

A Literature Review of the Relationship Between Oral Health and
Pneumonia Risk in the Geriatric Nursing Home Population

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Geriatric Nursing Home Population

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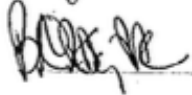
**A Literature Review of the Relationship Between Oral Health and
Pneumonia Risk in the Geriatric Nursing Home Population**

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Approval of the Dissertation

This Dissertation, by Tara M. Swift, CDA, MS has been approved by the committee members below, who recommend it be accepted by the University of Bridgeport, College of Health Sciences in partial fulfillment of requirements for the degree of Doctor of Health Sciences (D.H.Sc.)

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Abstract

Background: Respiratory illness has been concomitant with poor oral health and is particularly prevalent in institutionalized geriatric patients. Historically, there has been a decisive gap in preventive dental health in the nursing home population.

Objective: Poor oral health status in the older population has been linked to an increased pneumonia risk. This review sought to assess the correlation of poor oral health and respiratory illness and the benefits of preventive dental care in the nursing home population. Suitable recommendations for the implementation of preventive oral health care in this population were investigated. *Methods:* A total of 17 peer-reviewed studies and three articles were used to gather evidence for this literature review. Included studies were all peer-reviewed cross-sectional, prospective, interventional, retrospective studies, and cluster-randomized controlled trials. Perspective papers by experts in the field were also included. *Results:* A total of six studies identified poor oral health as a risk factor of pneumonia in nursing homes, while five studies showed the importance of oral contaminant elimination to be effective in reducing pneumonia incidence, and three found oral health education for caregivers to be helpful to reduce pneumonia in this population. However, two intervention studies did not find a significantly lower pneumonia risk with oral health care interventions. *Conclusions:* A positive association between poor oral health in the nursing home population and incidence of respiratory illness was suggested in the findings. Additionally, proper preventive oral care and oral hygiene education for nursing home caregivers is inadequate. Access to professional preventive dental care and an increase of oral health education in long-term care institutions is associated with a decrease in respiratory illnesses from dental disease.

Keywords: Aspiration pneumonia, respiratory illness, oral dysphagia, oral health, nursing home, oral bacteria, periodontal disease, elderly, and geriatric.

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First, I want to thank my guy and love, Lee, for keeping things together for both of us during this chaotic time. I could not have been able to balance everything and complete my degree without you. To my son Rylan, thank you for understanding when I was unavailable to you during the long periods of studying and writing. I strive to show you that anything is possible with hard work and dedication. I would like to thank my Mom, for the encouragement and support to take on this endeavor and to keep going when life challenges you the most.

The inspiration for this dissertation comes from my late grandmother, Violet Sisiam. Her inadequate oral health care in a nursing home coupled with oral dysphagia led to aspiration pneumonia and ultimately her death. Her passing prompted me to research and shine a light on the lack of oral health care in long-term care facilities. I know that she is so proud of my accomplishments.

Definition of Terms

For the purpose of this literature review, the following terms are defined.

AP. Aspiration pneumonia.

BOHSE. Brief oral health status examination.

CAP. Community-acquired pneumonia.

CCI. Charlson comorbidity index.

DMFT OR DMF. Decayed, missing, and filled teeth.

DPs. Dental plaques.

FOP. Frail older patients.

GOHAI. Geriatric oral health assessment index.

HAP. Hospital-acquired pneumonia.

LTCF. Long-term care facility.

MCWB. Mouth care without a battle program.

NHAP. Nursing home acquired pneumonia.

OD. Oropharyngeal dysphagia.

OHAT. Oral health assessment tool.

OHCE. Oral health care education.

OHI-S. Oral hygiene index score.

OHRQoL. Oral health related quality of life.

PEF. Peak expiratory flow.

PI. Plaque index.

POH. Personal oral hygiene.

VFS. Videofluoroscopy.

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A Literature Review of the Relationship Between Oral Health and Pneumonia Risk in the Geriatric Nursing Home Population

The number of older adults has steadily increased over the last century, and by 2035, they will outnumber children in the United States for the first time in history (U.S. Census Bureau, 2018). As of 2016, approximately 1.4 million people lived in long-term care facilities; among the older patients, respiratory illness has been a significant health concern leading to a high mortality rate (Harris-Kojetin et al., 2013). Systemic health conditions, including diabetes, atherosclerotic vascular disease, pulmonary disease, osteoporosis, pregnancy-related conditions, and kidney disease, have been linked to periodontal disease (Kane, 2017). Poor oral health in the nursing home population has been associated with aspiration pneumonia from periodontal bacteria due to inhalation of regurgitated acid and particulate matter (Terpenning et al., 2001; Yoneyama et al., 2002).

The level of oral hygiene significantly impacts the makeup of the oral microbiome. A healthy oral microbiome is characterized by simple flora dominated by gram-positive cocci with some gram-negative cocci. In comparison, those with poor oral health will present with a complex and more diverse flora that has been overtaken by anaerobic gram-negative organisms. The oral cavity is a hostile environment; pathologic bacteria are found in the periodontium, biofilm, and teeth. The presence of periodontal disease perpetuates the capability for multiplication and attachment of pathogens, which has shown a positive unidirectional relationship to pulmonary disease (Kane, 2017).

Chronic lower respiratory disease is among the top three leading causes of death in the United States' 65 and older populations. In long-term care facilities, nosocomial infections are the second most common (Harris-Kojetin et al., 2013). Investigations into the role of oral

pathogens and causation of pneumonia did not begin until the 1970s but were suspected since the beginning of the 20th century (Bartlett & Gorbach as cited by Awano et al., 2008).

This paper is focused on the high mortality rate associated with pneumonia in the geriatric nursing home population due to poor oral health (Terpenning et al., 2001; Yoneyama et al., 2002). The poor oral status of nursing home residents with an increased risk of mortality from pneumonia is significant. The efficacy of preventive oral care is also discussed in this paper because poor oral hygiene is linked to pneumonia. Insufficient daily oral health care and lack of access to professional dental care have been associated with poor oral health in older people who are institutionalized (Gaszynska et al., 2014).

History

In the 1920s, Dr. Smith studied lung abscess and found that about one-third of patients died from this infection. Autopsies revealed that bacteria found in patients' lung walls resembled microorganisms found in the gingival crevice, leading Smith to believe that oral bacteria aspiration was a conduit of infection (Bartlett, 2005). In more recent studies, the relationship between poor oral health and a high risk of respiratory illness has been well-established. Most notably, Bartlett et al. (1974) discovered the crucial pathogenic role of anaerobes in pulmonary infections following aspiration. Some recent studies have shown that respiratory pathogens in the oral cavity are responsible for aspiration pneumonia in older institutionalized adults.

Although these studies have generated additional research in this area, much work is still needed to reduce the risk of pneumonia mortality by closing the decisive gap in preventive dental care in the nursing home population. In the existing literature, several studies signify the association between oral health and pneumonia risk factors in older people (El-Solh et al., 2004; Hong et al., 2017; Ortega et al., 2014; Ortega et al., 2015; Linuma et al., 2015; Nishizawa et al.,

2019;). Furthermore, many studies showed that preventive dental care reduces pneumonia incidence (Gaszynska et al., 2014; Hollar et al., 2017; Ikeda et al., 2014; Izumi et al., 2016; Juthani-Mehta et al., 2014; Takeuchi et al., 2019). The findings from the literature confirm the relevance of this paper.

Statement of the Problem

Researchers have continued to show a significant correlation between poor oral health and systemic health diseases. Nursing home acquired pneumonia (NHAP) is currently the most common infection among patients. Among all conditions found in nursing home patients, NHAP is linked to substantial morbidity and mortality rates. Pneumonia incidence is ten times greater in nursing home patients (Lee et al., 2013). Evidence has suggested that oral care reduces the risk of pneumonia; however, little has been done about preventive oral health programs in nursing homes. Theoretically, enacting preventive oral health programs and increasing access to care would decrease the risk of pneumonia and lower mortality rates for older people in long-term care facilities.

Purpose of the Study

The purpose of this review is to examine the relationships among oral health status of older people, pneumonia risk, and the benefits of preventive dental care for the nursing home population. Recommendations for the implementation of oral health care in this population will be discussed. Peer-reviewed research studies concerning oral biome health concerning respiratory illness (pneumonia) published after 2011 were considered for this review. One notable study published before 2011 was included for historical perspective. For this review, all populations were excluded except people over 65 years old in institutionalized health care facilities.

Research Questions

The primary objective of this review is to determine if preventive oral health interventions effectively reduce pneumonia mortality in the older nursing home population. In this review, the impact of oral bacteria and the effectiveness of various therapies and interventions are analyzed.

The specific questions guiding this review are as follows:

- (1) What is the association between respiratory illness and poor oral hygiene in the nursing home population?
- (2) What is the relationship between oral health care and prevention of respiratory illness in the nursing home population.
- (3) Can implementing oral health education programs for care staff reduce respiratory illness in the nursing home population?

Literature Review

Oral Health and Respiratory Illness

In the population aged over 65 and under nursing care, a significant health concern exists for respiratory illnesses correlated with oral health (Ebihara et al., 2016; El-Solh et al., 2004; Hong et al., 2017; Ortega et al., 2014; Ortega et al., 2015; Linuma et al., 2015; Takeuchi et al., 2019). Pneumonia in older nursing home patients continues to be an ongoing global health problem and is linked to a high mortality rate (Juthani-Mehta et al., 2014).

El-Solh et al. (2004) performed the first investigation to confirm the association between colonization of dental plaques (DPs) and respiratory illness using an observational study of 49 older, institutionalized patients. Using molecular genotyping, lower respiratory tract infection due to DP colonization was investigated in older hospitalized nursing home patients who

required mechanical ventilation. Favorable conditions and proliferation of DPs can be seen for those with a declined activity of daily living (ADL), lack of oral hygiene, and xerostomia (El-Solh et al., 2004).

Researchers identified 33 pathogens from the DPs after the dental assessment of the study participants. A dental evaluation was performed in the intensive care unit on the first day of admission. Plaque index scores were taken on six teeth to characterize oral health status. The debris found around and between teeth is the measure for the plaque index (PI) score. Using a PI score ranging from 0 to 3, teeth or dentures were sampled (El-Solh et al., 2004).

Suspected pneumonia was based upon radiographic evidence and two or more of the following criteria: (a) a temperature of $> 38^{\circ}\text{C}$ or $< 35.5^{\circ}\text{C}$, (b) purulent endotracheal aspirates, (c) a WBC count of $> 12,000$ cells/ μL , and/or (d) left shift or leukopenia of $< 3,000$ cells/ μL .

Pneumonia cases were confirmed by radiographic evidence and daily observation for hospital-acquired pneumonia (HAP). A higher incidence of HAP was seen in patients with more teeth than those with dentures. Colonization of respiratory pathogens was less frequent in denture-wearing patients than in those who did not wear dentures (El-Solh et al., 2004).

