Association Between Pneumonia and Oral Care in Nursing Home Residents

Ali A. El-Solh

Abstract Pneumonia remains the leading cause of death in nursing home residents. The accumulation of dental plaque and colonization of oral surfaces and dentures with respiratory pathogens serves as a reservoir for recurrent lower respiratory tract infections. Control of gingivitis and dental plaques has been effective in reducing the rate of pneumonia but the provision of dental care for institutionalized elderly is inadequate, with treatment often sought only when patients experience pain or denture problems. Direct mechanical cleaning is thwarted by the lack of adequate training of nursing staff and residents’ uncooperativeness. Chlorhexidine-based interventions are advocated as alternative methods for managing the oral health of frail older people; however, efficacy is yet to be demonstrated in randomized controlled trials. Development and maintenance of an oral hygiene program is a critical step in the prevention of pneumonia. While resources may be limited in long-term-care facilities, incorporating oral care in daily routine practice helps to reduce systemic diseases and to promote overall quality of life in nursing home residents.

Keywords Oral care · Pneumonia · Nursing home · Chlorhexidine

Pneumonia in Long-term-care Facilities

The aging of the United States (US) population has occurred steadily over the last century, and this trend is expected to continue in the coming decades. In 1995, 33 million people aged 65 and older comprised 13% of the population. By 2030, the percentage of people aged 65 and older will rise to 20% of the population [1]. Currently, 4.1% of people in the US older than 65 reside in long-term-care facilities (LTCFs), and 15% of people older than 85 are nursing home residents [2]. Twelve studies conducted in a variety of North American LTCFs since 1978 indicate that the overall incidence of infections in these facilities ranges between 1.8 and 13.5 infections per 1,000 resident-care days [3]. Pneumonia remains the leading cause of death attributable to infection in patients aged 65 and older and accounts for 13-48% of infections in the nursing home setting, with mortality rates as high as 55% [4, 5]. The incidence of pneumonia among residents of LTCFs ranges from 0.27 to 2.5 per 1,000 patient-days, with a median reported incidence of 1 per 1,000 patient-days. Expressed as annual rates of infection, the reported annual incidence of pneumonia in long-term-care residents ranges from 99 to
nursing home residents [13]. Aspiration pneumonitis is a described in the literature that are most applicable to pneumonia (NHAP) of 1 episode per 1,000 resident care days and 0.7 episode per 1,000 resident care days [8, 9].

There are several factors that predispose nursing home residents to respiratory infections. Ineffective clearing of mucus from the respiratory tract makes older people, especially those with additional disease burden such as cerebrovascular accident, dysphagia, gastroesophageal reflux disease, presbyesophagus, or sedative-hypnotic medication use, more vulnerable to pneumonia [10, 11]. Institutionalized individuals are at particularly high risk for severe consequences of pneumonia due to decreased respiratory reserve, presence of comorbid diseases such as chronic obstructive pulmonary disease, diabetes mellitus, and coronary artery disease, and the waning of innate and specific immunity that occurs with aging. In addition, the more widespread use of an array of immunosuppressive drugs, such as corticosteroids, and cytotoxic agents to treat autoimmune, inflammatory, or malignant disorders has likely increased the frequency and severity of pneumonia. Several preventive measures, including influenza and pneumococcal vaccinations, have been linked to substantial reduction in illnesses in recent years, yet the incidence of pneumonia remains unchanged or even continues to rise in some age groups [12].

There are two pneumonic aspiration syndromes that are described in the literature that are most applicable to nursing home residents [13]. Aspiration pneumonitis is a noninfectious process secondary to macroaspiration of food, regurgitated acid, or particulate matter. These cases vary in severity. Some episodes may exhibit a protracted course and end up in death, while others may resolve rapidly. Aspiration pneumonia is an infectious process secondary to oropharyngeal dysphagia with inhalation of periodontal bacteria or pharyngeal colonizers or due to regurgitation of colonized gastric material. It has been argued that while aspiration pneumonia requires antimicrobial therapy, aspiration pneumonitis does not. Yet, practicing providers do not make this distinction for the following reasons: First, there is no clinical or biological marker that would differentiate these two entities; second, there is always the plausibility that these two entities may overlap. In this case, the risk of withholding antimicrobial therapy in a frail population outweighs the risk of overtreatment with antibiotics. Mylotte et al. [14] have developed an algorithm to distinguish between aspiration pneumonitis and aspiration pneumonia but the model had no microbiological documentation to substantiate a distinction between these two entities and does not impose a restriction on antimicrobial therapy for those with aspiration pneumonitis. For all practical purposes, the difference between aspiration pneumonia and aspiration pneumonitis remains theoretical in the eyes of practitioners and antimicrobial treatment is invariably prescribed for pneumonia irrespective of the underlying pathophysiology.

