR) has made a significant investment in research on this topic, with a large \$20 million research project that includes two independent multi-centre clinical trials. This research involves approximately 2,600 pregnant women.



**Figure 1.** Proposed biological mechanisms for induction of premature birth

Although the mechanism of action is still unclear, three mechanisms (figure 1) have been proposed to explain how periodontal disease may influence preterm low birth weight babies:<sup>1</sup>

- Periodontal infection causes the release of prostaglandins into systemic circulation.
- Lipopolysaccharides from cell walls of periodontal pathogens trigger the release or production of prostaglandins.
- Translocation of the periodontal micro-organisms to the fetoplacental unit and stimulate the release of prostaglandins.

## RESULTS

In 2003, a systematic review of twelve studies concluded that periodontal disease may be a risk factor for PT/LBW and there is preliminary evidence suggesting that periodontal intervention may reduce adverse pregnancy outcomes.<sup>22</sup> The review included six case control,<sup>23-28</sup> three cross-sectional and longitudinal,<sup>29-31</sup> and three intervention studies.<sup>18,19,32</sup> Due to study heterogeneity, meta-analysis was not possible.

A 2004 review on this topic included nine studies: four case control,<sup>23,25-27</sup> two prospective,<sup>24,29</sup> one prospective cohort,<sup>32</sup> one intervention,<sup>19</sup> and one cohort.<sup>18</sup> The review concludes that periodontal disease may act as a risk factor for PLBW.<sup>33</sup>

A 2005 meta-analysis of five observational studies concludes that periodontal diseases in the pregnant mother significantly increase the risk of preterm birth or low birth

weight.<sup>12</sup> This meta-analysis included two case-control studies and three prospective cohort studies.<sup>18,23,24,29</sup> These studies showed that pregnant women with periodontal disease have an adjusted odds ratio of 4.28 (95% CI, 2.62 – 6.99;  $P < 0.005$ ) for preterm birth and 5.28 (95% CI, 2.21 – 12.62;  $P < 0.005$ ) for preterm low birth weight babies. The authors identify several limitations to this meta-analysis; the most striking limitations include the poor-to-fair quality of the studies and the considerable variation in the definition of exposures and outcomes from one study to the next.

In 2006, a systematic review of 25 studies, from 14 countries, concluded that periodontal disease may be associated with an increased risk of adverse pregnancy outcome (including PT/LBW, LBW, preterm birth weight by gestational age, miscarriage or pregnancy loss, and pre-eclampsia).<sup>34</sup> The studies included 13 observational studies, case control, cross-sectional,<sup>23,26,27,35-44</sup> 9 cohort studies,<sup>9,19,28-30,45-48</sup> and 3 controlled trials (2 were RCTs).<sup>18,32,49</sup>

There were 18 studies suggesting an association between periodontal disease and increased risk of adverse pregnancy outcome (ORs ranging from 1.10 to 20.0) and 7 studies found no evidence of an association (ORs ranging from 0.78 to 2.54). Three clinical trial intervention studies, two of which were randomized controlled trials, suggest that oral prophylaxis periodontal treatment can lead to a 57% reduction in PT/LBW (pooled RR 0.43; 95% CI 0.24-0.78) and a 50% reduction in preterm births (RR 0.5; 95% CI 0.20-1.30). The authors note that it was not appropriate

to calculate the pooled risk in the case-control and cohort studies, due to heterogeneity. The authors also note some of the drawbacks to the studies, which include a large variation in the definition of periodontal disease status, small sample size in many of the studies, and a potential bias due to confounding effect of other variables, which were not controlled for in 15 of the 23 studies. (The two RCTs did not have potential bias from confounding variables.) The authors note that the effects of periodontal disease on adverse pregnancy outcomes may be different according to the socio-economic status and access to dental care, with studies of economically disadvantaged women.

In 2006, a systematic review concluded that periodontal disease is not a causal risk factor for PT/LBW.<sup>50</sup> Of the nine case-control studies, five found a relationship between periodontal disease and PT/LBW with odds ratios ranging from 3.4 to 7.9. Of the four cohort studies, two supported an association and two did not. Of the four intervention studies, two found a reduction in the incidence of PT/LBW following dental hygiene treatment, with one of these studies using a randomized controlled methodology. Two other intervention studies found no reduction in the incidence of PT/LBW. Of the two systematic reviews, both concluded that periodontal disease may be a risk factor for PT/LBW, but the evidence is limited.

### *The balance of this preliminary evidence supports an association between periodontal disease and PT/LBW.*

Another 2005 randomized controlled trial was not included in the above reviews and is therefore reported separately.<sup>51</sup> Study participants included 870 pregnant women with gingivitis. At 28 weeks, the treatment group received plaque removal, scaling every two to three weeks and daily rinsing with 0.12% chlorhexidine. After adjusting for several known risk factors, women with gingivitis in the control group had a significantly higher risk of PT/LBW than women who received periodontal treatment (OR 2.76; 95% CI 1.29-5.88; P=0.008).

#### **DISCUSSION**

There are several drawbacks to the reviews. First, although there is an internationally accepted World Health Organization definition of low birth weight (birth weight of <2500g),<sup>52</sup> some of the reviews did not report on their adherence to this definition. In addition, a number of the studies did not use consistent definitions of periodontal disease. Second, the 2003 systematic review by Scannapieco et al. identifies some of the drawbacks to comparing the studies, including the lack of a standard measure for periodontal disease, or which periodontal disease is being measured. Third, since risk factors such as race, low socio-economic status, low educational levels, tobacco, drug and alcohol abuse are common risk factors for PLBW and periodontitis,<sup>22</sup> the studies should have

more consistently mentioned controlling for these variables, or used subsets of these risk factors. Fourth, the 2005 meta-analysis of five observational studies indicates a wide range in the confidence interval for PTLBW OR, pointing to caution in the claim.