The prevalence of aerobic respiratory pathogens that colonize with DPs promotes a higher risk for pneumonia, especially in critically ill older patients. The majority of DP colonization by respiratory pathogens include *Staphylococcus aureus* and gram-negative enteric bacilli, which can act as a catalyst for HAP in geriatric hospitalized patients. The only limitation of this study was the small sample size, which could lead to incorrect inferences and less extrapolation of the findings (El-Solh et al., 2004).

Data in this study was consistent with other similar studies showing the connection between poor oral health and increased pneumonia incidence. Additionally, the sampling

technique used to measure bacterial aerobic and anaerobic plaque colonization was a valid method consistent with previous studies. El-Solh et al. (2004) used a more stringent definition and cut-off value for site plaque, and thus, they were more likely to find the bacterial DP ecosystem equilibrium than other studies. The inference is that these results hold a more substantial internal validity than previously reported research. This study was the first to confirm the relationship between lower respiratory infection and DP colonization in this population of institutionalized patients using molecular genotyping (El-Solh et al., 2004).

Geriatric nursing home staff provide little assistance with oral hygiene, and thus, controlling oral bacteria on teeth and dentures is a challenge. At the time of this study, the authors advocated for increased access to dental care for older adults, which persists today. More research is needed to study the causal relationship between respiratory events and dental disease (El-Solh et al., 2004).

Respiratory pathogens associated with the colonization of pre-existing oral bacteria are likely the primary conduit through direct aspiration for respiratory infections. (Hong et al., 2017; Ortega et al., 2014; Ortega et al., 2015). Hong et al. (2017) examined the prevalence of pre-existing oral bacteria and oral health status of older patients in long-term health care and the correlation of oral bacteria with pneumonia development. They included 60 geriatric patients with an average age of 64.2 years ($SD = 14.1$) in a 12-month longitudinal study residing in a long-term care facility in Singapore (Hong et al., 2017).

Data were collected using several methods. A team member performed oral examinations and took the following measures: (a) the number of decayed, missing, and filled teeth (DMFT); (b) periodontal health status using the Debris Index; (c) and Calculus Index and Simplified Oral Health Index (OHI-S). Classification of the Debris Index range of 0-3, with 3 representing the

maximum score whereby two-thirds of an exposed tooth surface is covered in soft debris. Calculus Index, ranging between 0-3 with 3 representing supragingival calculus on two-thirds of an exposed tooth or a continuous heavy band of calculus and subgingival around the cervical portion of the tooth or both are present. The Debris Index and Calculus Index scores from six teeth represented the OHI-S score. Study participants with OHI-S scores from 3 to 6 were considered as having poor oral hygiene (Hong et al., 2017).

Baseline oral samples were taken from the tongue and teeth using an oral swab (Omniswab) and retaken at the time of pneumonia diagnosis. Dentulous patients had samples taken from the buccal and lingual tooth surfaces and the tongue, while edentulous patients only had samples taken from the tongue. The dorsal side of the tongue was swabbed from posterior to anterior, using ten strokes. Sputum samples were also taken via patient rinsing or by suction tube (Hong et al., 2017).

Institution diagnosis of pneumonia was made using the following protocol. The patient must be positive for two or more of the following symptoms: (a) new or worsening cough, (b) temperature $>38^{\circ}\text{C}$, (c) newly purulent sputum, (d) tachycardia, (e) respiratory rate of more than 25 breaths/min, (f) decline in cognitive or functional status, (g) new or worsening hypoxia, and (h) physical findings on chest examination that are consistent with leukocytosis and chest infection. At the time of examination, tracheostomy tube and nasogastric feeding tube presence were noted (Hong et al., 2017).

Polymerase chain reaction (PCR) was used to examine the sputum samples, tongue biofilm, and plaque for respiratory pathogens (*Haemophilus influenzae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Staphylococcus aureus*, and *Streptococcus pneumoniae*). These pathogens are significantly linked to respiratory illness (Hong et al., 2017).

The diagnoses of patients at the time of admittance were grouped into two major categories: neurology-related (40%) or cardiovascular-related (25%). During the study, seven (11%) of participants passed away. Two of these deaths were pneumonia-related. The majority of these study participants were male (53.3%, $n = 32$; Hong et al., 2017).

Regarding oral hygiene, the DMFT overall mean was 22.8 ($SD = 9.2$, $n = 60$), and the overall DFT mean excluding missing teeth was 3.6 ($SD = 4.7$, $n = 32$). Completely edentulous individuals made up about 26.7% ($n = 16$) of the study population. Dependent older patients with teeth ($n = 42$) had a mean OHI-S of 4.0 ($SD = 1.0$), and there were eight that were considered to have fair or good oral hygiene ($OHI-S \leq 3.0$; Hong et al., 2017).

The researchers in this study recommend culturing the respiratory organisms in the future to determine sensitivity to antimicrobial agents. The PCR technique alone is a reliable method due to specificity and sensitivity. However, this study did not include culturing the chosen organisms in addition to the PCR technique and is a potential limitation (Hong et al., 2017).

The potential hierarchal importance of tongue colonization over plaque colonization in developing pneumonia was a significant outcome. The findings showed the prevalence and types of organisms found in the oral cavity of older ill patients. Eradicating specific oral bacteria can be done by removing tongue biofilm and is critical for reducing pneumonia mortality in this population (Hong et al., 2017).

A significant correlation between the use of a nasogastric feeding tube and elevated development of pneumonia was found. Calculus index and tongue colonization count also showed a strong association and higher risk of pneumonia in geriatric patients. However, future studies are needed to identify specific bacterial species to reduce developing pneumonia from the

oral microbiota. Mechanical removal of calculus and tongue biofilm is recommended for geriatric nursing home residents (Hong et al., 2017).

Oral health is greatly affected by the type and quantity of microbiota aspirate, which increases the risk of aspiration pneumonia (Ebihara et al., 2016; Ortega et al., 2014; Ortega et al., 2015). Oral biofilm is colonized by commensal microflora in healthy mouths and acts as a barrier against respiratory pathogen colonization. Conversely, pathogenic population growth and the change in the number of gram-negative microorganisms are associated with poor oral health in patients with caries and periodontal disease (Ortega et al., 2014).

Ortega et al. (2014) provided evidence of aspiration pneumonia due to impaired swallowing function attributed to bacterial colonization of oral secretions. They studied 50 older patients ($M = 79.7$ years, $SD = 6.6$) with oropharyngeal dysphagia (OD) and 15 older patients ($M = 77.0$ years, $SD = 4.5$) without OD over four months. Inclusion criteria were patients who had difficulty swallowing associated with neurological diseases or aging and were aged 70 and older. Baseline data for all participants were using a questionnaire, the Eating Assessment Tool (EAT-10), to evaluate dysphagia symptom severity. To assess health status and comorbidities, the Charlson Comorbidity Index (CCI) was administered. Videofluoroscopy (VFS) was used to evaluate those with swallowing complaints. The Penetration-Aspiration Scale classified VFS signs of impaired safety. Oral hygiene assessment included OHI-S, the DI (DI-S, dental plaque), and the Calculus Index (CI-S mineralized debris). Values of DI-S and CI-S range from 0-3; OHI-S values range from 0-6. Dental caries were measured by the percentage of teeth and surfaces affected (Ortega et al., 2014).

The development of oral dysphagia after a stroke is strongly correlated with aspiration pneumonia. The CCI scores were much higher in the OD group than the control group in this

study. Poor oral hygiene was detected in each study participant. Older OD patients were at significant risk of developing aspiration pneumonia when presenting with VFS signs of impaired safety of swallow, impaired health status with comorbidities and poly-medication, and poor oral health status with a high incidence of caries and periodontal disease.

The development of community-acquired pneumonia and respiratory tract infections in older patients is strongly related to immune function in the oral cavity. Oral dysphagia is an independent risk factor for respiratory illness in this population due to periodontal pathogens present in the oral cavity (Ortega et al., 2014).

There are several strengths to Ortega et al.'s study. The study design, observational-transversal, is optimal to examine the associations proposed by the researchers effectively. The study was the first in which researchers investigated older dysphagic patients' oral health status. The oral health and dysphagia assessments and questionnaires used were valid methods of measurement. Moreover, other studies have shown poor oral health to be associated with aspiration pneumonia incidence, severity, and mortality in the geriatric population (Ebihara et al., 2016; El-Solh et al., 2004; Hong et al., 2017; Nishizawa et al., 2019; Ortega et al., 2015).

The internal validity of the results could have been compromised by misreporting information on the questionnaires leading to information bias. Thus, loss of validity could be a weakness. The researchers did not perform a chewing assessment as a part of this study; chewing could be more causative to aspiration pneumonia due to difficulty chewing, leading to swallowing issues (Ortega et al., 2014).

To reduce the risk of aspiration pneumonia in the older population, these researchers suggested comprehensive oral hygiene programs. Reducing pneumonia leads to reduced morbidity and mortality in older long-term care patients. Identifying patients with OD with early

screening, routine oral examines, and chewing assessments could improve aspiration pneumonia risk (Ortega et al., 2014).

Bacterial oral pathogens have been recognized as a causative factor in aspiration pneumonia in frail older nursing home residents. In this study, the oral microbiota of patients with OD and the potential for aspiration pneumonia was investigated (Ortega et al., 2015). In a nine-month prospective, observational, transversal study, Ortega et al. (2015) assessed the colonization of respiratory pathogens in the oral cavity of 61 frail older patients (FOP) with oropharyngeal dysphagia.

Study participants were aged 70 or older and were recruited with the FOP phenotypes with OD. Three groups of participants comprised the study; one group was the designated control with participants without OD. Seventeen patients presented with acute pneumonia (APN), 15 were prior pneumonia patients, and the controls consisted of 14 patients without OD. Consistent with Ortega et al. (2014), these authors used the diagnosis criteria for pneumonia, clinical assessment of OD, videofluoroscopy, oral health assessment, and oral and nasal microbiota sampling for their study. Additional assessments included: (a) frailty with the Fried criteria, (b) functional capacity according to the Barthel Index (BI), (c) Body Mass Index (BMI), (d) nutritional status using the Mini Nutritional Assessment (MNA-SF), and (e) muscular force measured with a handgrip dynamometer (Ortega et al., 2015).

In both studies by Ortega et al. (2014, 2015), colonization of respiratory pathogens was highest among those with OD and was likely causative in aspiration pneumonia (AP) in the geriatric nursing home population. Other key factors contributing to AP in the older adults included OD with impaired safety to swallow with aspiration, impaired health status, and oral colonization of respiratory pathogens. The researchers' findings suggested that OD and

aspiration in older patients commonly lead to pneumonia caused by aspiration. In combination with OD, impaired health status and low functionality led to increased mortality (Ortega et al., 2015).

Consistent with other research on this topic, the findings suggested that respiratory pathogens colonized in the oral cavity are a critical factor in geriatric patients' pneumonia (Ortega et al., 2015). Consistent with Ortega et al.'s (2015) findings, two other studies also found that older patients with OD and aspiration are much more susceptible to pneumonia. Most pneumonia cases in older patients are caused by aspiration (Ortega et al., 2015).

