

Effectiveness of On-Site Professional Oral Health Care Programs and Service Delivery  
within Nursing Homes: Preventing Bacterial Mouth Infection  
and Pneumonia/Aspiration Pneumonia

by

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## Abstract

**Background:** Seniors who are dependent on others to brush their teeth, communicate their dental needs, and provide them access to professional oral health care define dentally dependent nursing home residents in the context of this dissertation. Oral problems in Canadian nursing home (NH) residents demonstrate poor oral health states and inadequate oral health care programmes. A novel gold standard on-site professional oral health care (POHC) programme and its components showing clinical effectiveness and cost-effectiveness outcomes to reduce dental disease does not exist and is required to support policy recommendations.

**Purpose:** This Systematic Review (SR) evaluates the existing evidence on the clinical effectiveness and cost-effectiveness - inclusive of gold standard on-site POHC programme components - for the safety, efficacy, and effectiveness of reducing dental disease when compared to usual care – no on-site POHC or intervention.

**Methods:** The review is based on 13 clinical effectiveness studies. The clinical studies include nine randomized controlled trials (RCT) based out of a total of forty NHs (3 x one, two, three, four, eight, nine, and 11 NHs), two non-RCTs based out of three NHs (one and two), and cross-sectional studies based out of three NHs (one and two). The cost-effectiveness studies include two economic analysis studies based solely out of NHs with the comparator of usual care – no on-site POHC or intervention.

**Findings and conclusions:** Oral health measures were improved showing better oral health outcomes in the experimental group who received the on-site POHC intervention. On-site POHC services once per week by Registered Dental Hygienists (RDH), twice daily oral hygiene care by nursing assistants (NA), and monthly education, improves NH resident safety by reducing preventable bacterial mouth infection, pneumonia, and fatal aspiration pneumonia (AP).

In addition, on-site POHC appears to provide motivation, remotivation, staff support, and staff evaluation in NHs which improves guidelines and standards and implements new routines using a contact person for oral care. The policy makers need to consider policy change that provides funding according to the “level of need” to ensure all dependent NH residents receive access to essential oral health care. Successful implementation includes funding the frequency and duration of POHC, implementing and evaluating NH guidelines and standards for daily mouth care and professional oral health care (POHC), using an POHC program to measure nursing staff oral health work in relation to defined standards, and organizing long-term presence and guidance by dental hygienists. Some limitations across the included studies were small sample size, no control group, or not able to provide randomization.

Economic analysis found the potential value of access to on-site POHC programme, compared to usual care, weighs heavily on reducing transportation and hospitalization costs and the price point set by the programme planner. On-site POHC is a novel oral health system delivery program that provides on-site access to clinically effective, and likely cost-effective, sustainable, and high-quality care to seniors who reside in Alberta NHs. Future studies are needed to determine the cost-effectiveness of full-time RDHs providing these essential POHC program components using a “level of need” approach for all dependent NH residents.

## Preface

This thesis is an original work by Michelle Marusiak, an independent researcher. No part of this thesis has been previously published.

Michelle Marusiak contributed to the journal articles by identification and design of the research program, determining the PICO, inclusion and exclusion criteria, writing of the abstract, and discussion. Dr. Tania Stafinski was second reviewer of articles. Becky Skidmore provided the literature search and had her search peer reviewed. Dr. Arto Ohinmaa was third reviewer of articles.

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## **Dedication**

This dissertation is dedicated to all the dependent residents – our Alberta and Canadian seniors - residing in nursing homes who require on-site professional oral health care. You are forever in my heart and soul. I will cherish you and continue to uphold all your contributions to society.

May you receive equity by receiving access to universal on-site professional oral health care as your fundamental basic human right as you do in health care - without financial burden. May you receive dignity and respect by having your teeth brushed as often as you have your brief changed - without having to call for help. May you receive justice by living an increased quality of life because you can chew your food free of dental pain, bad breath, and mouth infection – during your last years of life.

I also dedicate this dissertation to all the nursing home residents who lost their lives due to the COVID-19 Pandemic, their family caregivers, and nursing home staff.

Rest in peace. Amen.

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## **List of Abbreviations**

nursing home (NH)

professional oral health care (POHC)

nursing assistants (NA)

registered dental hygienists (RDH)

emergency department (ED)

Coronavirus Disease (COVID-19)

Aspiration pneumonia (AP)

chronic obstructive pulmonary disease (COPD)

American Society for Geriatric Dentistry (ASGD)

nursing home aspiration pneumonia (NHAP)

community-acquired pneumonia (CAP)

The Resident Assessment Instrument-Minimum Data Set (RAI-MDS) 2.0

National Institute for Health and Care Excellence (NICE)

Brief Oral Health Status Examination (BOHSE)

Revised Oral Health Assessment Guide (ROAG)

Oral Health Assessment Tool (OHAT)

Centers for Disease Control and Prevention (CDC)

College of Registered Dental Hygienists of Alberta (CRDHA)

Canadian Dental Hygienists Association (CDHA)

Continuing Care (CC)

Alberta Health Services (AHS)

Goals of Care Designation (GCD)

long-term care facilities (LTCF)  
residential aged care facility (RACF)  
systematic review (SR)  
randomized controlled trials (RCTs)  
Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)  
population, intervention, comparator, outcome, and study design (PICOS)  
Oral Health Related Quality of Life (OHRQoL)  
Geriatric Oral Health Assessment Index (GOHAI)  
Oral Health Impacts Profile (OHIP)  
non-randomized controlled trials (non-RCTs)  
Peer Review of Electronic Search Strategies (PRESS)  
Mucosal Plaque Score (MPS) index  
current practice (CP)  
Health Care Aids (HCA)  
Canadian Institute for Health Information (CIHI)  
Canadian Agency for Drugs and Technologies in Health (CADTH)

## **Chapter 1. Introduction**

Globally, untreated tooth decay in permanent teeth remains the most prevalent health condition with a prevalence of 35.8% in Western Europe and an incidence of 49,344 per 100,000 person years in 2010 (Kassebaum et al., 2015). In Canada, pneumonia was a leading cause of emergency department (ED) visits in 2017-2018 climbing 13% from 2016. Out of the 135,000 pneumonia-related ED visits in 2016-2017, older adults admitted to hospitals comprised 65% (Dobrescu, 2017). Prevalence of dental/oral disease and pneumonia also increases with age (Ettinger, 2017). Longer life expectancy means people are retaining their natural teeth longer contributing to growing complexities of their oral health needs (Thomson & Ma, 2014). As the population ages there is an increase in incidence of dementia with the current Canadian nursing home (NH) count at 60% (Yoon et al., 2018). The result is a larger number of dependent NH residents requiring access to on-site professional oral health care (POHC) in NHs, who may not be able to access dental care, make their own decisions, nor communicate tooth, gum, or jaw pain. These residents have limited mobility and functionality, are high-risk for bacterial mouth infection and pneumonia events, increased health status deterioration, and increasing mortality risks (Budtz-Jorgensen et al., 2000; Adachi et al., 2002).

### **Social systems and demographics**

#### *Addressing gaps in our social systems*

The September 2020 Thrones Speech (Governor General, 2020) by the Canadian Federal government recognized that central to addressing the gaps in our social system is recognizing that one of the greatest tragedies of the COVID-19 Pandemic is the lives lost in long-term care facilities. Elders deserve to be safe, respected, and to live with dignity. The federal government

pledged to take any action it can to support seniors while working alongside the provinces and territories to set new, national standards for long-term care so that seniors get the best support possible (Governor General, 2020). The severity of COVID-19 continues to highlight the significant impact pneumonia has to the increased number of cases and mortality rate of nursing home residents by the exacerbated inequity in death rates in NHs when compared to non-NH Canadians. Neglect of seniors is putting NH residents in danger in their own residence (Estabrooks, 2020). Fevers (Adachi et al., 2002, 2007), pneumonia (Yoneyama et al., 2002), deaths from pneumonia (Yoneyama et al., 2002) and fatal aspiration pneumonia (AP) (Adachi et al., 2002, 2007) in NH residents can be significantly reduced by providing daily oral mouth care and essential on-site professional oral health care (Zaitso et al., 2018).

### *Teeth, gums, and the lungs*

The health status of the teeth and gums can play a role in how well lung disease is controlled. Cavities and gum disease are partly due to bacterial infection which can spread bacteria to the lungs (American Thoracic Society, 2019). Bacteria live in dental plaque which is a film that forms on the teeth. If bacteria are not reduced by tooth brushing and flossing, then bacteria can be inhaled into the lungs via saliva and food. Disease-damaged lungs in NH residents are not able to defend themselves making the lung infection or re-infection likely or lung problems worse. Gum disease can also worsen chronic inflammation in lung diseases such as chronic obstructive pulmonary disease (COPD), asthma, or pneumonia (ATS, 2019).

Dentures are a place to build bacteria so if they are not removed and cleaned after eating and at bedtime there is a high risk that bacteria can then be inhaled into the lungs. Dentures are not as good as teeth to chew so there is more risk of choking and aspiration into the airways.

Many inhaled anti-inflammatory and bronchodilator medicine can cause dry mouth making it easier to get cavities and gum disease since saliva is not able to protect the teeth from bacteria (Iinuma et al., 2015; ATS, 2019).

Oral candidiasis (thrush) is a yeast infection in the mouth that can be caused by inhaled medications. If the immune system is lowered, the mouth flora cannot balance the yeast so it will grow and spread. In order to prevent the lung problems from dental or gum disease, daily oral hygiene will significantly decrease yeast counts (Budtz-Jorgensen et al., 2000) and help remove bacterial plaque from the teeth and gums (ATS, 2019). POHC will remove yeast colonies (Budtz-Jorgensen et al., 2000) and unreachable bacterial plaque, remove tartar (which acts like an irritating sliver under the gums), provide enamel protection with fluoride varnish, provide an interim temporary white filling which slowly releases fluoride and soothes the tooth, and/or laser treatment to heal swollen, inflamed, bleeding, infected, and/or smelly gums.