Cassolato et al.'s 2006 review<sup>50</sup> sets out to determine a causal link between periodontal disease and PT/LBW and concludes that none exists. However, only RCTs can determine this. This means that although the literature does not support a causal link, it does not mean that one does not exist. It simply means that the research available for analysis did not allow an assessment of this question. A second critique of this review is that the authors appear to treat all of the studies equally. However, Lopez's RCT may have been given extra weight in the argument, given that it was a gold standard research design.

The balance of this preliminary evidence supports an association between periodontal disease and PT/LBW. This review included a total of 51 studies, with 44 studies concluding that there may be an association between periodontal disease and preterm low birth weight babies. Only 7 studies concluded that there is no evidence of an association and these studies were not high-level evidence, as the studies were observational, case control, cross-sectional, and cohort. The strongest evidence comes from the one controlled trial (CT) and three randomized controlled trials, which are considered the gold standard. The CT shows striking evidence that dental hygiene services may be associated with a 50% risk reduction in PT/LBW and one RCT (Lopez et al. 2005) shows that dental hygiene services result in an OR of 2.76.

Meta-analysis using randomized control trials (RCTs) is the gold standard; however, the 2005 meta-analysis reports only on a meta-analysis of observational studies. Meta-analyses such as the one reported here, using observational studies, have become popular in biomedical literature and there are guidelines for reporting them.<sup>53</sup> The odds ratio estimate from the meta-analysis of observational studies reported in Khader et al.<sup>12</sup> (5.28 for PT/LBW and 4.28 for PTB) is consistent with the odds ratio from an RCT reported in the 2004 CDHA position paper. However, there are a number of limitations to Khader's meta-analysis. First, it does not follow accepted guidelines for reporting meta-analysis of observational studies. Second, there are limitations in the use of the odds ratio, since observational studies are commonly influenced by confounding and selection bias, which may distort the findings. In fact, some authors claim that statistical combination of data should not be a prominent feature of reviews of observational studies.<sup>54</sup> Third, the author combines results from different study designs without a discussion of the heterogeneity of the studies and the limitations of this approach. The results may indicate a possible association; however, the authors' conclusions that "periodontal disease significantly increases the risk of PLBW" may have somewhat limited applicability given the limitations of the study. These concerns point to caution in the claim for a causal relationship between periodontal disease and PT/LBW babies.

To determine a causal relationship will require a meta-analysis of high-quality randomized controlled trials. Therefore, additional longitudinal, randomized controlled clinical trials are needed that evaluate the efficacy and cost-effectiveness of different types of periodontal intervention on adverse pregnancy outcomes.

In light of the possible association between periodontal disease and PT/LBW, there should be increased interprofessional collaboration and communication between dental hygienists and prenatal programs in order to formalize support for pregnant women. These new opportunities can focus on oral/general health assessments, leadership capacity, policy development, surveillance, program delivery and evaluation. Due to the high social and economic costs associated with PT/LBW, the role of preventing oral infection in pregnant women may be an important one when planning the public health of Canadians. Dental hygienists should become more involved in educating clients about this association and providing early oral hygiene services for pregnant women and those considering pregnancy. This can be accomplished through a greater role for dental hygienists in public health programs targeting pregnant women, such as the Public Health Agency of Canada's Prenatal Nutrition Program. Dental hygienists could play an important role in achieving the program goal of reducing unhealthy birth weights.

## RESPIRATORY DISEASE

### Literature Review

The 2004 CDHA position paper concludes that there is a moderate association between periodontal disease and respiratory disease, with an odds ratio of approximately 3.04 for those at risk of developing respiratory disease.<sup>1</sup> The following statistics on respiratory disease incidence, impact on health, and health system expenses provide a rationale for the need to continue this research.

Respiratory disease is a leading cause of death in Canada, accounting for approximately 10% of all deaths.<sup>55</sup> In Canada in 2000-2001, approximately 11% of hospitalizations were due to respiratory diseases.<sup>56</sup> Over 3 million people of all ages in Canada were coping with serious respiratory diseases in 2001, and the expenses associated with these diseases account for nearly \$12.18 billion of expenditures per year, including direct and indirect costs.<sup>57</sup>

Many of the studies examining the link between periodontal disease and lung disease focus on nosocomial (hospital-acquired) pneumonia, or community-acquired pneumonia. In Canada, nosocomial pneumonia may be the second most common type of infection acquired in hospital. It is associated with the highest mortality rate<sup>57</sup> and substantial morbidity in intubated, mechanically ventilated clients.<sup>58,59</sup> In acute care hospitals, as many as 13.7% of patients develop this infection.<sup>60</sup> The seriousness of hospital-acquired infections is underlined by the Canadian Nosocomial Infection Surveillance Program, in place since 1995. A 2005 report from the surveillance program indicates that rates of nosocomial acquisition of methicillin-resistant *staphylococcus aureus* (MRSA) are on the rise with the rate of .91 out of 1000 admissions in 1997

increasing to 3.66 out of 1000 admissions in 2001.<sup>61</sup> In the United States, reported mortality rates from nosocomial pneumonia range from 20% to 50% and estimates place the total costs of this complication at \$1.2 billion per year.<sup>62</sup> In Canada, community-acquired pneumonia accounts for 60,000 hospitalizations per year costing \$100 million.<sup>62</sup>

Several biological mechanisms are hypothesized to explain the link between poor oral health and pneumonia.<sup>1,63-66</sup> (See figure 2.)