### Association Between Oral Health and Respiratory Pathogens in Nursing Home Residents

There are several avenues by which potential pathogens may gain access to the lower respiratory tract: (1) aspiration of the oropharyngeal contents, (2) inhalation of infectious aerosols, (3) spread of infection from contiguous sites, and (4) hematogenous spread from extrapulmonary sites of infection. Colonization of the oral cavity followed by aspiration of bacteria-laden oropharyngeal secretions into the lower respiratory tract remains the most common path of infection for typical bacterial pneumonia [15]. Indeed, it has long been recognized that anaerobic lung infections can occur following aspiration of salivary secretions, especially in patients with periodontal disease [16, 17]. Quagliarello et al. [18] found poor oral hygiene to be among the most common risk factors of pneumonia in nursing homes. Nine modifiable risk factors for NHAP were examined in 613 elderly patients at a nursing home, including inadequate oral care, difficulty in swallowing, lack of influenza vaccination, depression, feeding position of less than 90° from horizontal, active smoking, receipt of sedative medication, receipt of gastric acid-reducing medication, and use of angiotensin-converting enzyme inhibitors. The only two risk factors that were shown to have significant association with risk of developing pneumonia were inadequate oral care and difficulty swallowing [18].

Patients with periodontal disease harbor a large number of subgingival bacteria, including anaerobic and fastidious species. Langmore et al. [19] identified high levels of the periodontal pathogen *Porphyromonas gingivalis* and *Streptococcus sobrinus* in the oral cavity of elderly. These are the same organisms implicated in the etiology of pneumonia from patients associated with poor oral hygiene. In another study of 500 adults with refractory periodontitis, enteric rods and pseudomonads were cultured from subgingival sites in over 10% of the subjects [20]. A follow-up clinical investigation found 14% of patients with periodontitis to harbor enteric rods and/or *Pseudomonas* species in subgingival dental plaque [21]. Cantrell [22] asserted a “well-documented” role between severe gingival disease, heavy calculus deposition, and anaerobic pleuropulmonary disease, specifically pneumonia. In a series of cases of anaerobic pleuropulmonary disease, there
Table 1 lists potential risk factors implicated in poor oral plaque colonization by respiratory pathogens [18, 30, 31]. These results suggest that poor oral care overall as reflected by a higher degree of plaque and debris scores [29]. These findings confirmed the conclusions of Scannapieco et al. [34] who reported an overall relative risk of pneumonia of 9.6 when dental plaque was colonized and a significant association between decayed teeth (OR = 1.2), dental plaque (OR = 4.2), and dependency for oral care (OR = 2.8).

A recent study from Japan summarized these observations by showing a significant association between dental disease and mortality-related aspiration pneumonia. Awano and coworkers [35] showed that the adjusted mortality due to pneumonia was 3.9 times higher in persons with ten or more teeth with a probing depth exceeding 4 mm (periodontal pocket) than in those without periodontal pockets. In a recent systematic review, it was estimated that approximately one in ten cases of death from pneumonia in elderly nursing home residents may be prevented by improving oral hygiene [36].

Unfortunately, regimens for enhancing oral hygiene at LTCFs, where physical dependency often requires assistance in activities of daily living be provided by a caregiver, have largely been ignored. While limited controlled studies, in both scope and sample size, have identified this

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<td>Advanced malignancy</td>
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<td>Impaired swallowing reflex</td>
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<td>Dementia</td>
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<td>Cerebrovascular accident</td>
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<td>Parkinson’s disease</td>
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<td>Radiation therapy</td>
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<td>Human immunodeficiency virus</td>
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<td>Poor functional status</td>
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<td>Drug-induced xerostomia</td>
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problem, the effectiveness of programs for improving the oral health in nursing homes have not been thoroughly investigated.