Interestingly, nasal or nasopharyngeal sites, which are known as prime sites for colonization of respiratory pathogens, were less prevalent than in oral colonization. This result is due to poor oral hygiene, poor nutritional status, and low clearance of pathogens through impaired salivary function, which causes oral colonization (Ortega et al., 2015).

Fundamentally, AP is initiated by dysphagia and chronic repeated aspiration, leading to chronic inflammation (Ebihara et al., 2016). Impaired health status, age, OD, and colonization by respiratory pathogens make patients vulnerable to AP and other respiratory infections (Ortega et al., 2015). The management and standardization of oral health care in nursing homes and hospitals is needed. OD is a relevant and common risk factor in AP, and geriatric patients who had OD and AP had a high readmission rate. Dysphagia screening protocols are suggested along with professional dental care (Ortega et al., 2015).

Wearing dentures during sleep is associated with a higher risk of aspiration pneumonia in older adults. Poor oral health is recognized as a predisposing factor for increased oral pathogens and is a mechanism for aspiration-inducing pneumonia (Linuma et al., 2015). Linuma et al. (2015) performed an ongoing prospective survey using the Tokyo Oldest Survey on Total Health

(TOOTH). They randomly recruited 524 participants aged 85 and over who were living in Tokyo, Japan. Of these participants, the study included 228 males and 296 females. The associations between oral health behaviors and pneumonia in a geriatric community were investigated over three years. Follow-up procedures were conducted every 12 months by telephone or mail survey, and at 36 months, participants were re-examined using the same baseline methods (Linuma et al., 2015).

Oral health and medical assessments for this cohort included (a) face-to-face interviews, (b) oral health-related quality of life, (OHRQoL), (c) geriatric oral health assessment index (GOHAI), (d) dental examination using the Ambjornsen Denture Plaque Index and tongue scrapings, (e) physical functional status or BI, (f) cognitive function Mini-Mental State Examination, and (g) non-fasting blood samples were taken along with plasma concentrations. A severe pneumonia event was the outcome of interest and characterized as first hospitalization or death from pneumonia (Linuma et al., 2015).

Baseline data of denture habits and oral status concerning systemic conditions were assessed. Positive cultures for *Candida albicans* were more likely in those who wore dentures during sleep than those who did not. Those wearing dentures during sleep consequently had a higher incidence of denture plaque, tongue biofilm, higher circulating plasma levels of interleukin-6, and gum inflammation (Linuma et al., 2015).

Older individuals with swallowing difficulties and habitual wearing of dentures during sleep were more likely to develop pneumonia – at 2.3-fold higher risk – than those with AP risk factors other than wearing dentures overnight. Poor dental hygiene was also associated with wearing dentures during sleep and a high risk of pneumonia (Linuma et al., 2015).

The microbial load and inflammatory burden in the oral cavity provide a causal link between the incidence of pneumonia and wearing dentures during sleep. As a causative factor in aspiration pneumonia, overnight denture wearing could be an important marker for identifying an individual's risk for pneumonia in a nursing home setting. Medical and dental professionals' recommendations and guidelines advocate for removing a dental prosthesis for sleep (Linuma et al., 2015).

Linuma et al.'s (2015) results are consistent with other research in this area and showed a significant correlation between serious pneumonia events and wearing dentures during sleep. Outcomes in similar studies found that patients wearing a denture during sleep had a high risk of incident pneumonia. These outcomes lend support to the need to design effective oral health programs for older patients in community-health settings and are strengths of this study (Linuma et al., 2015).

The reliance on acute hospitalization or deaths from pneumonia as measures could underestimate pneumonia incidence and is a limitation for this study. The study included older adults living in Tokyo and may not be generalizable to other populations. The participants' ages may also be a limitation due to the inclusion of older patients who may have more comorbidities than younger seniors (Linuma et al., 2015).

Takeuchi et al. (2019) examined denture wearing as moderating the risk of aspiration pneumonia in nursing home residents. In a 1-year cohort follow-up study, nursing home medical records were obtained on pneumonia incidence. After exclusion, 156 residents who were over 70 years old from eight nursing homes in Aso City, Kumamoto Prefecture, Japan, were included in this study (Takeuchi et al., 2019).

Clinical oral health examinations, plaque index scores, aspiration risk screening using the modified water swallowing test, body mass index, the CCI, and ADLs with the BI were used as baseline characteristics. Based on the BI scores (0-100), participants were divided into two groups; those with scores greater than 60 indicating higher independence for basic ADL and those with scores less than 60 demonstrating lower independence for basic ADL. The patients were placed into three groups: non-aspiration risk, aspiration risk, and aspiration risk without denture wearing (Takeuchi et al., 2019).

There was a significant positive association between the risk of aspiration and the risk for pneumonia. However, residents who wore dentures even with a risk of aspiration did not have a significantly higher pneumonia incidence. Unlike the patients in the Linuma et al. (2015) study, the participants in this study (99.2%) removed and cleaned their dentures each night, mitigating denture plaques and oral biofilm. When worn as recommended, dentures can preserve the natural oral and pharyngeal anatomy, reducing the impact on chewing and swallowing function, diminishing the risk of aspiration (Takeuchi et al., 2019).

The prospective cohort design is a strength of this study. Takeuchi et al. (2019) were the first to show an association between denture wearing and a lower incidence of aspiration pneumonia in the institutionalized geriatric population (Takeuchi et al., 2019). The study limitations included a small sample of the older people in Japan and may not be generalizable to all nursing home populations. Even with careful control of potential confounders, some residual confounding may have occurred (Takeuchi et al., 2019).

Recommendations from these researchers included nursing home staff and dental providers' awareness of pneumonia risk for those with few teeth, and intensified public health

efforts regarding the importance of denture wearing and the prevention of aspiration to reduce pneumonia incidence (Takeuchi et al., 2019).

The Relationship of Oral Health Care and Prevention of Respiratory Illness

Ikeda et al. (2014) investigated oral care in institutionalized geriatric patients and the effective elimination of oral contaminants. They found that displaced contaminants remain in the mouth after removing dental plaque and food debris. For those with weak airway protection, these contaminants can be aspirated into the lower airway if not adequately removed after mechanical oral care (Ikeda et al., 2014). Their study participants included 31 institutionalized individuals with a mean age of 69.9 ($SD = 15.1$). This prospective cross-over study was conducted over five months in Japan (Ikeda et al., 2014).

Participants were selected if they were unable to brush their teeth properly. BI was used to assess physical function, including ten essential mobility and self-care activity functions. Other participant evaluation criteria were the number of teeth, denture use, comorbidities, diet status, and medications. Mechanical cleaning of teeth protocol was performed, and then procedures for eliminating contaminants were employed. Two elimination procedures included rinsing with 30 mL of tap water from an irrigating syringe, rinsed and suctioned via an oral suction handle, and wiping the entire oral cavity, including gums and teeth, palate, and tongue with an oral care mouth wipe. The procedures mentioned above were performed at least 24 hours apart and on different days on each patient. Measurements of oral bacteria were taken before oral care, immediately following oral care, and 1 hour after oral care (Ikeda et al., 2014).

Findings suggested a significant decrease in bacteria in the mouth when rinsing or wiping after oral care. For patients who cannot rinse, mouth wipes were as successful as rinsing to

decrease oral microbes. Elimination of oral bacteria can reduce aspiration pneumonia incidence in this population (Ikeda et al., 2014).

Xerostomia was not assessed in this study. Many participants likely had some dry mouth due to medications and comorbidities, which could be a limitation to this study. The participants' oral conditions differed and could have affected the results of oral care and elimination methods (Ikeda et al., 2014).

The strict established procedure for measuring dental plaque biofilm and food debris was a strength of this study. The use of two elimination methods of oral care for the same patients lent credibility to the findings and most likely reduced xerostomia's influence across the cohort (Ikeda et al., 2014). Daily oral hygiene by a health caretaker was critical to reducing oral biofilm and can help prevent respiratory illnesses. Elimination of contaminants after oral care is emphasized in this study to minimize aspiration pneumonia incidence (Ikeda et al., 2014).

Reducing the mortality rate from pneumonia in senior care facilities in Japan by incorporating tongue cleaning into daily oral care was investigated. Coughing ability is closely associated with the tongue and oral biofilm ingestion with poor coughing reflex (Izumi et al., 2016). Earlier studies were done using similar methods. These studies found that preventive oral care in older Japanese institutionalized residents leads to a lower incidence of aspiration pneumonia (Adachi et al., 2002 and Yoneyama et al., 1999, as cited in Izumi et al., 2016).

In this randomized controlled trial, 109 geriatric patients more than 65 years old participated in a 4-week trial period. After attrition for various reasons, there was a total of 96 participants in this study. The intervention group ($n = 52$) underwent routine oral care with tongue cleaning, and the control group ($n = 44$) continued with regular oral care without the intervention. Peak expiratory flow (PEF) was used to measure participant coughing ability. A

standardized interview questionnaire was given for demographic information, and the BI measured basic daily living activities (Izumi et al., 2016).

After the 4-week study period, tongue cleaning led to an improvement in coughing as there was a significant increase in PFE in the intervention group. Additionally, the ability to sufficiently cough to clear the airway was shown to reduce the incidence of aspiration pneumonia. Several research groups have reported prevention of aspiration pneumonia with oral care, thereby decreasing pathogenic organisms to improve swallowing and eating function in older patients (Adachi et al. 2002; Yoneyama et al., 1999; Yoneyama et al., 2002; Ishikawa et al., 2008, as cited in Izumi et al., 2016).

Follow-up with the participants commenced after three months and at the end of the study to evaluate sustained effects of the intervention. Continued PEF values in the intervention group were significantly lower at three months than at the end of the study period. The decline in PEF values at the follow-up shows the importance of continued tongue cleaning to improve coughing ability and prevent aspiration pneumonia (Izumi et al., 2016).

A possible limitation in the study was the use of PEF measurements to evaluate coughing ability instead of peak cough flow (PCF). However, in many other studies, PEF has been reported as equivalent in validity to PCF. Coughing ability evaluated in the study using PEF was considered sufficient. Moreover, the evaluation of swallowing and eating functions was also measured by PEF. Measurement by PEF was deemed useful in this context, although the gold standard is video endoscopy and VFS. The daily oral care and intervention protocols may have been strictly adhered to during the study but less so afterward, which could account for the steep decline at follow-up for the intervention group (Izumi et al., 2016).

The findings are consistent with prior research done on this topic and support the validity of this study. Randomization of the participants could also eliminate selection bias and possible confounders (Izumi et al., 2016). The incorporation of tongue cleaning, in addition to routine oral hygiene, is highly recommended for the prevention of aspiration pneumonia. Improved coughing ability resulting from tongue cleaning could be a likely outcome (Izumi et al., 2016).