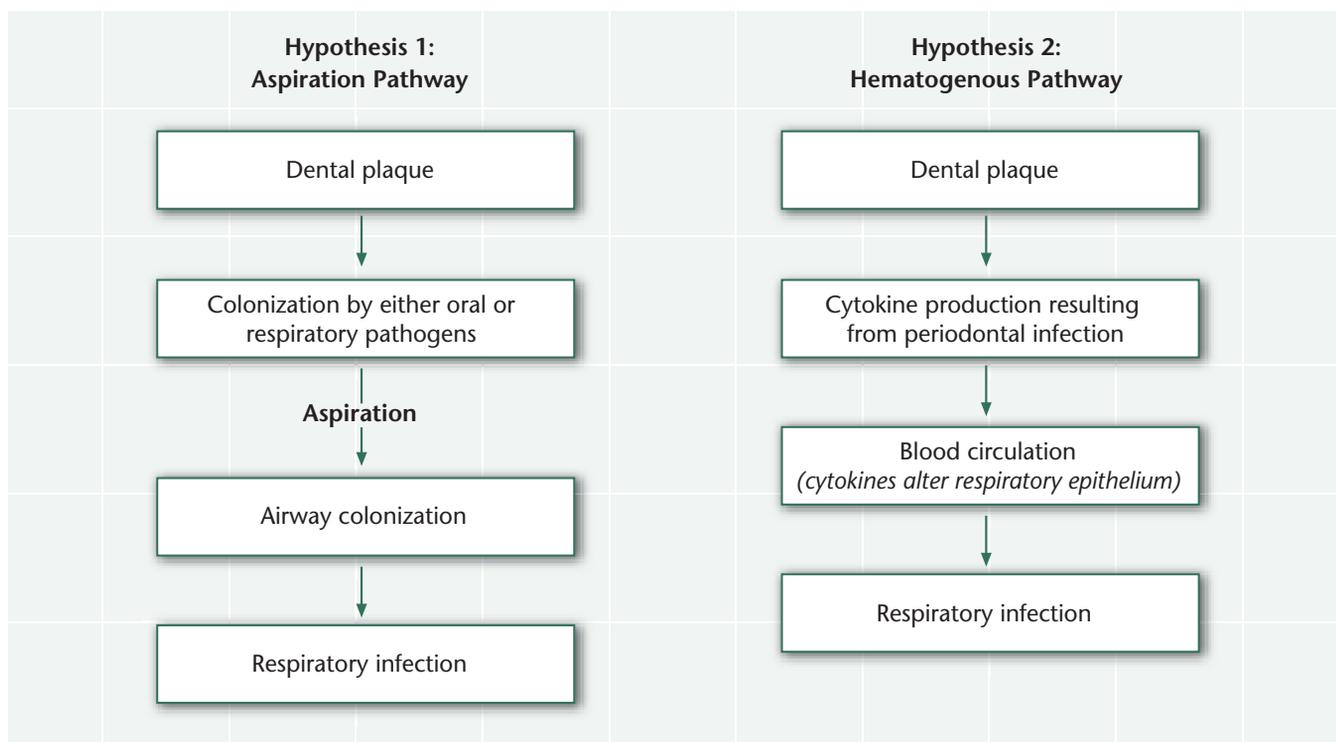
- Respiratory pathogens colonize the oral cavity, dental plaque, and oral mucosa. These pathogens may be aspirated into the lower airway to cause infection in health compromised clients.
- Cytokines originating from periodontal tissues may enter the blood and contribute to respiratory inflammation.

## RESULTS

A 2006 Systematic Review classified the research evidence using the Canadian Task Force on Preventive Health Care: Quality of Evidence and Grades of Recommendations.<sup>67</sup> Using evidence from 5 studies (four prospective cohort and one case-control,<sup>68-72</sup> they conclude that there is fair evidence of an association between respiratory diseases and oral health concludes (II-2, grade B recommendation). The odds ratio ranged from 1.2 to 9.6, depending on the oral health indicators. Using evidence from 10 studies (9 clinical trials, 3 non-randomized,<sup>73-82</sup> they found good evidence (I, grade A recommendation) that improved oral hygiene and frequent professional oral health care reduces occurrence of respiratory diseases among high-risk elderly adults in long-term care facilities and intensive care units. There was a low number needed to treat (NNT = 2 to 16) and a high relative risk reduction (RRR =34% to 83%). Using the evidence from four poor-to-fair studies,<sup>83-86</sup> they found a weak association between periodontal disease and chronic obstructive pulmonary disease (COPD).

A 2003 systematic review of 21 studies reports on the impact of periodontal disease and other indicators of poor oral health on the initiation or progression of pneumonia.<sup>87</sup> The following studies on pneumonia in intensive care and nursing homes were included: 11 case control and cohort,<sup>68-72,83,88-93</sup> and 7 controlled trials (5 randomized).<sup>73,76-80,94</sup>

A large variety of different interventions were included in the 7 controlled trials, including the following: regular cleaning of the oral cavity vs. regular oral hygiene; PNV (150mg of polymyxin B sulfate, 1g of neomycin sulfate, 1 g of vancomycin hydrochloride per 60mL of 5% dextrose) solution vs. placebo; chlorhexidine (CHX) oral rinse vs. placebo; CHX vs. isotonic bicarbonate and oropharyngeal aspiration; CHX oral rinse with ventilator weaning protocol(WP) vs. placebo and WP; topical antimicrobial prophylaxis: orabase® with gentamicin/colostin/vancomycin vs. placebo control: orabase® without antibiotics vs. control: no treatment; professional dental care once/day, plus gargling swabbing with povidone iodine. A meta-analysis of the 5 randomized controlled trials with institutionalized



**Figure 2.** Proposed biological mechanism for respiratory infection

clients showed that a number of oral hygiene interventions, such as mechanical and/or topical chemical disinfection or antibiotics, reduced the incidence of nosocomial pneumonia by an average of 40%, in high-risk subjects.