Effects of Edentulism

The microbial flora of edentulous elderly subjects is substantially different from dentate subjects [37]. Obviously, people without teeth would not be affected by periodontal inflammation. A recent study showed that dentate elderly individuals have a higher risk of harboring periodontopathic pathogens than those who are edentulous (91.4% vs. 40.3%, \( p < 0.001 \)) [38]. However, periodontal pathogens may persist in the oral cavity of edentulous subjects who have had periodontal disease for an extended period of time after the extraction of all teeth and in the absence of other hard surfaces in the mouth [39]. The current evidence suggests that the prevalence of respiratory tract infection is significantly greater among dentate than edentulous subjects (40% vs. 27%) and is also greater among subjects with selected oral disorders than those without such conditions [31, 40]. Similarly, Terpenning et al. [41] found a trend toward lower prevalence of pneumonia among edentulous elderly patients. However, Yoneyama and coworkers [42] showed that even in edentate patients, fever, nonfatal pneumonia, and fatal pneumonia occurred less frequently in the group assigned to enhanced oral care compared to the group assigned to routine oral care (18, 9, and 7% vs. 34, 20, and 13%, respectively). Abe et al. [43] raised the possibility that bacterial tongue-coating might represent another source of aspiration pneumonia in edentate subjects, making the argument that not only the dentate elderly should be targeted for oral cleaning.

Barriers to Oral Care

There are major barriers to oral care for patients in nursing homes. These include the lack of specific designated personnel to perform oral care, lack of adequate training of nursing staff, resident noncompliance with care, and choice of oral care itself [44, 45]. In a survey of 14 nursing homes in Virginia, patient uncooperativeness was listed as the major factor in whether oral services were provided [46]. Coleman [45] reiterated these findings in an observational study of a group of nursing home patients with dementia. However, in a separate investigation, over 70% of nursing home residents indicated that they had not seen a dentist for over 5 years and 82% of denture wearers were unable to clean their denture [47]. Yet none received regular assistance. While the staff had a good understanding of the role of oral care in preventing dental disease, only one third had received training in oral health or instructions on how to provide oral care. To complicate the matter more, dental coverage is curtailed under the Medicare and Medicaid programs because the majority of dental services are viewed as not medically necessary. Traditionally, Medicare provides coverage for acute care only, which generally does not include dental coverage. In the rare instances where Medicare will provide dental coverage, the dental procedure must be linked to an underlying health condition. As a result, reimbursement for oral care under the Medicare and the Medicaid program is severely limited and poorly funded.

Effectiveness of Oral Care Intervention Programs

The most compelling evidence obtained to date supporting the effectiveness of oral care comes from several interventional studies that have demonstrated a reduction in lower respiratory tract infections following improvement in oral hygiene (Table 2).

Mechanical Intervention

In a randomized study of elderly nursing home patients, Yoneyama et al. [42] randomized 417 patients to an oral care group or no oral care group. In the oral care group, nurses or caregivers cleaned the patients’ teeth with a toothbrush for approximately 5 min after each meal. The brushing was performed as usual daily tooth brushing, including brushing palatal and mandibular mucosa and tongue dorsum. If the toothbrush was not efficient, the oropharynx was scrubbed with an applicator with povidone iodine (1%). In the no oral care group, patients performed tooth brushing by themselves irregularly. During a 2-year follow-up, the incidence of pneumonia in the oral group decreased from 19 to 11%. Mortality from pneumonia was also about half that in patients not receiving oral care. The study was criticized for lack of blinding, failure to adjust for comorbidities, and the absence of a standard practice of oral care in the control group. More significantly, the oral care regimen implemented on those randomized to the treatment arm was both too stringent and labor-intensive, which made it impractical to be recommended as a standard of care for institutionalized subjects. In a similar study, Adachi and coworkers [48] compared the effectiveness of weekly professional oral health care given by dental hygienists to 77 residents of a long-term-care facility compared to 64 residents who did not receive professional oral health care. The prevalence of fevers of 37.8°C or more and the rate of fatal aspiration pneumonia in the subjects receiving professional oral health care were significantly lower (4% and 5% vs. 7% and 16.7%, respectively; \( p < 0.05 \)). Of interest, 49 patients were not included in the final analysis because of dementia and another 14...
dropped out of the study during the study period. In order to determine the optimal frequency of professional intervention by dental health-care workers, Ueda et al. [49] showed that oral hygienic condition could be improved by performing professional oral care in which an interdental toothbrush, an engine brush, and a scaler were used for tooth cleaning at an interval of 1 week for 12 consecutive weeks. The improved condition could be maintained when professional oral care was continued at a 1-week interval thereafter.