A prospective cohort study of 62 geriatric patients hospitalized between June 2017 and May 2018 with confirmed pneumonia diagnosis was investigated. Micro aspiration in older patients occurs daily with the reduction of swallow and cough function, with over 70% of the pneumonia cases in Japan reported AP. Patients were assigned to one of three groups: community-acquired pneumonia (CAP), AP, or control group. The Oral Health Assessment Tool (OHAT) was used to determine oral health status and oral bacteria count (Nishizawa et al., 2019).

Study participants with swallowing disorders, neurological disorders, and cerebrovascular disorders were at a higher risk for AP. When examining the OHAT scores, the AP group had the highest scores ranging between 4-7, indicating oral health was the worst among the AP group. Additionally, upon admission to the hospital, oral bacteria count in the AP group ($M = 7.2, SD = 0.1$) was significantly higher than the CAP group ($M = 6.9, SD = 0.1$) and is reflected in the OHAT scores. Oral health protocol included toothbrushing and sponge brushing by nurses, or self-supporting patients reported their oral hygiene routine (Nishizawa et al., 2019).

Bacteria counts were taken pre-and post-oral care in both the CAP and AP groups, and there was a significant decrease in bacterial counts after oral care for both patient groups.

Patients receiving or administering oral care with APN showed substantial improvement and

reduced aspiration pneumonia incidence. The findings suggest that oral care for APN patients should be provided to prevent AP in geriatric patients. (Nishizawa et al., 2019).

There were some limitations to this study. This design included a non-intervention method and may not be useful in examining the effect of reducing AP. A small sample is also not ideal for generalizing the study findings (Nishizawa et al., 2019).

The use of OHAT is a widely used and highly valued tool in the swallowing rehabilitation field. This study is the first to use this instrument to assess oral health as a causative factor of pneumonia. With a high diagnostic value, the use of OHAT increases the power of the findings in this study (Nishizawa et al., 2019).

In a 2014 cluster-randomized controlled trial, multicomponent interventions were assessed to prevent pneumonia in geriatric nursing home residents. In 36 nursing homes throughout Connecticut, 834 residents aged 65 years and older were recruited. Outcomes were documented at 2.5 years, including lower respiratory tract infection without radiographic documentation and radiographically documented pneumonia (Juthani-Mehta et al., 2014).

Screening procedures included swallowing difficulty and oral hygiene using plaque scores greater than 1. Homes in which staff spent less than 140 minutes per day with patients were considered low stratum, and those homes where staff give more than 140 minutes of aide time per day were considered high stratum. Participants were randomly assigned to each stratum. The intervention protocol included manual tooth and gum brushing and 0.12% oral chlorhexidine rinse given twice per day. Additionally, an upright feeding position was employed in the protocol. Participants in homes assigned to the control arm continued with usual oral care. Intervention patients ($n = 434$) and control patients ($n = 400$) were included in the target sample. There were no significant differences between groups at baseline (Juthani-Mehta et al., 2014).

At the culmination of this study, there was no significant reduction in the first incidence of radiographically confirmed pneumonia with the multicomponent intervention protocol implementation. Because there was no significant decrease in the first pneumonia incidence rate, the study was terminated (Juthani-Mehta et al., 2014).

The researchers noted that staff did not effectively adhere to the intervention protocol, which may have increased the risk of pneumonia. The control group's usual care could have been improved to mimic the intervention group closely. The study participants' microbiota could have changed during the study period and impacted the results (Juthani-Mehta et al., 2014).

This study design included a large cohort of older nursing home patients, which allows for examination of multiple outcomes and pneumonia incidence over time. The determination of a primary outcome of pneumonia was rigorous, with radiographic confirmation necessary to document an episode. The rigor is consistent with high validity in supporting the findings (Juthani-Mehta et al., 2014). Essential strategies for maintaining oral health in geriatric residents include an upright feeding position, clinically indicated use of chlorhexidine, and toothbrushing. Further investigation is suggested to initiate other innovative strategies to reduce respiratory illness (Juthani-Mehta et al., 2014).

Results similar to Juthani-Mehta et al. (2014) were found in an intervention study, Hollaar et al. (2017) using a daily application of 0.05% of chlorhexidine to reduce the incidence of AP. The participants were aged 65 years and older in The Netherlands nursing homes. After exclusion criteria were applied, 103 patients from 17 nursing homes were selected. Nursing home residents with dysphagia and pneumonia were the targeted population for this multicenter cluster controlled clinical trial (Hollaar et al., 2017). Baseline data collected from medical records included dysphagia function oral intake scale (FIOs-level 1 to 6), gender, age, medical

diagnosis, and medications. Oral examinations and Care Dependency Scale values were also included in the initial assessment (Hollaar et al., 2017).

The intervention involved twice daily application of a 0.05% chlorhexidine-containing oral rinse solution directly after usual oral care. Depending on the severity of dysphagia, participants either rinsed for 30 seconds or wiped tongue, gums, palate, teeth, and buccal mucosa with a gauze soaked in the same solution (Hollaar et al., 2017).

Of the 103 participants, the intervention group contained ($n = 52$) with 41 participants in the rinse group and 11 in the gauze group. The control group had 51 participants. Most of the participants were edentulous (68%), and 93% wore complete dentures. Twenty-four individuals dropped out before study completion: 23 in the intervention group and one in the control group. After the study, 48% ($n = 49$) of the participants continued and were monitored throughout the entire study period (Hollaar et al., 2017).

Diagnosis of pneumonia occurred in 26 (25%) of participants, 12 in the intervention group and 14 in the control group. Of those with confirmed pneumonia diagnosis, 15 died because of pneumonia. More participants died of pneumonia in the intervention group ($n = 8$) than in the control group ($n = 7$). There was no significant difference in pneumonia incidence between the two groups (Hollaar et al., 2017).

Although Hollaar et al. (2017) and Juthani-Mehta et al. (2014) did not find a significant reduction in pneumonia risk for patients aged 65 and older, the researchers did not use the same chlorhexidine solution percentages; they used 0.12% and 0.05%, respectively. The researchers in these two studies used a lower percentage of chlorhexidine than Sharif-Abdullah et al. (2016), who performed a similar study with a high percentage solution, i.e., 0.2% oral rinse.

There are limitations to this study. First, sufficient power was not achieved because there was an inadequate sample size. The lack of participants could be why a significant effect was not seen after using the chlorhexidine rinse. Attrition due to the study population comorbidities and the risk of dying is significant, affecting the sample population (Hollaar et al., 2017).

The length of the study and the inclusion of multiple nursing homes are strengths. The study is also the first reported to investigate the use and effect of a 0.05% chlorhexidine oral rinse solution on reducing nursing home residents with dysphagia incidence of pneumonia. Juthani-Mehta et al. (2015) had similar findings in a study of 834 nursing home residents with an intervention of a 0.12% chlorhexidine oral rinse and did not find a decrease in pneumonia. Hollaar et al. (2017) recommend more studies to investigate effective interventions to establish comprehensive oral health protocol. With a standardized protocol, researchers might find ways to reduce the incidence of aspiration pneumonia in nursing home residents (Hollaar et al., 2017).

Inclusion in this randomized clinical trial included; admission to the geriatric unit, patients aged 65 years and older who were edentulous or without dentures, and functional impairment. The intervention group received chlorhexidine 0.2% mouth wash while the control group received thymol gargle. Nurses provided oral care for seven days with the assigned solution. An oral cavity assessment was done before each oral care session, using the Brief Oral Health Status Exam form. Nurses analyzed patients' records to develop AP during the study period (Sharif-Abdullah et al., 2016).

There were 90 patients selected at the onset, and after attrition, 78 remained for the final analysis. Patients in the intervention group had a mean age of 81.2 years, while those in the control group averaged 79.9 years. The groups were comparable at baseline, with no significant difference between clinical, microbiology, and demographics (Sharif-Abdullah et al., 2016).

At the study conclusion, the oral colony count in the chlorhexidine group was reduced significantly after oral care. The majority of patients (74.4%) of patients in the intervention group showed oral colonization improvement from the baseline results. There was no significant reduction in colonization with thymol, 20.0% had 50-200 colonies, and 25.7% of patients had less than 50 reported at post-oral care. The patients that received routine oral care with thymol had close to a three-fold risk of oral colonization development than the intervention group. Chlorhexidine (0.2%) mouthwash effectively removed oral biofilm in geriatric patients (Sharif-Abdullah et al., 2016).

Consistent with other studies, at baseline, both groups had high counts of oral microbial colonization. The present study results are supported by previous research on chlorhexidine's benefits, reducing colonization in the oral cavity. Additionally, the random allocation of the two solutions eliminated some confounders and bias, and successful blinding procedures are added strengths of this research (Sharif-Abdullah et al., 2016).

Chlorhexidine use in oral hygiene and the prevention of aspiration pneumonia could not be firmly concluded. The study was short duration and contained a small sample size, which are limitations. Replication in other institutions and for a more extended period is recommended to validate findings (Sharif-Abdullah et al., 2016).

There is a 1.96 to 10 times higher pneumonia hospitalization risk for nursing home elders than those living in the community. Poor oral status induces an increased risk of developing pneumonia in this population, especially in the critically ill. Professional oral care intervention (POCI) was implemented for geriatric nursing home residents who were 74 years and older. Bacterial concentrations and distributions of *Staphylococcus aureus* found in saliva and sputum,

along with pneumonia hospitalization rates before and after the intervention, were assessed (Chiang et al., 2020).

This quasi-experimental study was conducted between August 2015 and December 2017 and included participants from two nursing homes in Taiwan. A total of 44 patients were included, with 28 in the intervention group and 16 in the control group. Baseline data information was collected through medical records of pneumonia history, standardized questionnaire survey, oral health examination, and sputum and salivary samples. The oral health assessment data were collected using plaque index (PI), tongue coating index (TCI), and gingival index (GI) scores (Chiang et al., 2020).

Usual oral hygiene was performed on the intervention group regularly, once, or twice daily, with foam swabs or a toothbrush with the addition of POCI by a hygienist one time per week for three months. The POCI included salivary gland massage, facial muscle massage, soft tissue cleaning, mouth rinse solutions containing chlorhexidine, and toothbrushing. Oral health education was provided to caregivers and family members. The study period for the intervention group ended after one year, at which the same POCI routine was implemented for the control group (Chiang et al., 2020).

After attrition, the final analysis included 25 participants in the intervention group and 16 participants in the control group. The researchers concluded that significant decreases in PI, TCI, and GI were seen after POCI was completed compared to the control group. Bacterial concentrations in the intervention group also showed significantly lower levels in salivary and sputum samples. Slower increases in bacterial concentrations were seen after POCI than in the control group. Furthermore, *Staphylococcus aureus* distributions in 24 randomly selected colonies were significantly decreased after POCI. Evidence of POCI effectiveness was realized

in the sharp decrease in pneumonia hospitalization rates annually for the intervention group. Duration of hospitalization was not significantly affected by POCI (Chiang et al., 2020).

The study demonstrated the effectiveness of POCI implementation in reducing pneumonia incidence in the geriatric nursing home population. These results concur with many previous oral health care intervention studies showing a decrease in oral bacterial colonization and pneumonia mortality rates in nursing home residents and is a strength of this study (Adachi et al., 2002; Juthani-Mehta et al., 2014; Yoneyama et al., 2002, as cited in Chiang et al., 2020).