Three additional intervention studies were published following the 2003 systematic review. They are included in this review as two of them are lengthy studies and the third is an RCT, which provides substantive weight to the argument for a connection between periodontal disease and respiratory disease. The findings from these studies are consistent with the systematic review findings. The first study examined 141 elderly persons in nursing homes who received weekly oral health care by dental hygienists for 24 months. The researchers found a ratio of fatal aspiration pneumonia that was significantly lower in the treatment group (2/40) than in the control group (non-treatment) (8/48) ( $p < .05$ ).<sup>74</sup> The second study was a randomized clinical trial that included 561 subjects who were undergoing heart surgery.<sup>75</sup> The treatment group received Peridex 0.12% chlorhexidine gluconate oral rinse and the control group received Listerine (phenolic mixture). For the patients intubated for more than 24 hours, the pneumonia rate was reduced by 58% ( $P = .06$ )

The third additional intervention study followed 417 participants from 11 nursing homes for two years. The participants were randomly assigned to an oral care group or a control group who received no oral care provided by caregivers or dental hygienists.<sup>81</sup> In the former group, nurses or caregivers brushed the residents' teeth after each meal with no dentifrice, and a dental hygienist or a dentist administered plaque and calculus control as necessary once each week and povidone iodine was used in some

cases. Pneumonia and death from pneumonia were both significantly lower in the oral care group, with a relative risk (RR) of 1.67 (95%CI = 1.01-2.75,  $P < .05$ ) for the former and an RR of 2.40 (95%CI = 1.54-3.74,  $P < .01$ ) for the later. The edentate and the dentate residents showed similar results.

## DISCUSSION

The conclusion from this research is that there may be an association between periodontal disease and pneumonia. There are 12 high-quality randomized controlled trials (RCTs) that provide moderate evidence of a link between periodontal disease and nosocomial pneumonia in institutionalized clients and evidence that oral hygiene (mechanical or chemical approaches) may reduce the incidence of pneumonia. The low number needed to treat (NNT = 2 to 16), combined with a high relative risk reduction for pneumonia (RRR = 34% to 83%), provides solid evidence for a call for dental hygienists to work with high-risk elderly adults in long-term care facilities and intensive care units.

These conclusions are consistent with the biological evidence indicating that pneumonia can be the result of anaerobic bacteria.<sup>95</sup> Dental plaque with anaerobic bacteria seems to be a logical source of the bacteria that causes pneumonia.

Given that dental hygiene services are inexpensive and easy to deliver and that pneumonia causes significant morbidity, mortality, and cost to the health care system, dental hygiene services may have a significant impact on individual's lives and reduce health costs. It is less costly to provide dental hygiene services than to treat a client with pneumonia in a hospital setting. In fact, some of the costs

have been estimated: the cost of using Peridex in one hospital to try to prevent nosocomial pneumonia in all cardiovascular surgery patients was \$700 a year, less than 10% of the cost associated with a single case of nosocomial pneumonia.<sup>75</sup> Oral rinses are inexpensive and easy to apply and may be readily used in hospital and long-term care settings.

Given that many seniors in long-term care facilities have poor oral health due to difficulty accessing professional oral health care and inadequate personal oral hygiene care,<sup>96</sup> it may be warranted to provide high-risk seniors in long-term care and hospital settings with access to oral health services. In addition, there should be increased collaboration and communication between dental hygienists and long-term care facilities, and critical care units of hospitals. These new opportunities can focus on oral/general health assessments, leadership capacity, policy development, surveillance, program delivery and evaluation.

One of the drawbacks of attempting to combine the results from the randomized controlled trials (RCTs) is that there was a high degree of difference in the interventions in the studies. Therefore, there is a need for increased RCTs that focus on the same treatment approach. This may help to strengthen the evidence. In addition, determining a causal relationship between periodontal disease and pneumonia will require a meta-analysis of high-quality RCTs. Also needed are large RCTs comparing different types of intervention with high-risk clients to determine the impact on nosocomial- and community-acquired pneumonia. Since there is growing international research on this topic, there is also a need to develop international standards. These would allow the pooling of original data, which would avoid the possibility of combining the odds ratios and P values from two non-significant studies that may give significant results. There is also a need for ongoing research to clarify if periodontitis or higher levels of oral bacteria and biofilm are implicated in the relationship with respiratory disease. This would clarify the need to focus on plaque and biofilm removal, or the periodontal diseases themselves.