There are four critical aspects of proper oral hygiene care for dependent NH residents: 1) twice daily oral hygiene care by a nursing assistant (NA) (Yoneyama et al., 2002) with guidance and supervision by a Registered Dental Hygienist (RDH) (Seleskog et al., 2018; Samson et al., 2009; Schou et al., 1989); 2) regular oral health screening upon admission and every 3 months by a RDH (Seleskog et al., 2018; Samson et al., 2009; Schou et al., 1989); 3) consistent on-site POHC provided by a RDH, once per week (Morino et al., 2004; Lee et al., 2020; Adachi et al., 2002, 2007); and 4) consistently embedded oral health hands-on education for NH staff (Seleskog et al., 2018; Samson et al., 2009; Schou et al., 1989). Good oral/dental health is important in NH residents because these seniors have a significantly higher percentage of cavities and gum disease and a significantly higher incidence of lung disease (Yoon et al., 2018),

predominantly of pneumonia (Yoneyama et al., 2002) or fatal aspiration pneumonia (AP) (Yoneyama et al., 1996; Adachi et al., 2002, 2007) than community-based seniors.

### *Dental/oral disease in the Canadian NH context*

A significant amount of dental/oral disease in Canadian NH residents can be prevented. NH residents experience problems in the mouth or jaw such as pain, gum, bone, and teeth infection; pus, swelling, broken, sharp, and decayed teeth; mouth sores; bad mouth odor; and denture-related tissue irritation (Yoon et al., 2018). The American Society for Geriatric Dentistry (ASGD) identified four objectives for oral health in the long-term care (NH) setting which provide the *dental professional perspective*. The four objectives were derived from the guidelines for delivering dental care in NHs via mobile and dental on-site care (Helgeson & Smith, 1996; Henry & Ceridan, 1994):

1. Oral health care should be provided to prevent disease, maintain chewing and speaking and preserve comfort, hygiene, and dignity.
2. Both the standard of oral health care and the access to it should be equal to that in the community.
3. Residents and or their representatives have the right to choose what specific oral health services will be provided.
4. All caregivers should advocate against neglect of oral health problems suffered by vulnerable adults who cannot advocate for themselves.

In response to the above objectives the interdisciplinary Delphi survey was developed so residents, their representatives, or other health professionals could corroborate recommendations from the ASGD.

To target outcomes for long-term care (NH) oral health care in persons with dementia, a three-round Delphi study was used to develop a list of target outcomes. Since nearly 60% of Canadian NH residents currently have dementia (Yoon et al., 2018), the Delphi Approach can be applied in the Canadian NH resident oral health care context. The Delphi Approach ranks the

top target patient-centered outcomes in decreasing order of importance according to family (*informal caregivers proxy preferences on behalf of NH residents with dementia*) and professional staff (Jones et al., 2000):

1. Patient will be free from oral pain;
2. Patient will not be at risk for aspiration;
3. Emergency dental treatment will be available when needed;
4. Prevent mouth infections;
5. Daily mouth care is as much a part of daily care as shaving or brushing hair;
6. Prevent discomfort from loose teeth or sore gums;
7. Teeth will be brushed thoroughly, daily;
8. Staff will be able to provide oral hygiene care as needed;
9. Provide dental care to prevent problems eating;
10. Recognize oral problems early;

### *Pneumonia*

Pneumonia describes an acute inflammation of the lungs and is commonly classified according to its origin of infection (Raghavendran et al., 2007). A standardized definition of infection for infection surveillance is used to define pneumonia (Loeb et al., 1999) (See Table 1.1).

**Table 1.1: Pneumonia Standardized definition of infection for infection surveillance** (Loeb et al., 1999)

Pneumonia is defined as the presence of compatible radiological findings and 2 of the following symptoms or signs:
New or increased cough
New increased sputum production
Fever $\geq 38^{\circ}\text{C}$
Pleuritic chest pain
New or increased chest examination findings
New or increased shortness of breath or respiratory rate of greater than 25 breaths/min
Worsening functional status

### *Aspiration pneumonia*

Aspiration pneumonia (AP) is defined as a misdirection of oropharyngeal or gastric contents caused by dysphagia. Contents include large amounts of oral bacteria flora and the section which invades the larynx and lower respiratory tract causing an infection in the lungs (Muller, 2015). Severe dental infections, pneumonia, and AP can lead to emergent hospital visits.

### *Risk factors for pneumonia*

For older adults, risk factors contributing to determinants of pneumonia, associated with increased hospitalization from pneumonia, include: needing to reside in a NH at an older age; being dependent on others for daily activities; being a lower income female; poorer health and socioeconomic status; and lack of access to oral health care (Australian Institute of Health and Welfare, 2006). In NHs, nursing home aspiration pneumonia (NHAP) is pneumonia occurring in NH or long-term care facility (LTCF) residents (Chalmers et al., 2009; Hopcraft et al., 2012).

Comorbidities that are risk factors for NHAP include: physical impairment, dementia, chronic obstructive pulmonary disease (COPD), mechanical ventilation, and ageing (Miegel & Wachtel, 2009; Vos et al., 2010). For NH residents, additional risk factors for AP are poor oral hygiene and oral hygiene-related factors such as denture use (Morgan M, 2012) and being edentulous (Tonmukayakul et al., 2015). Residents have an increased rate of dental plaque colonization acting as a possible reservoir for pathogenic organisms associated with community-acquired pneumonia (CAP) or NHAP (Azarpazhooh & Leake, 2006; Genco et al., 2001; Miremadi et al., 2017).

### *Burden of illness from dental problems and pneumonia*

Globally, untreated tooth decay in permanent teeth remains the most prevalent health condition with a prevalence of 35.8% in Western Europe and an incidence of 49,344 per 100,000 person years in 2010 (Kassebaum et al., 2015). Emergency department (ED) visits for dental problems not associated with trauma in Alberta, Canada reported a total of 147,357 (1.2%) ED visits over a 5-year period (Figueiredo et al., 2017). The visits were made by 111,362 individuals, representing 1.3 visits per person. Mortality rates reported for older patients in NHs with pneumonia are up to 30%.

The overall economic burden of pneumonia on the older adult population is evident by the percentage of hospitalizations in Canada. Pneumonia was a leading cause of ED visits in 2017-2018 climbing 13% from 2016 (CIHI, 2018).

### *Prevalence and incidence*

Overall, Albertans reporting the most prevalent primary diagnosis of ED visits was for periapical abscess (45%) (diseases of pulp and periapical tissues; K04), and toothache (18%) (pain in the tooth; K08). The frequency of ED visits for dental problems not related to trauma suggest barriers faced by the population in accessing dental care resources, especially for urgent dental needs. Policy efforts and political will are needed to provide alternative options for accessing emergency dental care (Figueiredo et al., 2017) but more importantly for preventing emergent dental care in the first place. Out of the 135,000 pneumonia-related ED visits in 2016-2017, older adults admitted to hospitals comprised 65%. In 2010 those aged 65+ utilized \$216.2 million in total direct health care costs for hospitalized pneumonia. Of that \$216.2 million health

care cost, those aged 75+ accounted for 78.1 percent of hospitalized pneumonia in Canada (Dobrescu, 2017).

The incidence of dental disease and pneumonia increases with age (Yoon et al., 2018). The incidence is becoming an increasing concern as the number of Canadians aged 65 years old or greater increased 14.1% between 2006 and 2011. This currently represents 14.8% of the population (Statistics Canada, 2011). The most-rapidly growing age group in Canada are persons aged 60 to 64 years. This number is expected to continue to grow.

### **Current management**

Diagnosis of oral/dental problems for NH residents is provided by nursing assistants (NA). NH residents are first assessed upon new admission into the NH and every three months consecutively. The NAs complete The Resident Assessment Instrument-Minimum Data Set (RAI-MDS) 2.0 oral/dental items tool by checking off the following: 1) K1. Oral problems: chewing problem, swallowing problem, mouth pain; 2) L1. Oral/Dental Status: Debris prior to going to bed at night, has dentures and/or removable bridge, broken, loose, carious teeth, inflamed gums, daily cleaning of teeth/dentures or daily mouth care by resident or staff. If the NA finds a dental problem, then they check it off on the RAI-MDS 2.0 and are supposed to communicate their findings to the LPN or RN (Yoon et al., 2018). In some NHs, an RDH, dentist or denturist is contacted to provide an on-site POHC visit if prior consent is obtained by the decision maker. NH residents are diagnosed with pneumonia according to the standardized definition as stated in the previous Table 1.1.

*NH intervention by NAs to help prevent cavities, gum disease, and lung problems*

A number of NH interventions can be provided by NAs to help maintain the oral health of dependent NH residents and include: 1) providing the resident with twice daily removal of food debris (swab or rinse) and bacterial plaque with a tooth brush and interdental brush with fluoridated tooth paste. If dentures are present, brush the denture to remove plaque and food debris with denture brush; 2) encouraging the resident to rinse out their mouth with water. If the resident cannot rinse out their mouth, then the NA can swab out the debris, so the pocketed food is removed; 3) providing the resident with water (or thickened fluids) after eating any foods. If the resident cannot drink water, then the NA can use a swab to remove debris; 4) If appropriate, provide the resident with sugarless gum or mints to stimulate saliva flow and reduce decay or moisturizing gel to lubricate the oral tissues; and 5) annual immunization against influenza and pneumococcal pneumonia to reduce the risk of respiratory infection (Alberta Health Services, 2015).