There were, however, some limitations. The participant recruitment was limited to two nursing homes, which produced a small sample size. With a small sample size, extrapolating the results to other populations or regions may not be possible. Additionally, staff members did not record AP episodes; thus, prevention of AP with POCI could not be determined. These researchers cultured only a limited number of bacterial strains, and pneumonia can be caused by many critical pathogenic species that may not have been accounted for or investigated (Chiang et al., 2020).

Oral Health Care Education in Nursing Homes

Oral health education of care staff in nursing home residents is a barrier to providing good oral care in this population. Care staff education relating to oral health is seriously inadequate in many facilities. A lack of training and knowledge has led to residents' poor oral health in long-term care facilities (Le et al., 2012).

Evaluation of support staff members' (SSMs) oral care education efficacy in improving long-term care facility resident oral health was the study's aim. Participants ($n = 47$ study group) ($n = 29$ control group) in this controlled intervention study completed an oral care pre-test of 20 items at baseline before receiving education in oral care. A posttest and a follow-up test were

given six months after training to measure the SSMs' retention of information. The given oral care education program, Mouth Care for Persons in Residential Care, was delivered to the SSMs in a 60-minute in-service across all residential care homes (Le et al., 2012).

Inclusion criteria included 60 geriatric residents with teeth and who were able to give informed consent. The 60 participants who met the criteria had a mean age of 79.18. The control group ($n = 39$) and the study group ($n = 41$) underwent oral health assessments, including Modified Gingival Index (GI), Modified Plaque Index (PI), and intraoral photographs of 24 tooth surfaces for external clinical evaluation. At baseline, there were no significant differences between the participating residents. At six months, both the study and control group PI levels decreased with no significant difference in GI scores at baseline and six months, respectively. Knowledge of SSMs oral care increased significantly after the educational course on oral health care (Le et al., 2012).

On average, SSMs in the study group cared for 16.28 residents, and those in the control group cared for 10.97. SSM participants aged 50 years or more scored much higher on the education tests than those in the younger age group. Many barriers were found for the SSMs, including residents with bad breath, insufficient time, uncooperative residents, and lack of oral health knowledge. The lack of knowledge was reported mostly before SSM oral health education, but some had continued lack of knowledge after improvements were made. Although oral care knowledge increased, routine daily oral care was not documented or observed, and the residents' oral health could not be confirmed (Le et al., 2012). Enhanced oral care knowledge could not be associated with improved oral health outcomes (Le et al., 2012).

Researchers showed that oral care of older nursing home residents was improved with SSM education for support staff. The results of this investigation confirmed the need for

comprehensive oral health programs in nursing homes and is a strength of this study. Plans should be individualized and reflect the patient's needs with modifications as necessary to promote good oral health (Le et al., 2012). Researchers in other studies reported similar findings to those reported in the current research, which lends strength of validity to this investigation (Imai et al., 2011; Logan et al., 1991; Smith et al., 2004; Wardh et al., 1997 as cited in Le et al., 2012).

Access to dental care is limited in nursing homes for several reasons: (a) transportation for dental care generates costs to the nursing homes, which limits the resources available for other purposes, (b) lack of training and education of the care staff, (c) dental treatment needs of older patients are regarded as secondary, and (d) dental issues are usually solved on an emergency basis (Gaszynska et al., 2014).

Poor oral health of older residents was reported in two studies of geriatric institutions. Findings in both studies suggested a very low prevalence of dental visits and insufficient hygiene levels. In Poland and India, the geriatric population is rapidly growing with reduced resources for their care (Gaszynska et al., 2014; Rekhi et al., 2018).

Gaszynska et al. (2014) investigated dental treatment needs, oral health status, and barriers to receiving dental care in 259 nursing home residents aged 65 and over. This cross-sectional study was carried out in seven geriatric care homes in Lodz, Poland. Data collection consisted of face-to-face participant interviews regarding oral hygiene habits. The participants were asked how much assistance was needed to perform oral hygiene, self-perceived dental needs, and when they last visited a dentist. They received an oral health evaluation by the sum of decayed teeth, missing and filled teeth (DMFT), mucosal plaque score (MPS) with a range of 1 to 4 (high), and tooth mobility according to Miller's classification (Gaszynska et al., 2014).

Nurses, caregivers, and medical staff with resident oral hygiene were deficient in the help they provided. The deterioration of oral function in this population leads to the development and exacerbation of pulmonary and cardiac diseases or metabolic diseases (Gaszynska et al., 2014). There is a high incidence of edentulism and prosthetic appliance needs in the institutionalized geriatric population in Poland. Due to low funding in the Polish health care system, geriatric nursing home residents do not receive an acceptable oral care level. Nursing and caregiver education and training programs in Poland do not include oral health care components. For older people's daily care, oral hygiene is not specified as a duty in nursing homes (Gaszynska et al., 2014).

The extensive sample of the population and the use of reliable oral health examination tools (DMFT and MPS) lend validity to the results. Self-reporting face-to-face interviews can skew results if oral hygiene practices are incorrectly reported and may be a limitation (Gaszynska et al., 2014). Gaszynska et al. (2014) suggested improving dental health awareness for the nursing home residents and including dental examinations as a part of the resident's yearly medical check-up (Gaszynska et al., 2014).

In a cross-sectional study of 500 geriatric nursing home residents aged 60 years and older in Delhi, India, results showed that periodontal disease significantly impacted oral health and premature mortality rate. Poor oral health can be seen as an increased risk of chronic diseases such as respiratory illness. Oral health is fundamental to general health and a determinant of quality of life (Rekhi et al., 2018).

Using the GOHAI, the participants' OHRQoL was assessed. Data were collected from oral health examinations and interviews to calculate oral health status and OHRQoL in residents. Social, psychological, and functional impacts of periodontal disease are captured in this

evaluation. Clinical indicators and social impact on health status was the focus of this study (Rekhi et al., 2018).

The OHRQoL scores concerning oral health were low, especially for the 279 (58%) female participants. As women's ages increased, the GOHAI scores decreased, indicating a negative perception of poor oral health status and quality of life in these institutionalized geriatric patients. The participants with more than 19 teeth present had higher GOHAI scores than those with fewer natural teeth (Rekhi et al., 2018).

The scope of disruption from oral health status can include effects on functionality and behavior. Those with perceived good general and oral health have higher GOHAI scores than those with the opposite perception. In India, dental care is relatively unavailable for those in institutions, and low importance is given to oral hygiene for this population. The extent to which oral health issues impact the quality of life for the older population is significant. The growing population of older people in developing countries need oral health education for health care workers (Rekhi et al., 2018).

Due to a lack of reference values for GOHAI score interpretation, data could not be interpreted as indicative of health level. The scarceness of studies that utilized this questionnaire within the geriatric population further restricts the interpretation of data. Additionally, various studies that used the GOHAI questionnaire showed a lack of consistency of the Likert scale (Rekhi et al., 2018).

This study highlighted the extent of oral health concerns in nursing homes and pointed to a need for more research in this area. The results show an extreme demand for preventive dental care and may initiate education and prevention measures (Rekhi et al., 2018).

The current standard of oral care in the nursing home setting is inadequate and more than 250,000 geriatric residents have been affected annually. This study aimed to evaluate the Mouth Care Without a Battle (MCWB) program's effectiveness in reducing pneumonia incidence.

MCWB is a standardized program to educate caregivers on the importance of and techniques to provide oral hygiene to resistant individuals or special populations (Zimmerman et al., 2020).

This pragmatic cluster randomized trial included 2152 residents mean age 79.4 years ($SD = 12.4$) from seven nursing homes in North Carolina for over two years. The intervention group included 1219 (56.6%), while the control group contained 933 (43.4%) of the study population. Older patients with dementia were of particular interest in this study due to high resistance to oral health care routines. Nursing home residents with cognitive impairment (moderate to severe) are approximately 61% of the population (Zimmerman et al., 2020).

Data were collected via medical records for all participants during the study period for pneumonia incidence quarterly. Other data collected at baseline associated with oral health include dental issues, eating dependency, health problems, demographic characteristics, swallowing, feeding, and medications. Intervention training was provided over three days for care personnel at the beginning of the study and monthly support visits over the two-year study period. One nursing assistant was selected as the dedicated oral health care aide. Additionally, after one year, another in-service training was conducted for all nurses, nursing assistants, and administrative staff (Zimmerman et al., 2020).

Throughout the study period, pneumonia incidence was 0.72 per 1000 resident days in the control group and 0.67 per resident days in the intervention group. Results did not show a significant reduction in pneumonia with the implementation of MCWB. The effectiveness to reduce pneumonia in geriatric nursing home residents was not statistically significant in year 1 or

2 of the study. However, adjusted post-hoc results for year 1 suggested a 31% reduction in nursing home pneumonia incidence in the intervention group than the control group. Notably, chlorhexidine gluconate 0.12% was recommended during the first year as part of the MCWB program but not the second year (Zimmerman et al., 2020).

Generalizability is a limitation due to the inclusion criteria of the nursing homes included; an under or overestimation of pneumonia diagnosis could have resulted from the review of medical records, which could have skewed the results. The intervention's sustainability was a challenge despite training and regular check-ins with the caregivers administering oral health care. A decrease in compliance with the intervention protocol was seen at 20 and 24 months (Zimmerman et al., 2020).

The study design is a strength of this research. How the nursing homes were matched and monitored gives confidence that later bias would not be expected between study groups. This was the first study to examine whether a practical oral health program provided by nursing home staff helps lower the incidence of pneumonia in geriatric residents (Zimmerman et al., 2020).

Methods

Search Procedure. A careful review of the literature related to poor oral health and respiratory illness was conducted. The review highlighted the following topics: (a) oral health and respiratory illness, (b) the relationship of oral health care and the prevention of respiratory illness, and (c) oral health care education in nursing homes.

Search Engines and Databases Used. Titles, abstracts, and full-text articles were found and analyzed for inclusion via PubMed and PMC as the starting point. Full-text studies were

obtained by various methods, such as journal publication websites, databases including PubMed and PMC, and the University of Bridgeport's Wahlstrom Library e-journal resources.

Search terms. Several keywords and search terms were used to identify sources for this literature review. The search terms included: (a) pneumonia; (b) respiratory illness; (c) nursing homes; (d) oral care; (e) dental care; (f) oral health education; (g) geriatric; and (h) elderly.

Boolean strings. Boolean strings were considered for the literature search. Boolean strings used: (a) oral health AND respiratory illness; (b) respiratory illness AND nursing home; (c) geriatric AND pneumonia; and (d) oral health education AND pneumonia.

Age of sources. Significant literature has been reviewed. Sources after 2011 have been considered for inclusion in the review of the literature. Pertinent historical or seminal articles were also considered.