## REFERENCES

- Lux J, Lavigne S. Your Mouth – Portal to Your Body. *Probe*. 2004;38(4):155-71.
- Canadian Dental Association. CDA position on association between periodontal disease and systemic disease [on-line]. Ottawa: CDA; 2005. Available from: [www.cda-adc.ca/\\_files/position\\_statements/perio\\_systemic\\_diseases.pdf](http://www.cda-adc.ca/_files/position_statements/perio_systemic_diseases.pdf). 05.
- Ismail AI, Lewis DW, Dingle JL. Prevention of periodontal disease. In: Canadian Task Force on the Periodic Health Examination. Canadian Guide to Clinical Preventive Health Care [on-line]. Ottawa: Health Canada; 2006. p. 420-31. [Cited 2006 April]. Available from: [www.ctfphc.org/Abstracts\\_printable/Ch37abs.htm](http://www.ctfphc.org/Abstracts_printable/Ch37abs.htm).
- Centers for Disease Control and Prevention. National Center for Health Statistics. Plan and operation of the Third National Health and Nutrition Examination Survey, 1988-94. Series 1, No. 32. Hyattsville (MD): Dept. of Health and Human Services. PHS 94-1308.
- Bureau of Nutritional Sciences. Dental Report. Ottawa, 1977. *J Can Dent Assoc*. 1977;67(1):34.
- Hoover JN, Tynan JJ. Periodontal status of a group of Canadian adults. *J Can Dent Assoc*. 1986;52(9):761-63.
- Brodeur J-M, Payette M, Benigeri M, Charbonneau A, Olivier M, Chabot D. Periodontal diseases among Quebec adults aged 35 to 44 years. *J Can Dent Assoc*. 2001;67(1):34.
- World Health Organization/UNICEF. Low birth weights [on-line]. Geneva: WHO; New York: UNICEF; 2004. Available from: [www.who.int/reproductive-health/publications/low\\_birthweight/low\\_birthweight\\_estimates.pdf](http://www.who.int/reproductive-health/publications/low_birthweight/low_birthweight_estimates.pdf).
- Health Canada. Public Health Agency of Canada. Canadian perinatal health report, 2003. Ottawa: PWGSC; 2003. Available from: [www.phac-aspc.gc.ca/publicat/cphr-rspc03/pdf/cphr-rspc03\\_e.pdf](http://www.phac-aspc.gc.ca/publicat/cphr-rspc03/pdf/cphr-rspc03_e.pdf).
- National Resources Canada. The Atlas of Canada. Low birth weight [on-line]. [Cited 2006 April.] Available from: <http://atlas.nrcan.gc.ca/site/english/maps/health/status/low-birthweight/1>.
- Jeffcoat MK, Geurs NC, Reddy MS, Goldenberg RL, Hauth JC. Current evidence regarding periodontal disease as a risk factor in preterm birth. *Ann Periodontol*. 2001;6(1):183-88.
- Khader YS, Ta'ani Q. Periodontal diseases and the risk of preterm birth and low birth weight: a meta-analysis. *J Periodontol*. 2005;76(2):161-65.
- Task Force on Periodontal Treatment of Pregnant Women, American Academy of Periodontology. American Academy of Periodontology statement regarding periodontal management of the pregnant patient. *J Periodontol*. 2004;75(3):495.
- Madianos PN, Bobetsis GA, Kinane DF. Is periodontitis associated with an increased risk of coronary heart disease and preterm and/or low birth weight births? *J Clin Periodontol*; 2002;29(Suppl.3):22-36.
- Paige DN, Augustyn M, Adih WK, Witter F, Chang J. Bacterial vaginosis and preterm birth: a comprehensive review of the literature. *J Nurse Midwifery*. 1998;43(2):83-89.
- Romero R, Mazor H. Infection and preterm labour. *Clin Obstet Gynecol*. 1988;31(3):553-84.
- Hay PE, Lamont R.F, Taylor-Robinson D, Morgan DJ, Ison C, Pearson J. Abnormal bacterial colonisation of the genital tract and subsequent preterm delivery and late miscarriage. *BMJ*. 1994;308(6924):295-98.
- Mitchell-Lewis D, Engebretson SP, Chen J, Lamster IB, Papapanou PN. Periodontal infections and pre-term birth: early findings from a cohort of young minority women in New York. *Eur J Oral Sci*. 2001;109(1):34-39.
- Lopez NJ, Smith PC, Gutierrez J. Periodontal therapy may reduce the risk of preterm low birth weight in women with periodontal disease. *J Periodontol*. 2002;73(8):911-24.
- Jared HL. Periodontitis and pregnancy outcomes. *Dimensions Dent Hyg*. 2005;November:14-18.
- National Healthy Mothers, Healthy Babies Coalition. Oral health and pregnancy position statement [on-line]. Alexandria (VA): The Coalition; 2001. Available from: [www.hmhb.org/ps\\_oralhealth.html](http://www.hmhb.org/ps_oralhealth.html).
- Scannapieco FA, Bush RB, Paju S.. Periodontal disease as a risk factor for adverse pregnancy outcomes. A systematic review. *Ann Periodontol*. 2003;8(1):70-78.
- Offenbacher S, Katz V, Fertik G, Collins J, Boyd D, Maynor G et al. Periodontal infection as a possible risk factor for preterm low birthweight. *J Periodontol*. 1996;67(10 Suppl):1103-13.
- 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;72(11):1491-97.
- Offenbacher S, Jared HL, O'Reilly PG, Wells SR, Salver GE, Lawrence HP, et al. Potential pathogenic mechanisms of periodontitis associated pregnancy complications. *Ann Periodontol*. 1998;3(1):233-50.
- Davenport ES, Williams CE, Sterne JA, Murad S, Sivapathasundram V, Curtis MA. Maternal periodontal disease and preterm low birthweight. *J Dent Res*. 2002;81(5):313-18.
- Dasanayake AP. Poor periodontal health of the pregnant woman as a risk factor for low birth weight. *Ann Periodontol*. 1998;3(1):206-12.