It is also recommended that residents, nursing staff, and informal caregivers receive education and NH-based clinic visits with a multidisciplinary team of health care professionals specialized in geriatrics (Yoon et al., 2020). Improving the training of care staff and providing appropriate time to conduct the assessments can improve the quality of RAI oral/dental assessments. Rewording some items or using more robust tools can also improve assessment quality. Also, ensure there is communication of oral/dental concerns by the NA's to the LPN/RN and follow-up with a referral (Yoon et al., 2020). NH staff and informal caregiver education and close supervision by an RDH would help to reduce the likelihood of noncompliance to current NH oral/dental assessments (AHS, 2015). It can also help in the early

detection of white spots on teeth enamel so that the future effects of pre-decay can be reversed and dental and pneumonia clinical episodes are avoided (Yoon et al., 2020).

### *Professional Oral Health Care (POHC)*

The aim of Professional Oral Health Care (POHC) is to maintain and improve NH residents' oral health. Most NH residents with oral/dental problems will need timely access to a POHC intervention. Prescribed therapies will vary depending on the severity of symptoms, the cause of oral/dental problems, and on the patients' response to the POHC (AHS, 2015).

According to the National Institute for Health and Care Excellence (NICE) guidelines (NICE, 2016), common oral health therapies recommended for most NH residents to reduce morbidity associated with oral and dental disease include:

1. Routine or specialist preventive care and treatment, as necessary. This includes dental checks, restorative, teeth cleanings, mouth care plans and denture need at intervals and frequencies dictated by the resident's oral health needs.
2. Oral health professionals provide residents with access to dental care to maintain good oral health.
3. Oral health professionals collaborate among a range of health care and home care professionals and provide oral health care according to the residents' decision maker including informal caregivers, who in many cases, speak on behalf of the dependent resident.
4. Reduce life-threatening conditions such as aspiration pneumonia by removing oral access barriers.

The NICE guidelines (NICE, 2016) informing oral health for adults (residents) in care homes (NHs) will be used in this dissertation as they provide the *public health care payer perspective* as the reference case. The public health care payer is also the reference case for this dissertation in the economic analysis section.

#### *NH staff and informal caregiver oral health education for resident's oral health*

NH staff need to be trained and supervised on an ongoing basis to ensure compliance with providing NH resident's daily oral hygiene care, as follows. First, a standardized, validated oral health assessment tool is used to improve the resident's oral health and help remove barriers to accessing dental treatment. Three evidence-based tools described in the best practice guidelines include: the Brief Oral Health Status Examination (BOHSE) (Kayser-Jones et al., 1995), Revised Oral Health Assessment Guide (ROAG) (Ribeiro et al., 2013), and the Oral Health Assessment Tool (OHAT) (Thapa et al., 2021). However, nursing skills may be needed to use the BOHSE and ROAG. Second, care staff should have the necessary confidence, skills, and knowledge, including ability to treat residents with sensitivity, compassion, and dignity. Resident care planning is important in relation to daily mouth care, oral health improvement, and access to dental treatment. These dental plans need to be delivered, regularly monitored, and evaluated for completion and accountability.

#### *Care staff knowledge and skills*

Care staff knowledge about oral health and the skills to perform daily mouth care affects the oral health care of residents. Sufficient or improved oral health knowledge and skills helps promote access to dental treatment services. If a care home has a positive attitude to oral health care this can lead to dental team involvement. If the local decision maker appoints a 'champion'

as the dedicated staff member, this member can lead the oral health program (Sheiham et al., 2001).

#### *Availability of local oral health services*

Many residents in Canadian NHs have unmet oral health needs (Yoon et al., 2018). Commissioners of NHs and public health services have a duty of care to ensure those oral needs can be met. Current funding structures and arrangements for dental services provided for care homes are poorly understood and confusing. Limitations to oral health professionals current fee-for-service restrictions as well as inadequate publicly funded dental benefits for NH residents may contribute to lack of POHC for NH residents. There is a need for POHC service delivery development to improve the access to dental care for residents. The outcomes of these actions help residents maintain their oral health and are likely to be cost saving to both health care and social care pathways. These savings would be realized from the opportunity costs of supporting residents to gain access to multiple treatments if their oral health declines. It would also avoid the inability to maintain an appropriate nutritious diet and other basic needs. One solution is on-site POHC provided in NHs.

On-site POHC in NHs would provide direct access for resident oral health care. It may require additional resources to implement frequent intervals of routine mouth care as this is not already in current practice. For example, currently the Alberta seniors' dental benefit only provides enough scaling units to provide professional bacterial plaque removal once every three months if the senior qualifies for extra scaling and root planning units (Government of Alberta, 2021). However, research shows that NH residents require POHC once per week, for the time period the resident is living in the NH. But the good news is this is likely to be more offset by the

benefit to residents in terms of quality of life. Identifying problems early will also reduce the likelihood of future treatment costs (Sheiham et al., 2001).

Access to dental services to meet NH resident's oral health needs is a basic right. Being able to access dental services for unmet treatment needs is an inequity in service provision. This inequity needs to be highlighted and addressed in policy as it could lead to potential health and social care cost savings. On-site POHC would lead to a systematic, less variable access to oral health treatment to diagnosed oral health problems at an earlier stage of the disease pathway.

Community dental clinics should act as first point of call for routine and preventive care and dental treatment in NHs. Many dental practitioners are unwilling to provide services in NHs due to lack of time, inadequate funding, lack of suitable equipment, and training to meet the residents' complex needs. An on-site POHC program by RDHs can provide the needed specialist equipment to take into the NH. The infection control is universal and at a high level. The RDH provides procedures that are non-aerosol generating, non-invasive, with no vibrations, smells, or noises.

This is particularly important considering the COVID-19 Pandemic guidelines according to the Centers for Disease Control and Prevention (CDC, 2020), the College of Registered Dental Hygienists of Alberta (CRDHA, 2020), the Canadian Dental Hygienists Association (CDHA, 2020), and Continuing Care Safety Association (CCSA, 2020; GOA, 2020). In many cases, the procedures are provided bedside facilitating a relaxing environment for successful dependent resident's oral health care in the comfort of their own NH. In many cases, the resident does not need to be taken off-site as they may have mobility issues, a disability, dementia, and complex medical conditions (Sheiham et al., 2001).

On-site POHC in NHs is permitted if the oral health professional is registered in good standing with their applicable licensing body. The oral professional must follow the licensing body Practice Standards and Code of Ethics for ensuring safe and informed POHC (CRDHA, 2020). In addition, the NH administrator must provide the oral health professional with authorization to deliver services in the NH. If the professional oral health care provider is an RDH, they will need to be working as an independent RDH without supervision of a dentist. The RDH should have a minimum of 5 years of experience and will need to be knowledgeable in providing safe and effective on-site POHC for medically complex and vulnerable dependent NH residents (CRDHA, 2020).

Short and long-term clinical effectiveness studies of NH resident on-site POHC is not needed in research and has been proven in other countries. However, more systematic evidence is needed on what components are implemented to make up the most effective POHC program intervention with the largest reduction in plaque bacteria, yeast, pneumonia and fatal aspiration pneumonia in NHs.

On-site POHC would meet the oral health needs of the growing NH population by ensuring timely access to oral health when needed. RDHs currently choose to provide on-site POHC and can be added to the Continuing Care (CC) standard of requirements for health professional workers in NHs. Given the COVID-19 Pandemic, the RDH essential services would provide decreased gum inflammation outcomes. This lessens the health professional burden and helps stimulate the economy. The demand for COVID-19 testing has enabled RDH's to provide nasal swabs to help speed up testing. In NHs the on-site RDH could swab the mouth to test the NH resident for COVID-19. The supervision by the RDH could be realized in NHs and finally the integration of RDHs into the specialty geriatric health care system.

Patterns of care are affected by the RDH's lack of access, as a custodian of medical records, to administrative healthcare files including Alberta NetCare, Electronic Health Records. As a result, the RDH must ask the NH to provide them with a copy of the residents' admission record and medication list, if the resident requires blood thinners lowered, premedication, or sedation prior in preparation for their appointment time. The NH may also be required to transfer the resident into their bed for on-site bedside POHC services.

In Canada, there are 1,360 continuing care NH facilities (residential care) with 207,424 residents. Alberta residential care comprises 175 facilities and 21,886 residents (CIHI, 2012). Projections in Canada predict that by 2052, the most elderly who are aged 85 and over, will account for nearly 25% of all older adults and 6% of the total population. This 25% increase will triple the current numbers (CIHI, 2012). The growing segment of this elderly group will increase required NH services. The forecast of an additional 200,000 beds will be required by 2035 which is almost double the existing number of beds in 2016 (CIHI, 2017-2018 and 2018-2019).

Prevalence of dental/oral disease also increases with age (Griffin et al., 2012). Longer life expectancy means people are retaining their natural teeth longer contributing to the growing challenges and complexities of their oral health needs (Griffin et al., 2012). There is also an increase in the incidence of cognitive impairment including dementia, as the population ages. In Canada, it is estimated that the number of people with dementia may double by 2030 and triple by 2050 (Hoben et al., 2016). It is predicted that by 2038, the demand for long-term care will increase 10-fold (Yoon et al., 2020) with one of the strongest predictors of admission being cognitive impairment (Gaugler et al., 2007). On-site POHC will provide oral health care access to these vulnerable NH residents in Alberta and Canadian.

Currently, there is some health system capacity in Alberta and Canada to deliver on-site POHC in NHs. There are mobile companies who provide on-site POHC in over 35 NHs in Edmonton. Similar providers are also in the surrounding areas and in other provinces in Canada. If mobile POHC companies accommodates this service in all the Alberta NHs then the hiring, training, and placement of additional independent RDHs will be required. Additional dental equipment will also need to be purchased. If public funding is provided so that all NH residents receive on-site POHC then it is feasible to make the change from a public-private payer system to a public health care payer system. Currently, there are enough RDHs to provide the workforce and infrastructure capacity to place over two RDHs per NH, five days per week.