Inclusion criteria. There were four inclusion criteria. Inclusion criteria included: (a) Peer-reviewed research studies; (b) literature published after 2011, except historical sources; (c) English-language text; and (d) websites related to oral biome health concerning respiratory illness (pneumonia).

Exclusion criteria. There were four exclusion criteria. The exclusion criteria included: (a) articles not peer-reviewed; (b) literature published before 2011, except historical sources; (c) text not published in English; and (d) websites not related to oral biome health concerning respiratory illness (pneumonia).

Results

For this review 17 peer-reviewed studies were included with the intention of investigating oral health and respiratory illness, oral health care and prevention of respiratory illness, and the effectiveness of oral health education for older nursing home patients. The first section of this

chapter describes the results of the studies related to probable links between poor oral health and respiratory illness. The second section discusses the results pertaining to oral health care and the prevention of respiratory illness. The last section will review the results of the studies concerning the importance of oral health care education for nursing home caregivers.

Oral Health and Respiratory Illness

Colonization of dental plaques and tongue pathogens are associated with respiratory illness in geriatric nursing home residents (Table 1). Several factors have affected this population's poor oral health and the increased incidence of pneumonia. Studies throughout the decades have provided strong evidence of this relationship.

El-Solh et al. (2004) investigated the relationship between the colonization of dental plaque and respiratory illness in geriatric hospitalized nursing home patients using molecular genotyping. They found more than 1000 units/mL of colony-forming bacterial growth on cultures that underlie the etiology of pneumonia. Critically ill geriatric patients have a high prevalence of cultivable flora identified as respiratory pathogens; for this population, these pathogens are considered colonized if DPs are greater than 1%. The number of natural teeth present was significantly associated with a higher plaque index and an increased HAP development risk (El-Solh et al., 2004).

Conversely, denture wearing patients had lower plaque indexes ($M = 1.7$, $SD = 0.3$) than those who did not wear dentures ($M = 2.3$, $SD = 0.43$). Denture wearers also had a lower frequency of respiratory pathogen colonization (27% vs. 66%; $P = 0.04$). The findings confirmed that the colonizing oral pathogens in the patient's samples consisted of, *Staphylococcus aureus* (45%), *Pseudomonas aeruginosa* (13%), and gram-negative bacilli (42%) had a significant impact on respiratory health (El-Solh et al., 2004).

El-Solh et al. (2004) conducted a well-designed study using rigorous measures for plaque colonization by aerobic and anaerobic bacteria. These researchers initiated molecular genotyping to measure plaque levels. This study was the first to confirm that dental plaque colonization and lower respiratory infection are concomitant using molecular genotyping.

In a similar study, Hong et al. (2017) investigated oral colonization and the risk of pneumonia in older dependent adults. Findings showed that the respiratory pathogens *Haemophilus influenzae* ($P = .015$, 95% CI: 1.097-5.5551) and *Pseudomonas aeruginosa* ($P = .003$, RR: 3.556, 95% CI: 1.745-7.246) are related to occurrence of pneumonia (Hong et al., 2017). Tongue colonization and calculus index were also significant indicators of pneumonia risk. There was a strong correlation between pneumonia and calculus index with the number of natural teeth remaining. Findings by El-Solh et al. (2004) found similar outcomes and concluded that oral microflora in older adults is an indicator of pneumonia risk (Hong et al., 2017).

The aims of this study included assessment of swallowing function, oral health status, and health status concerning respiratory bacteria colonization in geriatric patients. Results showed in the study performed by Ortega et al. (2014), stroke was responsible for the participant's oral dysphagia and is an important comorbidity for AP. The CCI score ($M = 3.0$, $SD = 1.8$), EAT-10 ($M = 10.5$, $SD = 7.6$), and the number of drugs taken by participants ($M = 7.5$, $SD = 3.0$) were important predictors for AP. When comparing the OD and control groups, the control group had much lower mean Charlson comorbidity scores. The EAT-10 score for the OD group was ($M = 0.2$, $SD = 0.6$) and ($P = .0001$). The swallowing function in the group with OD, through VFS testing, showed a high prevalence of impaired safety and efficacy to swallow. The majority of OD patients presented with a mean number of teeth ($M = 17.0$, $SD = 8.6$) and a high prevalence of poor oral hygiene ($M = 3.9$, $SD = 1.5$). No patients in the experimental group

were classified with healthy oral status. The control group patients presented with a mean number of teeth 18.1 ($SD = 8.8$) and an OHI-S mean value of 3.3 ($SD = 1.4$). Among this group, 14 of the 15 older patients were dentulous, 13 presented with periodontitis, and three with caries ($P = .046$). The number of affected teeth was also a smaller percentage than OD patients ($M = 7.6$, $SD = 3.5$, $P = .022$; Ortega et al., 2014).

Findings by Ortega et al. in a 2014 study concurred with the results of their 2015 study. Patients with the poorest outcomes had OD and malnutrition, with a 1-year mortality rate of 65.8% (Ortega et al., 2014, 2015). All patients in this study presented with poor oral health. Respiratory pathogens in all anatomical locations were present in 90% (5) of participants. In older adults with OD, previous findings of a high prevalence of periodontal disease (93%) and dental caries (53%), along with accumulated amounts of plaque and calculus being high was consistent with the current findings. In this study, 33.3% to 61.5% of patients presented with poor functionality, poly-medication, comorbidities, high oral bacteria load, and VFS scores indicating impaired safety to swallow, all strong indicators for AP incidence (Ortega et al., 2015).

Ortega et al.'s 2014 and 2015 studies appeared as well-done. Similar outcomes were realized, showing the link between poor oral health in patients with OD and a higher risk of pneumonia in frail older adults. Mechanical removal of oral debris was found to be effective as a preventive measure in pneumonia incidence.

In a study of 524 community-living seniors, researchers investigated the risk of pneumonia of those who wore dentures during sleep. There was a total of 20 deaths and 28 acute hospitalizations reported during a 3-year follow-up period. Severe pneumonia episodes occurred at 3.1 per 100 per year (Linuma et al., 2015). Of the 524 participants, 453 wore dentures, and

40.8% of those wore them during sleep, having a higher risk of pneumonia than those who did not (log-rank $P = .021$). Those geriatric participants who were consistently wearing dentures during sleep showed a 2.3-fold higher risk for pneumonia (hazard ratio [HR] 2.38; and 95% confidence ratio [CI], 1.25-4.56) and were more likely to have high levels of poor oral health (Linuma et al., 2015).

Higher levels of aspiration are shown as a critical factor in pneumonia risk with a potential association with denture wearing. For 173 older nursing home residents, aspiration was associated with a 4.4-fold higher risk (95% CI, 1.16-16.43) of pneumonia (Takeuchi et al., 2019). Older residents who did not wear dentures had a 7.3-fold higher HR of pneumonia than those who did not have a risk of aspiration (95% CI, 1.02-52.63). Over the follow-up period ($M = 448$ days), 7.1% of participants developed pneumonia. The patients with risk of aspiration and those not at risk showed a significant difference in mean pneumonia rate ($P = 0.509$). There was no significant difference observed between seniors that wore dentures and those who did not ($P = < 0.001$). Findings suggested that aspiration was a critical indicator for the risk of pneumonia (Takeuchi et al., 2019; Table 1 for summaries).

Table 1.

Oral Health and Respiratory Illness

Reference	Population	Design	Intervention	Outcomes
El-Solh et al., 2004	49 critically ill LTCF residents	Prospective observational	None	Colonizing dental plaques implicated respiratory infections
Hong et al., 2017	60 dependent LTCF	Prospective longitudinal	None	Colonization of respiratory pathogens on the tongue and amount of calculus at risk factors for pneumonia.
Ortega et al., 2014	50 w/ & w/o OD	Observational-transversal	None	Patients w/OD, impaired s to swallow & poor oral health, high AP incidence
Ortega et al., 2015	61 FOP patients w/ & w/o OD	Prospective, observational, transversal	None	High risk for AP in FOP w/ OD due to poor oral health and impaired safety to swallow.
Linuma et al., 2015	542, 85 years & older community living	Prospective, observational 3 yr. follow-up	None	Denture wearing during sleep associated w/ risk of pneumonia
Takeuchi et al., 2019	156 NH residents	Prospective cohort	None	Aspiration and risk for AP higher w/o dentures

Note. LTCF = long-term care facility, OD = oropharyngeal dysphagia, FOP = frail older patients, f-u = follow-up, NH = nursing home, population = the sample size and patient facility or living arrangement

The Relationship of Oral Health Care and Prevention of Respiratory Illness

The role of oral health care in preventing respiratory illness in older people has been the focus of many studies over the last six years. Most of the following studies show the benefits of routine oral care and a lower risk of respiratory illness. However, two included studies found little or no benefit with oral health care.

Elimination of oral contaminants in older patients with impaired swallowing function was investigated concerning the efficacy of reducing aspiration pneumonia. The benefits of wiping the oral cavity after oral care with mouth wipes and rinsing were assessed (Ikeda et al., 2014). Researchers found that the number of oral bacteria in any three locations before oral care in the rinse and wipe group was not statistically different (Ikeda et al., 2014). Locations measured for oral bacteria before oral care included the tongue ($P = .78$), palate ($P = .71$), and the buccal vestibule ($P = .89$). The decrease was significant in all locations after oral care for both groups. All participants had oral care performed by nurses for consistency. In both groups, an increase in oral bacteria was seen one hour after contaminant elimination. This finding suggests that oral bacteria levels may return to baseline numbers as soon as one hour after oral care. Early oral bacteria colonizers tend to be commensal bacteria and are generally harmless when compared to later colonizers. Later colonizers are likely to contain a higher load of respiratory pathogens. Prevention of later colonizers adhering to tooth structure can be achieved with the disruption of dental plaque in the early stages. Thus, respiratory illness can be reduced with daily oral hygiene (Ikeda et al., 2014).

Ikeda et al.'s (2014) intervention method was valuable when utilizing alternative contaminant removal methods after brushing. Moreover, the intervention appeared to have advantages for critically ill older patients. This study was five months in duration with 31 participants, with varying oral conditions and was a successful intervention in this short duration study.

Coughing ability in the geriatric population is critical for clearing oral contaminants to prevent aspiration pneumonia. Izumi et al. (2016) investigated the possible benefits of oral care with tongue cleaning on coughing ability. Researchers found a significant increase of peak PEF

in the intervention group with tongue cleaning. At the termination of the study, the PEF was $M = 2.54$ ($SD = 1.4 \text{ L s}^{-1}$) in the intervention group and the control group PEF was $M = 1.90$ ($SD = 1.20 \text{ L s}^{-1}$). Both groups showed PEF improvement at the end of the study period; however, the intervention group was significantly higher $M = 0.90$ ($SD = 1.0 \text{ L s}^{-1}$) than the control group $M = 0.31$ ($SD = 1.0 \text{ L s}^{-1}$; $p < 0.001$). Tongue cleaning and oral care were important for preventing AP (Izumi et al., 2016).

The randomized controlled trial design of this study was optimal for reducing selection bias and confounding variables. The results of this study showed good generalizability across nursing home residents in Japan. The effects of the intervention were evident at three months post-termination which shows clinical relevancy for this patient population.