28. Romero BC, Chiquito CS, Elejalde LE, Bernardoni CB. Relationship between periodontal disease in pregnant women and the nutritional condition of their newborns. *J Periodontol.* 2002;73(10):1177-83.
29. 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.* 2001;132(7):875-80.
30. Offenbacher S, Lief S, Boggess KA, Murtha AP, Madianos PN, Champagne CM, et al. Maternal periodontitis and prematurity. Part I Obstetric outcome of prematurity and growth restriction. *Ann Periodontol.* 2001;6(1):164-74.
31. Madianos PN, Lief S, Murtha AP. Maternal periodontitis and prematurity. Part II. Maternal infection and fetal exposure. *Ann Periodontol.* 2001;6(1):175-82.
32. Lopez NJ, Smith PC, Gutierrez J. Higher risk of preterm birth and low birth weight in women with periodontal disease. *J Dent Res.* 2002;81(1):58-63.
33. Sanchez AR, Kupp LI, Sheridan PJ, Sanchez DR. Maternal Chronic infection as a risk factor in preterm low birth weight infants: the link with periodontal infection. *J Int Acad Periodontol.* 2004;6(3):89-94.
34. Xiong X, Buekens P, Fraser W, Beck J, Offenbacher S. Periodontal disease and adverse pregnancy outcomes: a systematic review. *BJOG.* 2006;113(2):135-43.
35. Sembene M, Moreau JC, Mbaye MM, Diallo A, Diallo PD, Ngom M, et al. Periodontal infection in pregnant women and low birth weight babies. *Odontostomatol Trop.* 2000;23(89):19-22.
36. Louro PM, Fiori HH, Filho PL, Steibel J, Fiori RM. Periodontal disease in pregnancy and low birth weight. *J Pediatr (Rio J).* 2001;77(1):23-28.
37. Mokeem SA, Molla GN, Al-Jewair TS. The prevalence and relationship between periodontal disease and pre-term low birth weight infants at King Khalid University Hospital in Riyadh, Saudi Arabia. *J Contemp Dent Pract.* 2004;5(2):40-56.
38. Goepfert AR, Jeffcoat MK, et al, Andrews WW, Faye-Petersen O, Cliver SP, Goldenberg RL. Periodontal disease and upper genital tract inflammation in early spontaneous preterm birth. *Obstet Gynecol.* 2004;104(4):777-83.
39. Radnai M, Gorzo I, Nagy E, Urban E, Novak T, Pal A. A possible association between preterm birth and early periodontitis. A pilot study. *J Clin Periodontol.* 2004;31(9):736-41.
40. Canakci V, Canakci CF, Canakci H, Canakci E, Cicek Y, Ingeg M, et al. Periodontal disease as a risk factor for pre-eclampsia: a case control study. *Aust N Z J Obstet Gynaecol.* 2004;44(6):568-73.
41. Moore S, Randhawa M, Ide M. A case-control study to investigate an association between adverse pregnancy outcome and periodontal disease. *J Clin Periodontol.* 2005;32(1):1-5.
42. Buduneli N, Baylas H, Buduneli E, Turkoglu O, Kose T, Dahlen G. Periodontal infections and pre-term low birth weight: a case control study. *J Clin Periodontol.* 2005;32(2):174-81.
43. Jarjoura K, Devine PC, Perez-Delboy A, Herrera-Abreu M, D'Alton M, Papapanou PN. Markers of periodontal infection and preterm birth. *Am J Obstet Gynecol.* 2005;192(2):513-19.
44. Fraser et al. Unpublished work. Cited in Xiong X, Buekens P, Fraser W, Beck J, Offenbacher S. Periodontal disease and adverse pregnancy outcomes: a systematic review. *BJOG.* 2006;113(2):135-43.
45. Moore S, Ide M, Coward PY, Randhawa M, Borkowska E, Baylas R, et al. A prospective study to investigate the relationship between periodontal disease and adverse pregnancy outcome. *Br Dent J.* 2004;197(5):251-58.
46. Holbrook WP, Oskarsdottir A, Fridjonsson T, Einarsson H, Hauksson A, Geirsson RT. No link between low-grade periodontal disease and preterm birth: a pilot study in a healthy Caucasian population. *Acta Odontol Scand.* 2004;62(3):177-79.
47. Dortbudak O, Eberhardt R, Ulm M, Persson GR. Periodontitis, a marker of risk in pregnancy for preterm birth. *J Clin Periodontol.* 2005;32(1): 45-52.
48. Rajapakse PS, Nagarathne M, Chandrasekra KB, Dasanayake AP. Periodontal disease and prematurity among non-smoking Sri Lankan women. *J Dent Res.* 2005;84(3):274-77.
49. Jeffcoat MK, Hauth JC, Geurs NC, Reddy MS, Cliver SP, Hodgkins PM, et al. Periodontal disease and preterm birth: results of a pilot intervention study. *J Periodontol.* 2003;74(8):1214-18.