There are also new developments such as tele dentistry which has been quickly implemented to help meet the needs of NH residents who are isolated during the COVID-19 Pandemic. Telephone consultations minimize the number of in-person visits and lessen the spread of infectious disease. This is a cost-effective way to provide supervision to NAs, timely access to oral assessments, and ensure the residents quarterly meetings are attended by the multidisciplinary team.

As of June 25, 2012, Canadian Agency for Drugs and Technologies in Health (CADTH) provided a *Rapid Response Report: Summary With Critical Appraisal* to report on routine dental care programs in long-term care with focus on the clinical effectiveness and guidelines (CADTH, 2012). Currently, there are no ongoing clinical trials for on-site POHC in Alberta or Canadian NHs. There have been no adverse effects reported from providing on-site POHC in NHs if non-aerosol and non-invasive practice guidelines are followed for working with vulnerable, medically complex NH residents particularly with dysphagia.

Best practice guidelines for oral health for adults in care homes in England was provided by the NICE according to the public health care payer perspective (NICE, 2016). For assessment, referral, and treatment of pneumonia in NHs, AHS has provided an online document (AHS, 2017).

One gap in AHS's document, *Toward Optimized Practice*, is the document does not contain any direction for oral care nor mention of oral care in the Goals of Care Designation (GCD) Order (AHS, 2015). This document does provide details on diagnosis and management of NHAP including a summary of the Alberta clinical practice guidelines. Prevention measures in these guidelines promote good oral hygiene. However, neither the guidelines nor checklist provide direction for daily mouth care nor on-site POHC program intervention components in the treatment nor prevention of viral respiratory tract infections.

Filling this gap by providing clear clinical requirements are warranted in both the AHS's policy document and the Alberta Doctors guidelines because a poor oral health state predisposes residents to pneumonia and recurrent pneumonia. The risk factor of poor oral hygiene inducing aspiration pneumonia (Muller, 2015) can be prevented by implementing RDH's as part of the clinical team in NHs to ensure guidelines are adequate.

The therapy research question for this dissertation is "In nursing home residents with oral health needs, what components of on-site professional oral health care are clinically effective and cost-effective in reducing dental disease and pneumonia/AP, when compared to usual care?"

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## **Chapter 2. Clinical Effectiveness of On-site Professional Oral Health Care for Nursing Home Residents compared to Usual Care: A Systematic Review**

### **Abstract**

#### **Background**

Nursing home-acquired pneumonia (NHAP) is the leading cause of mortality among residents. NHAP is defined as pneumonia occurring in residents living in long-term care facilities (LTCF) and nursing homes (NH). Aspiration of oropharyngeal flora into the lungs and the failure of the individual's defense mechanisms to eliminate the aspirated bacteria is one cause of NHAP. Different types of professional oral health care (POHC) and daily mouth care can reduce harmful oral bacterial plaque and yeast and can be an effective intervention in decreasing the risk of pneumonia and fatal aspiration pneumonia.

#### **Objectives**

To determine the effectiveness and components of on-site POHC interventions/programs delivered to NH residents to reduce dental disease and pneumonia/aspiration pneumonia (AP) when compared to usual care.

#### **Search methods**

An expert medical information specialist (BS) searched the PubMed (MEDLINE) database on 26 March 2020. The lead author (MM) searched several bibliographical databases up to the end of April 2021.

#### **Selection criteria**

We included randomized controlled trials (RCTs), non-RCTs, and cross-sectional studies, comparing the effectiveness of POHC components of oral hygiene interventions and educational

programmes by dental professionals on the reduction of dental disease and prevalence of fever and fatal aspiration pneumonia (AP).

## **Results**

Thirteen studies were included in this review. We found 40 NHs (1,216 residents) from nine RCTs, three NHs (274 residents) from two non-RCT, and three NHs (176 residents) from two cross-sectional studies. On-site POHC improved NH resident safety by reducing preventable bacterial mouth infection, pneumonia, and fatal aspiration pneumonia (AP). On-site POHC services once per week by RDHs, twice daily oral hygiene care by NAs, and monthly education, motivation, remotivation, and staff support improves NH resident safety by reducing preventable bacterial mouth infection, pneumonia, and fatal aspiration pneumonia. On-site POHC supports NHs staff to follow guidelines and standards and implements new routines using a contact person for oral care.

## **Conclusion**

Oral health measures were improved showing better oral health respiratory infection outcomes in the experimental group who received on-site POHC intervention. Successful implementation includes funding the frequency and duration of POHC, implementing and evaluating NH guidelines and standards for daily mouth care and professional oral health care (POHC), using an POHC program to measure nursing staff oral health work in relation to defined standards, and organizing long-term presence and guidance by dental hygienists. Some limitations across the included studies were small sample size, no control group, or not able to provide randomization.

## Introduction

Longer life expectancy means seniors are retaining their natural dentition into their dependent years contributing to growing complexities of their oral health needs (Thomson & Ma, 2014). To add to the oral health complexities there is a 60% incidence of nursing home (NH) residents now diagnosed with dementia (Yoon et al., 2018), that has been proven to negatively impact oral health resulting in high level of oral diseases (Chalmers et al., 2002; Jockusch et al., 2020).

Prevalence of dental/oral disease increases with age (Ettinger, 2017). The estimated prevalence of oral health problems in Canadian nursing home (NH) residents is on the rise. The NS residents' oral problems include lip problems (69.8%), thick saliva (39%), bad breath (31.1%), no teeth (42.4%), angular cheilitis (5.1%), denture stomatitis (8.5%), denture induced hyperplasia (2.0%), glossitis (7.2%), moderate to severe gum inflammation (79.6%), teeth or jaw pain (<20%), poor fitting denture (44.6%), required urgent dental treatment for broken teeth, infection, severe decay, and ulcers (8.6%), oral health to significantly impact food intake (19.5%), and oral health status that makes food intake challenging (30%) (Yoon et al., 2018).

In Canada, pneumonia was the leading cause of emergency department (ED) visits (65%) in 2017-2018 with older adults who were admitted to hospitals (Dobrescu, 2017). In NHs, nursing home acquired pneumonia (NHAP) is the leading cause of mortality among residents (Cho et al., 2011; Nicolle et al., 1996). Comorbidities that are risk factors for NHAP include physical impairment, dementia, chronic obstructive pulmonary disease (COPD), mechanical ventilation, and older age (Klapdor et al., 2012; Ticinesi et al., 2016). For NH residents, additional risk factors for aspiration pneumonia (AP) are poor oral hygiene and oral hygiene-

related factors such as denture use (O'Donnell et al., 2016) and being edentulous (Abe et al., 2008). Residents having an increased rate of dental plaque colonization acting as a possible reservoir for pathogenic organisms have associated NHAP (Bassim et al., 2008; Janssens et al., 2005; Scannapieco et al., 2003).

## **Rationale**

The severity of COVID-19 continues to highlight the significant impact pneumonia has to the increased number of cases and mortality rate of nursing home residents by the exacerbated inequity in death rates in NHs when compared to community living Canadians. Canada has the highest number of excess death rates in nursing homes when compared globally (Hsu et al., 2020). NH residents are in danger in their own residence. The care provision problems are a tragedy because the suffering and pain caused by pneumonia and aspiration pneumonia in NH residents can be reduced or prevented by providing daily oral mouth care and essential on-site professional oral health care (POHC). The Centers for Disease Control and Prevention (CDC) guidelines state during the COVID-19 Pandemic non-aerosol generating POHC are essential to reduce gum inflammation especially for vulnerable seniors residing in NHs (CDC, 2021).

On-site POHC is a mobile and on-site delivery health system that provides essential non-aerosol generating and non-invasive oral health care access within the clinical treatment pathway. On-site POHC is essential for vulnerable dependent NH residents who are medically compromised, mobility challenged, have dementia, are fearful of dental care, and cannot easily be moved nor transported to conventional dental clinics. The design of on-site POHC facilitates systematic interdisciplinary oral health care for NH residents. On-site POHC delivery systems in

NHs could provide the following standardized preventive programs: 1) a daily oral care system; 2) Registered Dental Hygienists (RDHs) training nursing assistants (NAs) to provide daily mouth care; 3) providing direct and indirect supervision; 4) providing oral assessments; 5) providing education for nursing staff; and 6) participation in the medical-dental management of medically compromised and vulnerable dependent residents (Helgeson & Smith, 1996).

On-site POHC provides accessible oral health services in the NH residents bedroom either in a chair with headrest or bedside. On-site POHC services include routine (oral health examinations and dental hygiene therapy), emergency oral health services (atraumatic restorative treatment and/or laser treatment, referral to medical doctor, referral to hospital or university dental clinic), and regular dental visits. The service is delivered in the most cost-effective system by bringing mobile and portable clinics into NHs. Portable clinics are the only delivery system able to provide access to care for bedridden residents and can still maintain high-quality dental care services (Helgeson & Smith, 1996).

For the purposes of this systematic review (SR) and the nursing home context of oral health problems, dental disease is defined as a poor oral health state (Yoon et al., 2018). In the context of content and quality of oral health care and exacerbation of lung problems, pneumonia and NHAP is defined as preventable lung infection by reducing oral bacterial, dental disease, and mortality rates in NH residents.

## **Objectives**

A systematic review was conducted to assess the existing evidence on clinical effectiveness of on-site POHC program components in NHs for reducing dental disease as a primary outcome and pneumonia or aspiration pneumonia (AP) as a secondary outcome. This

study aims to provide rigorous evidence needed to support future policy deliberations regarding the value of universal oral health care as a publicly funded health care service delivery system in Alberta NHs.

The primary objective addressed in this study is to determine the effectiveness and components of on-site POHC interventions/programs delivered to NH residents to prevent, assess, and treat dental disease and pneumonia/AP. The therapy research question is “In nursing home residents with oral health needs, is on-site professional oral health care clinically effective in reducing dental disease and pneumonia/AP, when compared to usual care?”