Nishizawa et al. (2019) developed a procedure to evaluate the risk of aspiration pneumonia in geriatric patients with AP and CAP. Findings suggested that the AP group showed significant impairment compared to the CAP group and control on the OHAT ($M = 5.1$, $SD = 0.2$; $M = 4.4$, $SD = 0.3$; $M = 3.9$, $SD = 0.2$; $P < 0.05$) in this study. A high OHAT score (> 4.5) with odds ratios (95% CI) in the AP group 13.6 (56.34 to 94.27%) and the CAP group 4 (56.34 to 94.27%) were predictive of incidence (Nishizawa et al., 2019). Additionally, differences in OHAT scores in the AP and CAP groups were represented by an area under the curve (Wilcoxon or Kruskal-Wallis test) of 0.68 with 95% CI. The cut-off value for the AP group was optimal at 5.5 diagnosed, with a sensitivity of 31.8 and specificity of 85, and was calculated by the Youden index. High OHAT scores and oral bacterial counts were diagnostic of aspiration pneumonia (Nishizawa et al., 2019).

Nishizawa et al.'s (2019) findings supported that risk factors, such as swallowing disorder, cerebrovascular disorder, and chronic neurological disorders, were prominent in the AP

group but were absent in the control and CAP groups. In the AP group at the admission time, the oral bacteria count ($M = 7.2$, $SD = 0.1$) compared to the CAP group ($M = 6.9$, $SD = 0.1$) was significantly greater, which is reflected by OHAT scores. Oral care successfully reduced the oral bacteria count in both AP and CAP groups when comparing the bacteria counts from before and after oral hygiene during hospitalization (Nishizawa et al., 2019).

In an intervention study of 834 participants, Juthani-Mehta et al. (2014) used a multicomponent oral health intervention protocol to test for reducing pneumonia in older nursing home residents. Researchers found no significant difference in results between the control and intervention group outcomes. The intervention group had a reported first pneumonia incidence rate of 27.4%, and the control group had a rate of 23.5%. Using a competing risk model, relative risk (RR) findings were similar. Mean adherence in the intervention arm of patients using chlorhexidine was 87.9% ($SD = 20.5\%$) and those using toothpaste was 75.0% ($SD = 23.4\%$). Patients' upright feeding adherence was 100% (Juthani-Mehta et al., 2014).

The findings of the Juthani-Mehta et al. (2014) study did not discover a significant correlation between the use of chlorhexidine 0.12%, toothbrushing twice daily, and upright positioning when eating with a lower incidence of pneumonia. Comparatively, the control group's usual oral care rendered similar results (Juthani-Mehta et al., 2014). These outcomes demonstrate the importance of some daily oral care in the reduction of respiratory illness in nursing home residents.

The purpose of Hollaar et al.'s (2017) study was to determine if the addition of daily use of a 0.05% chlorhexidine rinse was useful in the reduction of AP. Geriatric nursing home residents with dysphagia received an oral chlorhexidine rinse in addition to usual daily oral care. Twenty-five percent of residents were diagnosed with pneumonia. Of those with a pneumonia

diagnosis (26), 14 were in the control group (27%), and 12 were in the intervention group (23%). Overall, eight intervention group participants died of pneumonia, and 7 in the control group. The control group only received routine oral care. Survival curves were calculated for the intervention group, and these showed no significant difference in pneumonia incidence between the groups (log-rank, $P = .571$). However, dysphagia was associated with AP incidence in this group (Hollaar et al., 2017).

Due to the small sample size, the power was insufficient, limiting the interpretation of results. This likely skewed the data and contributed to invalid results. The association between the intervention and AP incidence was not sufficiently tested, and this compromised the outcomes. The low concentration of chlorhexidine oral rinse (0.05%) may have been ineffectual.

In a study of geriatric residents, 78 received chlorhexidine 0.2% oral rinse as an intervention to examine possible benefits for reducing oral colonization. There was no significant difference at baseline in the BOHSE scores between groups ($M = 1.5$, $SD = 1.3$) and ($M = 1.8$, $SD = 1.3$; $P = .427$), respectively (Sharif-Abdullah et al., 2016). About 74% of the intervention group showed a significant reduction in oral bacteria colonization from the baseline data. The control group showed a little reduction of oral bacteria with the use of a thymol gargle. Development of oral bacteria colonization was a three times higher risk in this group than for those in the intervention arm (95% CI; $M = 1.6$, $SD = 5.2$; Sharif-Abdullah et al., 2016).

Sharif-Abdullah et al. (2016) utilized a higher concentration of oral chlorhexidine rinse than the Juthani-Mehta et al. (2014) and Hollaar et al. (2017) studies. Samanth and Varghese (2017) investigated effective concentrations of chlorhexidine mouth rinse and found dose-dependence. Chlorhexidine mouth rinse solutions with concentrations below 0.2% were less effective for decreasing microbial load (Samanth & Varghese, 2017).

Chiang et al. (2020) implemented professional oral care in a nursing home population to investigate changes in oral health and pneumonia status. The study included 41 hospitalized nursing home residents, many of whom were unconscious (80%) with a history of pneumonia (76%). At baseline, the control and intervention groups did not significantly differ in plaque index, gingival index, tongue coating index, salivary bacterial concentration, or *Staphylococcus aureus* distribution in salivary samples (Chiang et al., 2020).

Post-intervention improvements were significant across all variables measured at baseline: plaque index ($M = 1.7, SD = 0.8$ vs. $M = 0.9, SD = 0.6, P < .010$), gingival index ($M = 2.4, SD = 0.8$ vs. $M = 1.7, SD = 0.8, P < .01$), tongue coating index ($M = 1.0, SD = 1.1$ vs. $M = 0.2, SD = 0.5, P < .010$), salivary bacterial concentration ($[4.3 \pm 3.7] \times 10^5$ vs. $[0.8 \pm 1.2] \times 10^5, P < 0.01$), and *Staphylococcus aureus* distribution ($M = 11.1, SD = 14.5\%$ vs. $M = 1.7, SD = 3.8\%, P = .020$). The intervention group had a significantly lower pneumonia hospitalization incidence ($M = 1.2, SD = 1.5$ vs. $M = 0.5, SD = 0.6, P = .010$; Chiang et al., 2020).

The length of the study (28 months) and the low attrition rate ($n = 3$) in the intervention group lend validity to the findings (Chiang et al., 2020). The study design and intervention were appropriate for determining the efficacy of professional oral care in geriatric nursing home residents' care to lower the risk of pneumonia (Table 2 for summaries).

Table 2.

The Relationship of Oral Health Care and Prevention of Respiratory Illness

Reference	Population	Design	Intervention	Outcomes
Ikeda et al., 2014	31 institutionalized	Prospective Cross-over	Rinse w/ water & suctioning or wipes.	A significant decrease in oral bacteria using both methods.
Izumi et al., 2016	114 geriatric residents	RCT	Oral care w/ tongue cleaning.	Oral care increased PEF & coughing ability.
Nishizawa et al., 2019	62 patients	Prospective	None	Oral bacteria were significantly reduced w/ oral care & prevent AP
Juthani-Mehta et al., 2014	834 residents of 36 NHs	Cluster-RCT	Manual tooth-gum brush, 0.12% chlorhexidine & upright feeding.	The first incidence of radiographically confirmed pneumonia was not significantly reduced.
Hollaar et al., 2017	103 NH residents	Multicenter cluster RCT.	0.05% chlorhexidine oral rinse.	Chlorhexidine did not reduce the incidence of aspiration pneumonia.
Sharif-Abdullah et al., 2016	78 geriatric	RCT	Chlorhexidine 0.2% oral rinse	A significant reduction in oral bacteria.
Chiang et al., 2020	220 NH residents	Quasi-experimental	Professional oral care	Reduced salivary bacteria & <i>Staphylococcus aureus</i> w/ decreased pneumonia incidence.

Note. NH = nursing home, RCT = randomized control, population = the sample size and facility or living arrangement

Oral Health Care Education in Nursing Homes

Le et al. (2012) assessed current oral health care education among nursing home caregivers and the impact of improved education on the oral health of the residents. Baseline and post-education knowledge were measured. Residents' oral health was assessed by PI and GI at baseline and at a 6-month follow-up to evaluate oral health care improvements.

The support staff members showed an increase in oral health education knowledge from pre-test to post-test which was reflected in the outcomes for the residents' oral health status. There were noted improvements to the study group's modified PI and GI scores. PI at baseline was ($M = 1.90, SD = 0.61$) and at follow-up was ($M = 1.62, SD = 0.79$), respectively. GI at baseline was ($M = 1.72, SD = 0.65$) and ($M = 1.47, SD = 0.77$) at follow-up (Le et al., 2012).

Patients in the long-term care population may have several oral conditions that need attention and can affect general health. The incorporation of supplementary oral health care education for nursing home support staff members was found to be effective in improving the oral health of the residents. Oral health education is imperative for both the residents and most especially those that are caregivers.

Gaszynska et al.'s (2014) objective was to investigate dental treatment needs, oral health status, and barriers to oral health care in geriatric home residents. Older nursing home residents' current dental status showed that 46% were edentulous, and only 9.2% wore upper and lower dentures. Of the dentate residents with many dysfunctional teeth, less than half used partial dentures. Hygiene levels were inadequate for 47.2% of individuals. Furthermore, 75% of the participants reported they had not received dental care for more than 12 months (Gaszynska et al., 2014).

Rekhi et al. (2018) studied 500 participants with ages distributed as 203 (40.6%) aged 60 to 69 years, 206 (41.2%) aged 70 to 79 years, and 91 (18.2%) more than 80 years old. The Add-GOHAI score mean was 41.5 ($SD = 6.1$) and the Sc-GOHAI reported mean was 6.27, $SD = 1.54$). Gender and age differences were highly significant, with GOHAI scores lower in females than males with a direct decrease in scores as age increased ($P = .012$). As participant educational level increased, they had higher GOHAI scores; thus, those with low or no education

had lower scores than those with higher educational status ($P < 0.001$). Participants with more than 19 teeth reported higher GOHAI scores compared to those with fewer than 19. Periodontal findings suggested a direct relationship between low OHRQoL scores and loss of attachment (LOA) and tooth mobility. For the entire population in this study, the mean GOHAI score was 41.6, which is at the upper limit of the scale's measurement range (Rekhi et al., 2018).

Zimmerman et al. (2020) conducted a large-scale study over two years. They aimed to implement the MCWB program to determine the effects of improving the oral health status of nursing home residents. They reported pneumonia incidence from 0.35 to 1.26 per 1000 resident days after implementing the program intervention. Some residents experienced more than one case of pneumonia with 509 cases among 395 participants (46% control and 53.9% intervention). Despite the randomization of patients, those in the intervention arm were found to be more likely to have Alzheimer's Disease or other dementias (49.6%), chronic renal disease (15.4%), and recent flu vaccination (47.1%), which potentially contributes to poor oral hygiene and increased pneumonia risk. After the first year, pneumonia cases decreased through the remaining period, but the incidence change was statistically insignificant at two-years. The researchers concluded that sustainability is likely to blame for the insignificant study results in the second year (Zimmerman et al., 2020; Table 3 for summaries).