50. Cassolato S, Chen A, Chvartzsazid D, Sander M. Is periodontal disease a risk factor for preterm low birth weight infants? A systemic review. Presented at the Royal College of Dental Surgeons of Ontario Symposium, "Oral health: a window to systemic disease"; 2005 Feb 4; Toronto, Ontario. Dispatch. 2006;20(2 Suppl):1-12 [cited 2006 Jun 12]. Available from: [www.rcdso.org/pdf/PEAKSpring06.pdf](http://www.rcdso.org/pdf/PEAKSpring06.pdf)
51. Lopez NF, Da Silva I, Ipinza J, Gutierrez J. Periodontal therapy reduces the rate of preterm low birth weight in women with pregnancy-associated gingivitis. *J Periodontol.* 2005;76(11 Suppl):2144-53.
52. World Health Organization. Health Status Statistics: Morbidity. Geneva: WHO Health Statistics and Health Information Systems; 2006.
53. Stroup DF, Berlin JA, Morton SC, Olkin I, Williamson GD, Rennie D, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis of observational studies in epidemiology (MOOSE) group. *JAMA.* 2000;283(15):2008-12.
54. Egger M, Schneider M, Davey Smith G: Spurious precision? Meta-analysis of observational studies [on-line]. *BMJ.* 1998;316(No. 7125) [cited 2006 May 10]. Available from: [bmj.bmjournals.com/archive/7125/7125ed2.htm](http://bmj.bmjournals.com/archive/7125/7125ed2.htm).
55. Health Canada. Public Health Agency of Canada. Cardiovascular disease surveillance on-line: leading causes of death. Ottawa: PHAC; 2002. Available from: [http://dsol-smed.phac-aspc.gc.ca/dsol-smed/cvd/index\\_e.html](http://dsol-smed.phac-aspc.gc.ca/dsol-smed/cvd/index_e.html)
56. Health Canada. Public Health Agency of Canada. Centre for Chronic Disease Prevention and Control. Chronic respiratory disease [on-line]. Ottawa: PHAC. Available from: [www.phac-aspc.gc.ca/ccdpc-cpcmc/crd-mrc/facts\\_gen\\_e.html](http://www.phac-aspc.gc.ca/ccdpc-cpcmc/crd-mrc/facts_gen_e.html).
57. Canadian Institute for Health Information, Canadian Lung Association, Health Canada, Statistics Canada. Respiratory disease in Canada, September 2001 [on-line]. Ottawa: CIHI; 2001. Available from: [www.phac-aspc.gc.ca/publicat/rdc-mrc01/pdf/rdc0901e.pdf](http://www.phac-aspc.gc.ca/publicat/rdc-mrc01/pdf/rdc0901e.pdf).
58. Kingston GW, Phang PT, Leathey MJ. Increased incidence of nosocomial pneumonia in mechanically ventilated patients with subclinical aspiration. *Am J Surg.* 1991;161(5):589-92.
59. Baxter AD, Allan J, Bedard J, Malone-Tucker S, Slivar S, Langill M, et al. Adherence to simple and effective measures reduces the incidence of ventilator-associated pneumonia. *Can J Anesth.* 2005;52(5):535-41.
60. Gravel D, McGeer A, Johnson L, Matlow A, Moore D, Taylor G, et al. Severe respiratory illness (SRI) surveillance within acute-care institutions participating in the Canadian nosocomial infection surveillance program CNISP [abstract]. Presented at the Canadian Association for Clinical Microbiology and Infectious Diseases meeting, April 14-17, 2005, Ottawa Ontario. Available from: [www.cacmid.ca/abstracts\\_05/11\\_05.htm](http://www.cacmid.ca/abstracts_05/11_05.htm).
61. Health Canada. Public Health Agency of Canada. Canadian Communicable Disease Report [on-line]. 2005;31(3):1-8. Available from: <http://dsp-psd.pwgsc.gc.ca/Collection/HP3-1-31-3.pdf>.
62. Guidelines for prevention of nosocomial pneumonia. *MMWR.* 1997;46(RR-1):1-79. Available from: [www.cdc.gov/mmwr/preview/mmwrhtml/00045365.htm](http://www.cdc.gov/mmwr/preview/mmwrhtml/00045365.htm).
63. Johanson WG, Dever LL. Nosocomial pneumonia. *Intensive Care Med.* 2003;29(1):23-29.
64. Niederman MS, Ahmed QA. Community-acquired pneumonia in elderly patients. *Clin Geriatr Med.* 19(1):101-20.
65. Scannapieco FA. Role of oral bacteria in respiratory infection. *J Periodontol.* 1999;70(7):793-802.
66. Travis J, Pike R, Imamura T, Potempa J. The role of proteolytic enzymes in the development of pulmonary emphysema and periodontal disease. *Am J Respir Crit Care Med.* 1994;150(6Pt 2):143-46.
67. Azarpazhooh A, Leake J. Systematic review of the association between respiratory diseases and oral health. *J Periodontol.* 2006;77(9):1465-82.