The benefit of oral care has also been shown to translate into a reduction in influenza infection. Abe et al. [50] assigned randomly 190 elderly patients to either professional oral care once a week or to self-care. The intervention group had a significant drop in bacteria colony-forming units (CFUs), NA, and TLPs compared to the control group, and the rate of developing influenza was reduced by tenfold in those assigned to professional oral cleaning (\( p = 0.008 \)).

A recent study involving 143 residents of a nursing home investigated the association between the assignment of an oral hygiene aide staff member and mortality from pneumonia [29]. The oral care provided by the nursing home oral hygiene aides included setting up for, encouraging, and monitoring self oral hygiene care for all residents who were aware and able to participate in their own care. This included tooth brushing, antiseptic mouthwash use, and oral and denture cleaning for edentulous or partially edentulous residents. For patients who were unable to perform oral care, the aides would provide this care directly. Looking at the records up to 79 weeks retrospectively, patients in the oral care group had significantly lower plaque and debris scores (using the Simplified Oral Hygiene Index) than did patients in the no oral care group.

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<th>Ref.</th>
<th>Population</th>
<th>Design</th>
<th>Intervention</th>
<th>Outcomes</th>
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<tr>
<td>Yoneyama et al. [42]</td>
<td>417 NH residents</td>
<td>Randomized controlled trial over 2-year period</td>
<td>Daily tooth brushing plus scrubbing of pharynx with povidone iodine 1% (including professional care once a week) vs. routine oral care</td>
<td>RR of developing pneumonia 1.67 in the group on no oral care compared with oral care (( p = 0.04 ))</td>
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<td>Simons et al. [59]</td>
<td>111 dentate elderly</td>
<td>Double-blind, randomized controlled trial over 12-month period</td>
<td>CHX/xylitol gum vs. xylitol (X) gum vs. no gum</td>
<td>Significant reduction in denture debris, stomatitis, and cheilitis in CHX/X and X groups compared to no gum</td>
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<td>Ueda et al. [49]</td>
<td>105 long-term-care residents</td>
<td>Prospective interventional study</td>
<td>Oral care intervention at intervals of 1, 2, 3, 4, and 6 weeks</td>
<td>Oral hygienic condition could be improved by performing oral care at intervals of 1 week for 12 consecutive weeks, and maintained at intervals of 1 week thereafter</td>
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<td>Abe et al. [50]</td>
<td>190 elderly patients</td>
<td>Prospective, randomized for 6 months</td>
<td>Weekly professional oral care versus self oral care</td>
<td>RR of developing influenza while under professional oral care compared to that in the control group was 0.1 (95% CI 0.01-0.81, ( p = 0.008 ))</td>
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<td>Adachi et al. [62]</td>
<td>216 NH residents</td>
<td>Prospective interventional study over 24 months</td>
<td>Daily routine oral care plus either mechanical cleaning weekly vs. basic oral hygiene (swabbing and denture cleaning)</td>
<td>Fatal aspiration pneumonia (RR = 2.67; ( p &lt; 0.5 )) higher in those who did not receive professional oral care compared to intervention group</td>
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<tr>
<td>Ishikawa et al. [63]</td>
<td>202 NH residents</td>
<td>Prospective interventional study over 5-month period</td>
<td>Professional oral care weekly vs. gargling with 0.35% povidone iodine daily vs. no professional care</td>
<td>Professional oral care decreased burden of oropharyngeal bacteria and was more effective than gargling with povidone iodine</td>
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<tr>
<td>Bassim et al. [29]</td>
<td>143 NH residents</td>
<td>Retrospective review up to 79 weeks</td>
<td>Assisted oral hygiene (toothbrushing, antiseptic mouthwash) vs. no assisted oral care</td>
<td>Odds ratio for dying from pneumonia 3.57 higher in the control group than the oral hygiene group</td>
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NH nursing home, CHX chlorhexidine, RR relative risk
When the data were adjusted for risk factors found to be significant for mortality from pneumonia, the odds of dying from pneumonia in the group that did not receive oral care was more than three times that of the group that did receive oral care (OR = 3.57, \( p = 0.03 \)). However, the non-randomized controlled trial studies contributed to inconclusive evidence on the association and correlation between oral hygiene and pneumonia or respiratory tract infection in elderly people.