## **Methods**

### *Protocol and registration*

We followed the systematic review standard procedures and reported results according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). The project protocol was not publicly posted prior to data extraction.

### *Eligibility criteria*

A preliminary literature search of randomized controlled trials (RCTs) and other peer reviewed studies of relevant clinical and cost-effective outcomes helped define the population, intervention, comparator, outcome, and study design (PICOS). The search was limited to English and human studies without date limits. Monthly update searches in PubMed were performed from March 2020 to April 2020 and March 2021 to April 2021. We added economic search

terms which could be used in a separate SR. For economic evaluation searching an economic filter was applied.

#### *Inclusion criteria*

The study characteristics for the PICOS included NH residents with dental disease (**P**); POHC services delivered in NHs (**I**); usual care as current practice (CP) (**C**); primary outcomes were dental disease specific assessment tools measuring plaque levels, gum inflammation, bones levels, and decayed teeth (**O**); secondary outcomes were pneumonia rates, aspiration pneumonia ratios, Oral Health Related Quality of Life (OHRQoL) tools that target the elderly such as Geriatric Oral Health Assessment Index (GOHAI), Oral Health Impacts Profile (OHIP) (**O**); and randomized controlled trials (RCTs), non-randomized controlled trials (non-RCTs), single-arm trials, cohort studies, case-control studies, and case-series studies (**S**).

#### *Exclusion criteria*

The excluded PICOS study characteristics included non-NH patients (**P**); independent living or supportive/assisted living environments and not a program (**I**); POHC services delivered in independent or supportive/assisted living environments (**C**); studies without any defined clinical outcomes or relevant clinical outcomes (**O**); non-English language as no translator was available and single case reports, expert reviews, editorials, and opinion pieces (**S**).

#### *Information sources*

An expert medical information specialist (BS) developed and tested the search strategy using an iterative process in consultation with the lead author (MM). The strategy was peer

reviewed by another senior information specialist prior to execution using Peer Review of Electronic Search Strategies (PRESS) Checklist (McGowan et al., 2016).

### *Search strategy*

A comprehensive literature search was conducted to identify studies on the effectiveness of on-site POHC interventions in NH residents. Full details of the literature search are reported in Appendix A. The lead author (MM) searched the following bibliographic databases: The Cochrane Library (28 March 2020), the Centre for Reviews and Dissemination (DARE, NHS, EED, and HTA) (29 March 2020) databases, EMBASE (Ovid 1974 to 2020 March 28), Web of Science (29 March 2020), CINAHL (28 March 2020), and EconLit (30 March 2020). The US National Institutes of Health Trials Registry (ClinicalTrials.gov) were searched for ongoing trials (29 March 2020). No restriction was placed on the language or date of publication when searching the electronic database. MM also searched NHS Evidence (<https://www.evidence.nhs.uk/>) (20 March 2020), International Prospective Register of Systematic Reviews (PROSPERO); National Institute for Health Research (<http://crd.york.ac.uk/prospero/>) 29 March 2020, US National Library of Medicine; US National Institutes of Health; US Department of Health & Human Services; Canadian Health Services Research Foundation (CHSRF) (29 March 2020) and Institute for Research on Public Policy (IRPP) (30 March 2020); National Institute for Health and Care Excellence (NICE) (<https://www.nice.org.uk/guidance/ng48/>) (29 March 2020). (Appendix A). An update of the search was completed in March 2021. An exemplary search strategy from the PubMed (MEDLINE database can found in Table 2.1).

### *Study selection*

Reference lists of relevant papers were reviewed. Two reviewers (TS and MM) independently reviewed the titles and abstracts of the search results to identify studies for inclusion. Seventeen citations were selected from the literature search results for full text review of potentially relevant papers for eligibility according to the PICOS inclusion and exclusion criteria (Figure 2.1). Four met the inclusion criteria for the assessment. Of the 13 excluded citations, 4 (2 abstracts and 2 case studies) reported on the same populations as the 2 included studies. These 4 citations were excluded as they did not provide any additional details.

Two reviewers (AO and MM) independently reviewed manually searched titles and abstracts retrieved from the reference lists of included studies and Google search. Two authors were contacted for a copy of their article, but no response was received. One author was contacted for the included number of nursing homes and responded. Fifteen citations were selected from the manual search results for full text review. Nine met the inclusion criteria for the assessment. The total number of included studies was increased from four to 13 (Figure 2.1). The total number of excluded studies was increased from 12 to 19 (Table 2.2.).

## PRESENTING SEARCH RESULTS - POHC

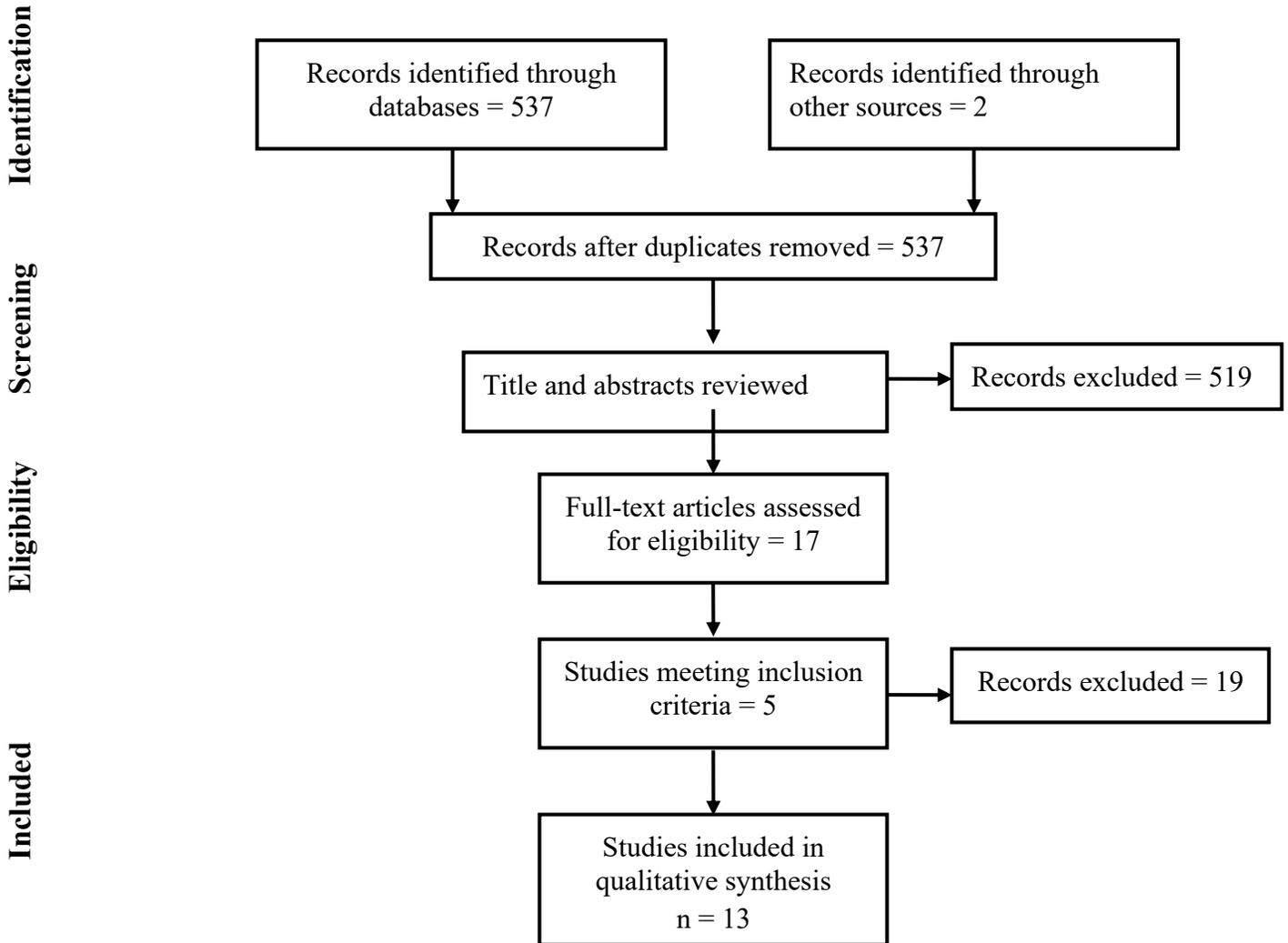


Figure 2.1 PRISMA flow diagram (<http://www.prisma statement.org/statement.htm>)

### *Overall description of included studies*

The review articles were published between 1989 and 2020. These studies are based out of Belgium (Budtz-Jorgensen et al., 2000); Japan (Yoneyama et al., 1996; Adachi et al., 2002; Yoneyama et al., 2002; Adachi et al., 2007; Morino et al., 2014); Korea (Lee et al., 2020); Scotland (Schou et al., 1989); Switzerland (Mojon et al., 1998); Norway (Samson et al., 2009); Germany (Zenthöfer et al., 2013); and Sweden (Seleskog et al., 2018; Girestam et al., 2020).

### *Data collection process and study selection*

The reviewer (MM) extracted information from the included studies using a standardized extraction table. Data was extracted by adhering to the PICOS inclusion criteria of study characteristics. Studies and reasons for exclusion are located in Table 2.2. Details of methodologies of included studies are summarized in Table 2.3 and major findings summarized in Table 2.4. The reviewers MM and AO compared results, and discussed and resolved any disagreements between them.

### *Risk of bias and study quality*

Quality assessment regarding the methodological quality of the included studies were evaluated using the GRADE (Table 2.5) checklist, a validated method for evaluating studies on their reporting, internal validity (bias and confounding), external validity, and power (Balshem et al., 2011). The included studies were ranked based on their design and methodological rigor from highest (SR of RCTs) to lowest (expert opinion) quality level.