68. Terpenning M, Taylor GW, Lopatin DE, Kerr CK, Dominiguez BL, Loesche WJ. Aspiration pneumonia: dental and oral risk factors in an older veteran population. *J Am Geriatr Soc.* 2001;49(5):557-63.
69. Fourrier F, Duvivier B, Boutigny H, Roussel-Delvallez M, Chopin C. Colonization of dental plaque: a source of nosocomial infections in intensive care unit patients. *Crit Care Med.* 1998;26(2):301-8.
70. El-Solh AA, Pietrantonio C, Bhat A, Okada M, Zambon J, Aquilina A, et al. Colonization of dental plaques: a reservoir of respiratory pathogens for hospital-acquired pneumonia in institutionalized elders. *Chest.* 2004;126(5):1575-82.
71. Langmore SE, Terpenning MS, Schork A, Chen Y, Murray JT, Lopatin D, et al. Predictors of aspiration pneumonia: how important is dysphagia? *Dysphagia.* 1998;13(2):69-81.
72. Mojon P, Budtz-Jorgensen E, Michel JP, Limeback H. Oral Health and history of respiratory tract infection in frail institutionalized elders. *Gerodontology.* 1997;14(1):9-16.
73. Pugin J, Auckenthaler R, Lew DP, Suter PM. Oropharyngeal decontamination decreases incidence of ventilator-associated pneumonia. A randomized, placebo-controlled, double-blind clinical trial. *JAMA.* 1991;265(20):2704-10.
74. Adachi M, Ishihara K, Abe S, Okuda K, Ishikawa T. Effect of professional oral health care on the elderly living in nursing homes. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2002;94(2):191-5.
75. Houston S, Hougland P, Anderson JJ, LaRocco M, Kennedy V, Gentry LO. Effectiveness of 0.12% chlorhexidine gluconate oral rinse in reducing prevalence of nosocomial pneumonia in patients undergoing heart surgery. *Am J Crit Care.* 2002;11(6):567-70.
76. Bergmans DC, Bonten MJ, Gaillard CA, Paling JC, van der Geest S, van Tiel FH, et al. Prevention of ventilator-associated pneumonia by oral decontamination: A prospective, randomized, double-blind, placebo-controlled study. *Am J Respir Crit Care Med.* 2001;164(3):382-88.
77. DeRiso AJ 2nd, Ladowski JS, Dillon TA, Justice JW, Peterson AC. Chlorhexidine gluconate 0.12% oral rinse reduces the incidence of total nosocomial respiratory infection and non-prophylactic systemic antibiotic use in patients undergoing heart surgery. *Chest.* 1996;109(6):1556-61.
78. Fourrier F, Cau-Pottier E, Boutigny H, Roussel-Delvallez M, Jourdain M, Chopin C. Effects of dental plaque antiseptic decontamination on bacterial colonization and nosocomial infections in critically ill patients. *Intensive Care Med.* 2000;26(9):1239-47.
79. Genuit T, Bochicchio G, Napolitano LM, McCarter RJ, Roghman MC. Prophylactic chlorhexidine oral rinse decreases ventilator-associated pneumonia in surgical ICU patients. *Surg Infect (Larchmt).* 2001;2(1):5-18.
80. Yoneyama T, Hashimoto K, Fukuda H, Ishida M, Arai H, Sekizawa K, et al. Oral hygiene reduces respiratory infections in elderly bed-bound nursing home patients. *Arch Gerontol Geriatr.* 1996;22(1):11-19.
81. Yoneyama T, Yoshida M, Ohru T, Mukaiyama H, Okamoto H, Hoshihara K, et al. Oral care reduces pneumonia in older patients in nursing homes. *J Am Geriatr Soc.* 2002;50(3):430-33.
82. Fourrier F, Dubois D, Pronnier P, Herbecq P, Leroy O, Desmettre T, et al. Effect of gingival and dental plaque antiseptic decontamination on nosocomial infections acquired in the intensive care unit: A double-blind placebo-controlled multicenter study. *Crit Care Med.* 2005;33(8):1728-35.
83. Russell SL, Boylan RJ, Kaslick RS, Scannapieco FA, Katz RV. Respiratory pathogen colonization of the dental plaque of institutionalized elders. *Spec Care Dentist.* 1999;19(3):128-34.
84. Hayes C, Sparrow D, Cohen M, Vokonas PS, Garcia RI. The association between alveolar bone loss and pulmonary function: the VA Dental Longitudinal Study. *Ann Periodontol.* 1998;3(1):257-61.
85. Scannapieco FA, Ho AW. Potential associations between chronic respiratory disease and periodontal disease: analysis of National Health and Nutrition Examination Survey III. *J Periodontol.* 2001;72(1):50-56.
86. Scannapieco FA, Papandonatos GD, Dunford RG. Associations between oral conditions and respiratory disease in a national sample survey population. *Ann Periodontol.* 1998;3(1):251-56.
87. Scannapieco F, Bush RB, Paju S. Associations between periodontal disease and risk for nosocomial bacterial pneumonia and chronic obstructive pulmonary disease. A systematic review. *Ann Periodontol.* 2003;8(1):54-69.
88. Chabrand F, Allamand JM, Duroux P, Rabate B, Laudenbach P, Doyon D. Are orodental infectious foci responsible for bacterial pneumopathies? A statistical study. [In French] *Rev Stomatol Chir Maxillofac.* 1986;87(2):73-77.
89. Scannapieco FA, Stewart EM, Mylotte JM. Colonization of dental plaque by respiratory pathogens in medical intensive care patients. *Crit Care Med.* 1992;20(6):740-45.
90. Treloar DM, Stechmiller JK. Use of clinical assessment tool for orally intubated patients. *Am J Crit Care.* 1995;4(5):355-60.
91. Bonten MJ, Bergmans DC, Ambergen AW, et al. Risk factors for pneumonia, and colonization of respiratory tract and stomach in mechanically ventilated ICU patients. *Am J Res Crit Care Med.* 1996;154(5):1339-46.
92. Terpenning M, Bretz W, Lopatin D, Langmore S, Dominguez B, Loesche W. Bacterial colonization of saliva and plaque in the elderly. *Clin Infect Dis.* 1993;16(Suppl 4):S314-S316.
93. Preston AJ, Gosney MA, Noon S, Martin MV. Oral flora of elderly patients following acute medical admission. *Gerontology.* 1999;45(1):49-52.
94. Kuriakona NV. Effect of oral cavity sanitization on the activity of the course of chronic pneumonia in children (in Russian). *Stomatologia* 1977;56:94-95.
95. Scannapieco FA, Mylotte JM. Relationships between periodontal diseases and bacterial pneumonia. *J Periodontol.* 1996;67(10 Suppl):1114-22.
96. Lux J. Access Angst: CDHA position statements on access to oral health services. *Probe.* 2003;37(6):261-72.