Chemical Intervention

It is not always possible for disabled nursing home residents to brush their teeth or their dentures effectively, hence chemical solutions for removing plaques and disinfecting acrylic resin became an alternative for mechanical oral care in this population. Among these agents, chlorhexidine appeared on the market in mid-1970s for use by individuals undergoing periodontal treatment and dental implant surgery. Chlorhexidine has bactericidal, fungicidal, and some virus-killing properties. When used topically, the N-chlorinated derivative of chlorhexidine binds covalently to proteins in the skin and mucosa and results in a persistent antimicrobial effect with limited systemic absorption, even after an oral ingestion. Compared to other antiseptics, chlorhexidine is superior to Listerine and Meridol in its ability to maintain low plaque scores and gingival health during a 3-week period of no mechanical oral hygiene [51, 52]. Although decreased susceptibility to chlorhexidine has been reported, it has not been convincingly shown to be associated with repeated exposure to chlorhexidine [53]. Oral ingestion of chlorhexidine is usually well tolerated because negligible systemic absorption occurs.

The effectiveness of oral chlorhexidine in reducing respiratory tract infections has been examined in a number of critical care studies with conflicting results [54–58]. The data on chlorhexidine from nursing homes is scarcer and definite evidence is still lacking. Nonetheless, Simons et al. [59] described significant improvement in the stomatological health of nursing home residents following the mastication of chlorhexidine-containing chewing gum twice daily for 12 months compared that of residents who chewed a nonchlorhexidine-containing gum and that of a group that did not chew gum. There were also increased salivary flow rates, stabilized *Streptococcus mutans* and *Lactobacilli* counts, and decreased prevalence of angular cheilitis, denture stomatitis, and denture debris. However, the study did not assess the rate of respiratory infections in the treatment arm nor in the placebo arm. More recently, Watando and coworkers [60] investigated the effects of intensive oral hygiene measures such as dental prophylaxis and chlorhexidine rinses on impaired cough reflex sensitivity, which is a known risk factor for pneumonia. The results of the study showed that cough reflex sensitivity at 30 days in those with intensive oral hygiene measures (intervention) was significantly higher than in the control (no intervention) group. The odds ratio for improvement of cough reflex was 5.3 in the intervention group compared with the control group; however, no significant effect was seen with respect to serum substance P, cognitive function, and activities of daily living. The authors concluded that intensive oral hygiene measures might reduce the incidence of pneumonia by improving cough reflex sensitivity in the elderly. However, pneumonia was not included among the end points. Nonetheless, the result of this study supports the need for oral health-care interventions and indicates that improved oral care may reduce the incidence of pneumonia.

Conclusion

The current review finds strong support for the need to implement a program that uses oral hygiene in the long-term-care setting as part of daily routine. With skyrocketing health-care costs and the increasing incidence of aspiration pneumonia in the aging population, dental hygiene represents an effective cost-saving intervention. Programs to improve oral health-care knowledge and skills, delivered by dental professionals, must be included in the curricula of all nurse-training establishments. In addition, programs for practical training of care assistants in basic oral health care need to be actively promoted in nursing homes. There is also an urgent need for randomized controlled studies to determine the optimal regimen(s) of an oral hygiene program in the prevention of NHAP [61].

References

population of four municipalities in eastern Finland. Am J Epidemiol 137:977–988