### *Summary Measures*

The principal summary measures of outcomes were severity and change in oral hygiene state or level after the professional oral health care programme intervention. Changes were measured as mean or median numbers (percentages) and the significance level set to  $P \leq 0.05$ . Primary outcome measures include: abnormal pathogens of sputum, *C. albicans*, debris indices, febrile days, dental plaque index or levels, maxillary denture plaque, mucosal-plaque score, and/or muscosal score (primary outcomes), and aspiration pneumonia (AP) by number of deaths, and the change in mortality rate was measured by the number of patients who received the POHC program, and health-related quality of life (HRQoL) (secondary outcomes) (Table 2.4).

## **Results**

### *Quality of included studies*

Out of the thirteen studies assessed in this report and included in the review, nine of the studies were RCTs (Yoneyama et al., 1996; Adachi et al., 2002; Yoneyama et al., 2002; Morino et al., 2004; Lee et al., 2020; Schou et al., 1989; Mojon et al., 1998; Zenthöfer et al., 2013; Girestam et al., 2020) and they were considered to be on a high quality of evidence (Balshem et al., 2011). The two non-RCTs (Budtz-Jorgensen et al., 2000; Seleskog et al., 2018) and the two cross-sectional studies (Adachi et al., 2007; Samson et al., 2009) were considered to be on the medium quality of evidence (level 2-3) (Table 2.5). The total number of patients in these studies was 1666.

Assessment of the studies using the GRADE guidelines (Balshem et al., 2011) (Table 2.5) for rating the quality of evidence allowed for certain weaknesses to be identified. Failure to report conflict-of-interest (COI) was identified in eight studies (Yoneyama et al., 1996, 2002; Adachi et al., 2002, 2007; Schou et al., 1989; Mojon et al., 1998; Budtz-Jorgensen et al., 2000;

Zenthöfer et al., 2013) and one study had potential conflict interest (Samson et al., 2009). In the Mojon et al. (1998) study, the controls were likely contaminated by receiving dental treatment during the study. In the Selesko et al. (2018) study, the short 3-month intervention period may not have provided the time required to see significant improvement in the nursing staff attitudes and values and the study was missing a control group for the nursing staff.

Failure to report confidence intervals (CI) was identified in 10 studies (Yoneyama et al., 1996; Adachi et al., 2002, 2007; Lee et al., 2020; Schou et al., 1989, Mojon et al., 1998; Budtz-Jorgensen et al., 2000; Samson et al., 2009; Seleskog et al., 2018; Girestam et al., 2020). The study by Zenthöfer et al. (2013) had a small sample size with very low statistical power. The study by Seleskog et al. (2018) had a small sample size and underpowered study (Table 2.5).

Certain strengths were also identified using the GRADE guidelines (Balshem et al., 2011) (Table 2.5). The RCT's by Mojon et al. (1998) and Girestam et al. (2020) are of highest methodological quality. In the RCT by Mojon et al. (1998), to increase reliability two different dentists were calibrated and to reduce bias were blinded to the ward the resident lived in and to previous examination forms. In the RCT by Girestam et al. (2020), residents were randomly assigned to the intervention or control group at the NH level and three RDHs were blinded and calibrated.

In the RCT study by Lee et al. (2020) the residents were randomly assigned to the same RDH and RDHs were blinded to group selection. In the RCT by Morino et al. (2014) the intervention and control group only differed in who was providing the oral care and the sample examiners were blinded to the intervention. In the RCT by Schou et al. (1989) the four

institutions were randomly allocated to a control group or one of the three programmes and were blinded to the examiners.

Comparison of the quality of evidence between studies shows that in the RCT's by Yoneyama et al. (2002, 1996) and Adachi (2002) residents were randomly assigned to groups however there was no mention of blinding or calibration of evaluators. In the prospective, single blinded Randomized Clinical Trial, Zenthöfer et al. (2011) did not state if the residents or the NHs were randomized.

In the Controlled Clinical Trial with longitudinal design, Seleskog et al. (2018) randomly assigned NHs for intervention or control, each resident served as their own control, and clinical evaluators were blinded to the assignment of facilities to the intervention or control group. In the non-RCT by Budtz-Jorgensen et al. (2000) inter-reliability of the evaluator was compared by previous and current evaluators independently scoring 10 randomly drawn residents.

In the cross-sectional studies by Samson et al. (2009) and Adachi et al. (2007) the residents served as their own control but were not randomized to the treatment or control group inducing the risk of selection bias and confounding. However, in the Samson et al. (2009) study inter-reliability of the evaluators increased reliability whereas in the Adachi et al. (2007) study (weakest) there was no mention of blinding or calibration of clinical evaluators thus reducing reliability (Table 2.5).

### **Professional Oral Health Care Programs**

Overall, the POHC Programs were divided into five categories. Service provision only, education only, both service provision and education, and POHC and education/motivation/remotivation or staff evaluation and POHC (Table 2.3).

### *Service provision only*

The interventions of the included studies in the service provision only category were as follows: (1) professional oral care (POC) by a dentist and/or RDH once/day for six months (Yoneyama et al., 1996); (2) Professional oral health care (POHC) by RDHs using scaling, electric brush with automatic water supply, interdental brush, sponge brush to clean teeth and dentures once/week for six months (Adachi et al., 2002); (3) POHC by dentists or RDHs of plaque and calculus control and denture cleaning with denture brush daily and daily cleanser once/week for two years (Yoneyama et al., 2002); (4) POHC by RDH of brushing teeth using an electric brush with automatic water supply, interdental brush and sponge brush and cleaned dentures for two years (Adachi et al., 2007); (5) POHC by two RDHs using manual toothbrushing only, after breakfast once/week for one month (Morino et al., 2014); and (6) POHC by four RDHs providing denture cleaning using a suction device and teeth cleaning using rolling, Watanabe and Bass brushing, interdental brushes and resident rinsing with water, debris removal and tongue wiped using chlorhexidine-soaked sponge brush for six minutes/resident using 1-week intervals for 12 weeks or 2-week intervals for 12 weeks (Lee et al., 2020) (Table 2.3).

### *Education only*

The intervention of the one included study in the education only category was as follows: (1) Provision of dental health education (DHE) programme provided by three RDHs comprised of three one-hour sessions at monthly intervals in groups of five to six residents and/or staff in each institution for eight months (Schou et al., 1989) (Table 2.3).

### *Service provision and education*

The interventions of the included studies in both the service provision and education category were as follows: (1) Oral health prevention education provided by one RDH to groups of eight to ten healthcare providers for forty-five minutes over 18 months. POHC provided by two RDHs of prophylaxis, scaling, resident brief oral hygiene instruction, instruction to nurse or nurse aide and adapted recall system to needs of the resident with a maximum six months between visits over 18 months (Mojon et al., 1998); (2) POHC provided by two RDHs of preventive OHC program including examination, treatment planning, scaling and recall system for POHC. Dentate residents received a maximum six-month frequency and edentulous residents received a once/year frequency in between visits over 18 months. Oral health education was provided to health caregivers (Budtz-Jorgensen et al., 2000) (Table 2.3).

*Education/motivation/remotivation and professional oral health care*

(1) Education/motivation was provided to nursing staff, oral care cards provided for guidelines, distribution of adequate oral hygiene aids for standards (e.g., electric brush), and implementation of new routines using an oral-care contact person. Screening was provided by a RDH to provide regular Mucosal Plaque Score (MPS) index, measuring routines and feedback to the ward for improvements at six to eighteen months intervals over six years (Samson et al., 2009); (2) Remotivation was provided by a dentist who re-instructed and remotivated the elderly residents after four and eight weeks. At baseline, staff completed a two-hour oral hygiene lesson and provided remotivation to elderly residents twice/week. POHC was provided by a dentist using a portable ultrasonic unit, then polishing. Dentures were cleaned using an ultrasonic bath. Dentists tailored oral hygiene according to resident oral hygiene needs, manual, and cognitive ability for 30 minutes within a 12-week and three-year follow-up period. Exams were performed after two, six, and twelve weeks for all resident groups. All three therapy groups had teeth and

dentures cleaned professionally and received individual oral hygiene instruction (Zenthöfer et al., 2013) (Table 2.3).

### *Staff evaluation and professional oral health care*

(1) A dentist provided dental examinations of all participating elderly residents in two nursing homes (NHs). Two RDHs provided nursing staff support once/week over three months by a) Participating in staff meetings at the beginning of the study, after six weeks and the end of the study; b) Individualizing theoretical hands-in support per resident once/week; and c) Customizing written oral hygiene prescriptions per resident for specialized oral care devices and routines. Nursing staff completed a questionnaire at baseline and three months (Seleskog et al., 2018); (2) POHC was provided by three RDHs including tooth brushing, interproximal cleaning and scaling of supragingival calculus, individual oral hygiene instruction and products once/months for 30 minutes, for six months. Oral examinations were performed at baseline, three and six months. Nursing staff completed two questionnaires to analyze nursing staff attitudes (priorities) and knowledge regarding oral hygiene care and oral health care needs for care-dependent elderly residents at baseline and at six-month follow-up (Girestam et al., 2020) (Table 2.3).

Out of the 13 studies included, six studies were short-term (3 months to 8 months) (Yoneyama et al., 1996; Morino et al., 2004; Lee et al., 2020; Schou et al., 1989; Seleskog et al., 2018; Girestam et al., 2020) and seven studies were long-term (18 months to 6 years) in the nursing home setting (Adachi et al., 2002, 2007; Yoneyama et al., 2002; Mojon et al., 1998; Budtz-Jorgensen et al., 2000; Samson et al., 2009; Zenthöfer et al., 2013). The total number of residents included in the studies were 1,666 (mean by study 128) with a sample size ranging

from 13 to 184. All included studies contained older adult residents with focus on oral health interventions. Methodologies regarding the included studies are summarized in Table 2.3.