Table 3.

Oral Health Care Education in Nursing Homes

Reference	Population	Design	Intervention	Outcomes
Le et al., 2012	76 SSMs 80 NH	Controlled intervention	Mouth Care for persons in residential care.	Improved resident OHC w/supplemental education for SSMs.
Gaszynska et al., 2014	259 geriatric residents	Cross-sectional	None	Need for more SSM education and OHC resources.
Rekhi et al., 2018	500 NH	Cross-sectional	None	Extensive dental health issues w/ NH residents & education & preventive measures needed.
Zimmerman et al., 2020	2152 NH	Matched pairs cluster-RCT	Mouth care w/o battle program.	Reduced pneumonia incidence 1st yr, not 2nd yr. with incorporation of educational program.

Note. NH = nursing home, RCT = randomized control trial, NHAP = nursing home acquired pneumonia, OHC = Oral Health Care, SSMs = support staff members.

Discussion

The purpose of this review was to determine the relationship between poor oral health and respiratory illness, possible effective interventions to prevent pneumonia, and the importance of oral health education for caregivers in the geriatric nursing home population. This was accomplished by a review of the relevant literature. The research and review of poor oral health and the link to systemic conditions is critical to the health of the aging population.

An estimated 75% of baby boomers will have most of their natural teeth upon entering the long-term care facility system in the United States. Access to dental care is imperative to the physical, social, economic, and psychological health of the geriatric population (Kane, 2017).

Past and current research points to an immediate need to prioritize oral health care for the older population.

As evidenced by the research in this review, colonization of pathogenic micro-organisms in the oral cavity of humans have been associated with aspiration pneumonia (El-Solh et al., 2004; Hong et al., 2017; Ortega et al., 2014; Ortega et al., 2015; Linuma et al., 2015; Takeuchi et al., 2019). In addition, dental plaque colonization in geriatric nursing home residents, leading to an increased risk of pneumonia has been well-established (El-Solh et al., 2004). Findings have been consistent throughout the history of research in this area linking poor oral health as a causal factor in respiratory illness.

Periodontal bacteria with a high calculus index were found to have a direct cause to aspiration pneumonia. The lack of oral hygiene and compromised physical and immunological oral defenses in the institutionalized population provides favorable conditions for the propagation of harmful pathogens (Hong et al., 2017). A link has been established between respiratory pathogens and oral colonization. There is a strong association between the severity of AP and mortality in geriatric patients with oral pathogen colonization.

Contributing to a frail older patient's risk of AP is their functional status and impaired safety to swallow. The OD research demonstrates the increased risk of AP for these patients and was not a surprising outcome. Aspiration is common with a weakened airway or OD allowing saliva that contains oral bacteria to reach the lungs to grow and cause respiratory illness. For geriatric patients with OD, good oral health is critical along with routine mechanical removal of debris to avoid aspiration of respiratory pathogens collected from oral biofilm.

Showing a causal relationship between the prevalence of oral bacteria and pneumonia is well demonstrated by the reviewed research. The included studies pertaining to oral health status

and respiratory illness were valid and representative of the elderly institutionalized population. The inclusion of studies from Japan, Singapore, and Spain show a broad generalization and consistency in the results showing the association of poor oral health and respiratory illness. Compared to the general population, the oral health status of elderly patients in nursing homes is poor (Rekhi et al., 2018). Preventive dental care in nursing homes can no longer be ignored, with more individuals keeping their natural teeth, who have poor oral hygiene (Kane, 2017). In particular, geriatric institutionalized patient's oral health is compromised by xerostomia, systemic diseases, and physical function which promotes the formation of dental biofilm (Ikeda et al., 2014).

Prevention methods implementing chlorhexidine in various percentages had mixed findings. Two of the three included studies showed no decrease in pneumonia incidence with the addition of chlorhexidine in geriatric nursing home resident's daily oral health care routine. This was an unexpected finding since chlorhexidine has been shown to reduce oral bacteria for decades and is commonly used for this purpose. Chlorhexidine has been shown as effective in the elimination of various oral pathogens and has excellent anti-plaque activity. Preventive oral health care has been well documented and is indicated to reduce the incidence of pneumonia in the institutionalized elderly population. The researchers in both studies employed a low concentration of chlorhexidine (0.12% & 0.05%) which can be contributed to no significant positive effects from the intervention.

The interventions that showed success in decreasing oral bacterial and improving the oral status of geriatric residents included; rinsing with water and suctioning or oral wipes for debris elimination; the addition of tongue cleaning to routine oral care; inclusion of professional oral care; and chlorhexidine oral rinse 0.2%. The decrease in oral bacteria resulted in a lower

incidence of pneumonia in this population. Preventive oral care plays an essential role in reducing HAP or HCAP incidence with an established and consistent routine. The capacity to reduce bacteria, especially due to calculus accumulation, can help prevent pneumonia. The evidence demonstrates the positive relationship between oral health and the incidence of respiratory illness.

Even with the implementation of educational programs, oral hygiene education for caregivers in nursing homes is still short of ideal (Rekhi et al., 2018). Countries all over the world have a continuous problem with nursing home residents not receiving adequate oral care. As evidenced in the studies represented in this literature review, attention to the dental needs of the institutionalized geriatric population is far below adequate. This studied population commonly has an increase in disease and conditions resulting in poor oral health and loss of function. A lack of oral health education for caregivers and restricted access to medical and dental care in nursing homes exacerbates the probability of illness. With the reduction of physical and mental capacities, the ability for nursing home residents to maintain good oral health on their own is a significant challenge. Studies have identified the lack of knowledge and training in oral health care for caregivers as a critical gap in maintaining the overall health of the geriatric population. Even with educational programs for support staff members, daily oral care is not routinely performed for various reasons.

The current research has confirmed that the prevention of oral diseases is crucial to overall systemic health and related complications in the senior population. Despite the multitude of evidence confirming the association of poor oral health and respiratory illness, barriers persist in providing adequate oral hygiene to geriatric nursing home residents. A lack of oral health education for care staff in long-term care facilities is a significant barrier. Additionally, subpar

education and training for caregivers, poor attitudes about oral care, and inadequate time allocated to daily oral hygiene routines continue to affect the oral health of older adults. Providing dental care is seen as an economic burden in many countries and allocation of funds to address dental health issues are sparse (Sharif-Adbullah et al., 2016). The benefits of preventive and not reactive dental care are yet to be realized in many cultures. Benefits of routine preventive dental care include a reduction of cost for medical and dental treatment and lowering mortality rates from respiratory illness.

Revealing the magnitude of dental problems in nursing homes and the importance of assistance in oral care and regular dental visits for the elderly was consistent in the research findings. These findings illustrate the inadequacies of treatment in long-term care facilities, which is affecting the lives of the older population. Lending validity and generalizability to the findings are the similar outcomes. The reliable and valid tests that were used to assess the quality of oral health in the nursing home population, shows the consistency of poor oral health worldwide.

Recommendations

To lower the risk of respiratory illnesses with improvement of oral health in the nursing home population Kane (2017) recommends better collaboration between medical and dental professionals to share information on patient information to optimize patient's health. Launching oral health education programs for nurses and care staff with established procedures for daily oral care that includes elimination protocols, POH, and chlorhexidine oral rinse (when indicated) is necessary to improve the quality of life of geriatric residents (El-Solh et al., 2004; Hollaar et al., 2017; Ikeda et al., 2014; Izumi et al., 2016; Le et al., 2012; Rekhi et al., 2018). Additionally, yearly dental check-ups, increased access to dental care services, and the use of tools to assess

the risk of AP should be incorporated into long-term care facilities (Gaszynska et al., 2014 & Nishizawa et al., 2019).

The Centers for Disease Control and Prevention and the World Health Organization have recommended implementing oral health programs for geriatric populations (Sharif-Abdullah et al., 2016). Evidence-based protocols for oral hygiene practices to prevent pneumonia must be established for nursing home residents (Hollaar et al., 2017). An increased level of involvement from care staff in performing daily oral hygiene activities is essential to improve quality of life.

Dedicating one oral health care aide to provide dental care is essential to track compliance and be implemented in future studies. One oral health care aid would help in the consistency and sustainability of the program. The allocation of time for oral care twice daily in long-term care facilities especially for patients who are at high risk for AP should be implemented. Chlorhexidine is also recommended in combination with toothbrushing for maximum benefits of increasing the oral health status in the geriatric nursing home population (Zimmerman et al., 2020).

Bacterial counts and OHAT are beneficial instruments for identifying patients at higher risk and are suggested by researchers (Nishizawa et al., 2019). Advanced microbiology strategies to identify the microorganism types are recommended for future research. Identifying critical pathogenic species associated with pneumonia are needed (Sharif-Abdullah et al., 2016). The identification of microorganisms would produce more reliable research and data to develop standard procedures for reducing aspiration pneumonia. Development of standard procedures would bring increased awareness and action in practicing oral care for geriatric patients (Sharif-Abdullah et al., 2016). Moreover, the effects of intensive oral care when hospitalized for pneumonia and the reduction in stay duration should be investigated (Chiang et al., 2020).

Improvement of dental awareness is possible even in the poorest economic circumstances for nursing home residents and caregivers. The financial cost is low to provide basic dental education programs and to motivate individuals to perform oral hygiene routinely. A dental check-up could be included with yearly routine medical examinations to off-set costs (Gaszynska et al., 2012).

Limitations

This can be a complex population to study due to many possible comorbidities that could confound the relationship between poor oral health and respiratory illnesses. A consequence of increased comorbidities in the study population can lead to a high attrition rate and can be a limitation across some studies with geriatric participants. Resistance to intervention compliance and failure to report are potential issues that can be expected with senior participants. However, there are consistent outcomes among the studies (see Tables 1-3) that point to strong evidence suggesting the association between oral diseases and an increased incidence of respiratory illness, the importance of oral health education for caregivers, and the significant need for preventive care in the geriatric nursing home population.

Conclusions

Respiratory infection caused by poor oral health in this population is a concern due to the high incidence and mortality rate. It is important to consider effective interventions for institutionalized elderly patients with high pneumonia mortality rates being reported across the globe. The extensive preventive dental care gap in nursing homes persists despite the evidence and the advancement of oral health education training for those working with the geriatric population. The implications of ignoring the oral health of the nursing home population are

grave. The older generation will suffer from respiratory illnesses that otherwise could be avoided with basic routine dental care.

In the future, a steady progression towards a mandatory universal standard of daily and professional oral health care in long-term care facilities would be highly beneficial for this population. Although the importance of good oral health concerning overall general health has been emphasized over the last several years, there is still an absence of understanding amongst caregivers. Implementation of oral health standards in nursing homes, reforms to medical profession curricula, and improved access to care are crucial to the growing elderly population's health.

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