The results and conclusions data for the 13 study findings are detailed in Table 2.4. The following studies confirm causality between the programs and outcomes: Yoneyama et al. (1996 ; 2002), Adachi et al. (2002), Morino et al. (2014), Lee et al. (2020), Schou et al. (1989), Mojon et al. (1998), Zenthöfer et al. (2013), and Girestam et al. (2020). The following studies show associations between the programs and outcomes: Adachi et al. (2007), Budtz-Jorgensen et al. (2000), Samson et al. (2009), and Seleskog et al. (2018).

### **Analysis of included studies – Clinical Effectiveness of POHC Programs**

#### *Frequency and Duration*

Results (Table 2.3) for frequency and duration of POHC in NHs are as follows. Six out of the 13 studies reported POHC services by RDH(s): once a day for 6 months (Yoneyama et al., 1996); once per week from 1 month (Morino et al., 2014); 1-week or 2-week intervals for 12 weeks (Lee et al., 2020); once per week for 6 months (Adachi et al., 2002, 2007); and once per week for 2 years (Yoneyama et al., 2002). Three out of the 13 studies reported services and education by RDH(s): once per month for 6 months (Girestam et al., 2020), and once every 6 months for 18 months (Budtz-Jorgensen et al., 2000; Mojon et al., 1998).

Three studies out of 13 studies reported: 1) support to nursing staff by RDH(s) participating in staff meetings, providing hands-on theoretical support and customized oral hygiene prescriptions per resident: Once per week over 3 months (Seleskog et al., 2018); 2) screening in 3-month intervals and education by an RDH(s) for 6 years (Samson et al., 2009);

and 3) dental health education (DHE) by RDH(s) once per month for 8 months (Schou et al., 1989 (Table 2.3).

### *Clinical causal effect and relationship*

For studies with data available, the statistical analysis was performed using Risk Ratios (RR) and Odds Ratios (OR) (Table 2.4). Results for on-site POHC Service Provision on Incidence (Causal Effect) and Prevalence (Relationship) of abnormal sputum, *C. albicans*, debris indices, (Primary Outcomes) and fever and mortality due to pneumonia/AP (Secondary Outcomes) are as follows.

### *Clinical outcomes*

Thirteen (100%) studies showed a significant reduction of bacterial infections in the mouth from a significant decrease in: abnormal sputum (Yoneyama et al., 1996); *C. albicans* incidence (Adachi et al., 2002; Zenthöfer et al., 2013) and its prevalence (Adachi et al., 2007; Budtz-Jorgensen et al., 2000); debris incidence (Yoneyama et al., 2002); plaque incidence (Seleskog et al., 2018; Lee et al., 2020; Zenthöfer et al., 2013); association (Morino et al., 2004;) positive correlation of the plaque index (Mojon et al., 1998) and prevalence (Samson et al., 2009); incidence of mucosal disease (Girestam et al., 2020) and risk of poor maxillary denture plaque (Schou et al., 1989).

Four (31%) out of 13 studies showed a significant reduction in fever (Yoneyama et al., 1996; Adachi et al., 2002), its incidence (Yoneyama et al., 2002) and its prevalence (Adachi et al., 2007). One (8%) study showed a significant decrease in the number and proportion of deaths due to pneumonia and/or risk of getting pneumonia (Yoneyama et al., 2002). Three (23%) studies showed a significant reduction in: number and proportion of deaths due to AP

(Yoneyama et al., 1996; Adachi et al., 2002, 2007) and fatal AP ratio (Adachi et al., 2007).

None of the studies measured the health-related quality of life (secondary outcome) of residents.

### **One Essential on-site POHC intervention for Best Practice Guidelines**

Provision and maintenance of on-site Professional Oral Health Care (POHC) by a Registered Dental Hygienist (RDH) is required at a frequency of once per week (Morino et al., 2004; Lee et al., 2020; Adachi et al., 2002, 2007). Daily mouth care is required at a frequency of twice per day by caregivers/Health Care Aids (HCA) to all dependent residents within nursing homes (Yoneyama et al., 2002).

Based on the results of the systematic review, the following program components seem to be the most beneficial for helping improve NH residents' oral health and respiratory health. One essential on-site preventative POHC program within NHs would reduce bacterial mouth infection from spreading to the lungs. This preventative POHC program would include maintaining the frequency and duration of the above intervention while planning, implementing, and evaluating the following program components.

#### *Services*

1. Examination and Treatment Planning: RDHs provide oral examinations and treatment planning to dependent NH residents upon admission and every three months (Girestam et al., 2020). Dentate residents receive a maximum six-month frequency and edentulous residents receive a once per year frequency in between visits (Budtz-Jorgensen et al., 2000). A dentist provides dental examinations of all participating elderly residents (Seleskog et al., 2018). Exams are performed after two, six, and twelve weeks for all resident groups (Zenthöfer et al., 2013).

All therapy groups receive teeth and dentures cleaned professionally and receive individual oral hygiene instruction (Zenthöfer et al., 2013).

2. Debris removal: once per week, RDHs, encourage mouth rinsing with water, if possible, and the tongue is wiped using chlorhexidine-soaked sponge brush for six minutes per resident (Lee et al., 2020). After each meal, caregivers brush the residents' teeth for five minutes and/or swab the oropharynx with povidone iodine, if required. (Yoneyama et al., 2002).

3. Bacterial Plaque Removal: Once per week, RDHs provide manual toothbrushing only, after breakfast (Morino et al., 2014). RDHs provide teeth cleaning using rolling, Watanabe, and Bass brushing (Lee et al., 2020), and interdental brushes (Lee et al., 2020; Adachi et al., 2002, 2007) for interproximal cleaning (Girestam et al., 2020) and sponge brush (Adachi et al., 2002, 2007). Or the residents' teeth are brushed using an electric brush with automatic water supply (Adachi et al., 2002, 2007). RDHs or a dentist provide prophylaxis (Mojon et al., 1998; Zenthöfer et al., 2013); and

4. Calculus Removal: Once per week, RDHs provide scaling (Adachi et al., 2002, 2007; Mojon et al., 1998; Budtz-Jorgensen et al., 2000) to remove supragingival calculus (Girestam et al., 2020) or dentists or RDHs provide plaque and calculus control (Yoneyama et al., 2002) using a portable ultrasonic unit (Zenthöfer et al., 2013).

5. Denture Cleaning: Once per week, provided by RDHs (Adachi et al., 2002, 2007) or by dentists or RDHs using a denture brush daily and daily cleanser (Yoneyama et al., 2002); or by RDHs using a suction device (Lee et al., 2020) or using an ultrasonic bath (Zenthöfer et al., 2013).

6. Adapted Recall System: provided by RDHs, according to needs of the resident with a maximum six months between visits (Mojon et al., 1998; Budtz-Jorgensen et al., 2000). Dentate residents receive a maximum six-month frequency and edentulous residents received a once per year frequency in between visits (Budtz-Jorgensen et al., 2000).

### *Education*

1. Dental health education (DHE) programme: Once per month, RDHs provide three one-hour sessions in groups of five to six residents and/or staff in each institution (Schou et al., 1989) and individual resident oral hygiene instruction and products, for 30 minutes (Girestam et al., 2020). Dentist's tailor oral hygiene according to the resident's oral hygiene needs, manual, and cognitive ability for 30 minutes within a 12-week and three-year period (Zenthöfer et al., 2013).

2. Oral health prevention education, once per under six months maximum: provided by one RDH to groups of eight to ten healthcare providers for forty-five minutes. RDHs provide resident brief oral hygiene instruction, and instruction to nurse or nurse aide (Mojon et al., 1998). Oral health education is provided to health caregivers (Budtz-Jorgensen et al., 2000).

### *Education/motivation/remotivation*

1. Screening and Feedback: Screening is provided by a RDH to record regular Mucosal Plaque Score (MPS) index, measuring routines and provide feedback to the ward for improvements at six-month intervals (Samson et al., 2009).

2. Guidelines: oral care cards are provided for guidelines at six-month intervals (Samson et al., 2009).

3. Standards and Implementation: distribution of adequate oral hygiene aids for standards (e.g., electric brush), and implementation of new routines using an oral-care contact person (Samson et al., 2009).

4. Education/motivation: Education/motivation is provided to nursing staff, at six-month intervals (Samson et al., 2009).

5. Remotivation: Remotivation is provided by a dentist who re-instructs and remotivates the elderly residents after four and eight weeks. Staff complete a two-hour oral hygiene lesson and provide remotivation to elderly residents twice per week (Zenthöfer et al., 2013).

#### *Staff Support and Staff Evaluation*

1. Staff Support: Once per week, RDHs provide nursing staff support by:

- a) Participating in staff meetings; and
- b) Individualizing theoretical hands-in support per resident; and
- c) Customizing written oral hygiene prescriptions per resident for specialized oral care devices and routines (Seleskog et al., 2018).

2. Staff Evaluation: Nursing staff complete a questionnaire at baseline, three months (Seleskog et al., 2018), and six-months (Girestam et al., 2020) to analyze nursing staff attitudes (priorities) and knowledge regarding oral hygiene care and oral health care needs for the care-dependent elderly resident (Girestam et al., 2020).

The number of RDHs in each NH needs to be calculated based on the workload and number of residents.

## Discussion

Our systematic review of POHC programs identified 13 studies that all showed positive outcomes of the programs delivered by RDHs and/or a dentist. The main types of POHC programs were mostly provided by RDHs, on-site within NHs. The programs contained a combination of program components and services for NH residents. Five studies included programs with mostly POHC service provision (Adachi et al., 2002, 2007; Yoneyama et al., 2002; Morino et al., 2004; Lee et al., 2020). Whereas only two studies provided POHC services for residents and education for residents, staff, and caregivers (Mojon et al., 1998; Budtz-Jorgensen et al., 2000).

Most of the studies reported that POHC services should be included in NHs/LTCFs/home care. The clinical outcomes were significant showing reduction of latent bacterial mouth infections by providing oral care to reduce the incidence of lower respiratory tract infection thus preventing pneumonia in older NH residents (Yoneyama et al., 2002, Japan). POHC provided by dental hygienists to elderly persons needing daily nursing care was associated with a reduction in prevalence of fever and fatal pneumonia (Adachi et al., 2002, Japan). Overall, POHC was effective in preventing respiratory infections (Adachi et al., 2007, Japan).

The essential components that seem to be the most beneficial for helping improve residents' oral and respiratory health are POHC including screening, oral examinations, scaling, prophylaxis, resident rinses with water, debris removal, wiping the tongue using a chlorhexidine-soaked sponge brush, and oral hygiene education by dental professionals. Provision of essential mouth care for dependent NH residents includes tooth brushing twice per day and/or swab the oropharynx with povidone iodine by nursing assistants.

Best practice guidelines include POHC at the frequency of once per week for the duration of 30 minutes with monthly education, motivation, remotivation, and staff support for 45 minutes. Also, staff evaluation every three months to ensure implementation of regulations, standards, and guidelines.

The quality of the studies based on the indicators of improved oral health status, reduction in bacterial plaque and decrease in pneumonia and AP, are moderate to high quality. All the studies provided POHC in NHs and most of them provided POHC for dependent residents thus increasing the strength of the results. However, over half of the studies did not report whether there was or was not a conflict of interest. Also, a few studies were either underpowered or lower powered thus reducing the quality of evidence.

The oral hygiene of the residents will likely be significantly improved on a long-term basis (Samson et al., 2009, Norway). The oral hygiene and ongoing provision of oral hygiene of LTC residents' teeth and dentures will likely be improved (Zenthofer et al., 2013 Germany). A combination of education and weekly hands-on guidance to staff in their performance of oral care will likely decrease plaque levels and help nursing staff overcome the challenges in performing proper oral care (Seleskog et al., 2018, Sweden). In addition, the most effective implementation, with POHC interventions at 1-week intervals, will likely enhance the oral health and salivation in the elderly showing that dental hygienists should monitor and manage oral health of the elderly in long-term care homes (Lee et al., 2020, Korea). A combination of monthly professional oral care and individual oral health care instructions will likely improve oral hygiene and reduce root caries among NH residents as well as contribute to a more positive attitude among NH staff (Girestram et al., 2020, Sweden).

Upon analysis, the following studies show some weaknesses and strengths. In the study of Budtz-Jorgensen et al. (2000), program participants could not be randomly allocated because of the involvement of the health care providers. However, the groups were similar in size, social, medical, and oral characteristics at baseline and the examiner was unbiased, not knowing whether the residents examined were from the experimental or control group. Even though the conflict of interest was not reported in this study, the overall risk of bias was low.

In the Ueda et al. (2003) longitudinal study, the study setting, and intervention location were not clear and potentially violated the PICOS inclusion criteria. The unclear intervention location and study setting may have skewed the reporting accuracy and missed details for the analysis, so it was left out of the final systematic review.

In the 2002 study of Adachi et al. an important strength in the study is that the elderly nursing home care residents were found to have significantly higher aspiration pneumonia fatal ratio in persons not receiving POHC compared those given POHC. In the 2018 study of Seleskog et al. the weaknesses included a small sample size and not including a control group of nursing staff.

In the Schou et al. (1989) study, an important weakness that limits the results regarding why denture hygiene did not obtain reduced plaque levels is that: 1) The number of subjects who answered questions was low; 2) Some answers may not be reliable as patients may have been too confused; and 3) Only half the group of participants were capable of understanding the dental health education (DHE) programme messages. Also, denture stomatitis may have increased because there was a change in diagnostic criteria between Time 1 and Time 2.

The authors state that for future studies, only well elderly should be included, who are capable of benefiting from instruction (Schou et al., 1989). This means that this study would

take place in independent or assisted living facilities where only well elderly would receive DHE instruction. In this way, a larger sample size could be studied, more reliable answers received, and successful oral health education measured. The results from this study are limited in use for analysis in this thesis and explain why denture plaque levels and denture stomatitis were not reduced. In future studies, elderly who likely live in NHs with higher level of care needs and who are not capable of understanding instruction should be provided with daily oral health care, professional oral health care once per week, consistently, by an RDH or DDS and their caregiver and staff evaluated in their education and provision of resident oral health instruction.

In the study by Mojon et al. (1998) a weakness was that treating residents in the control group would likely explain why there was no significant decrease in plaque levels. For future studies the residents could be provided treatment at the completion of the study, after the study results have been recorded, to prevent possible reduction in plaque levels and reduce bias. The reason is that providing treatment to residents reduces plaque levels because clinicians need to remove plaque in order to prevent plaque bacteria from entering the treatment site.

In the study by Seleskog et al. (2018) dental plaque levels decreased significantly after the 3-month intervention however the questionnaire from nursing staff did not show significance, just tendency of improvement. The reason for the lack of significance of improvement from nursing staff is likely because the intervention was too short in length. Future studies with a longer study period of 24 months would likely see a significant improvement in nursing staff confidence, in their ability to influence reluctant residents who refuse help with oral care.

None of the thirteen studies show a complete recommendation of an essential POHC program and all the required components. An essential POHC program and its components provided by full-time RDHs, on-site within NHs, contains a combination of studies inclusive of:

1) POHC services for NH residents (Adachi et al., 2002, 2007; Yoneyama et al., 2002; Morino et al., 2004; Lee et al., 2020); and 2) services for residents and education for residents, staff, and caregivers (Mojon et al., 1998; Budtz-Jorgensen et al., 2000).

The on-site POHC program within NHs is more about the teeth cleaning services, (Adachi et al., 2002, 2007; Yoneyama et al., 1996, 2002; Morino et al., 2014; Lee et al., 2020) or teeth cleaning services and education, (Mojon et al., 1998; Budtz-Jorgensen et al., 2000) or just education alone (Schou et al., 1989). All the 13 studies show that on-site POHC is effective and show a positive impact on oral health status and health (Adachi et al., 2002, 2007; Yoneyama et al., 1996, 2002; Morino et al., 2014; Lee et al., 2020; and Mojon et al., 1998; Budtz-Jorgensen et al., 2000; and Schou et al., 1989; Samson et al., 2009; Zenthöfer et al., 2013; and Seleskog et al., 2018; Girestam et al., 2020).

## **Conclusion**

Based on our study, these 13 programs were effective, at varying extents. There were a limited number of studies that provided evidence of POHC programs within nursing homes. Although there was a positive impact in oral health and respiratory health, it was from different types of POHC programs with varied content, frequency, and duration. There would be uncertainty in how effective an on-site POHC program and components from all 13 programs, provided by RDHs within Alberta NHs would be in practice. Therefore, more research is needed to study the implementation of the combined POHC components and services to enable treatment and prevention that reduces bacterial mouth infections, pneumonia, and fatal AP for all dependent NH residents.

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## Chapter 3 Discussion

There is evidence that POHC within NHs has a positive impact on health and oral health. Current findings indicate public health benefits in terms of improved oral health status, reduction from pneumonia related hospitalizations and fatal aspiration pneumonia.

### Practice Implications

#### *Studies Recommending Professional Oral Health Care in NHs/LTC and Home Residence*

Eight studies have reported POHC services and state that they should be included in NHs/LTCFs/home care for the following reasons. Removal of latent oral infections and providing oral care will likely reduce the incidence of lower respiratory tract infection preventing pneumonia in older NH residents (Yoneyama et al., 2002, Japan). POHC provided by dental hygienists to elderly persons needing daily nursing care is associated with a reduction in prevalence of fever and fatal pneumonia (Adachi et al., 2002, Japan). POHC is effective in preventing respiratory infections (Adachi et al., 2007, Japan).

Also, the oral hygiene of the residents will likely be significantly improved on a long-term basis (Samson et al., 2009, Norway). The oral hygiene and ongoing provision of oral hygiene of LTC residents' teeth and dentures will likely be improved (Zenthofer et al., 2013, Germany). A combination of education and weekly hands-on guidance to staff in their performance of oral care will likely decrease plaque levels and help nursing staff overcome the challenges in performing proper oral care (Seleskog et al., 2018, Sweden).

In addition, the most effective implementation, with POHC interventions at 1-week intervals, will likely enhance the oral health and salivation in the elderly showing that dental hygienists should monitor and manage oral health of the elderly in NHs (Lee et al., 2020, Korea).

A combination of monthly professional oral care and individual oral health care instructions will likely improve oral hygiene and reduce root caries among NH residents as well as contribute to a more positive attitude among NH staff (Girestram et al., 2020, Sweden).

The potential reasons why there is variation in the studies are because the studies have different comparators, components of RDH(s) services and education, and length of the program intervention. The POHC programs that seem to be more effective than the others are the five interventions listed below. This is because the intervention study results explicitly conclude that POHC should be provided in NHs AND recommend that an actionable policy lever be used to achieve positive clinical health and oral health outcomes.

## **Policy Implications**

*Studies Recommending Professional Oral Health Care in NHs - Defined Standards, Policies, Guidelines, Procedures, Benefits, and Insurance*

Five studies that show providing on-site POHC for NH residents is clinically effective also suggest taking action by implementing the following policy levers: 1) expanding oral health benefits (Yoneyama et al., 2002, Japan); 2) using an oral health care programme as an instrument to measure nursing staff oral health work in relation to defined standards (Samson et al., 2009, Norway); 3) providing financial rewards through healthcare insurance and politics for home visits and examinations (Zethofer et al., 2013, Germany); 4) organizing long-term presence and guidance by dental hygienists (Seleskog et al., 2018, Sweden); and 5) establishing relevant oral health care guidelines requiring daily oral hygiene care and regular dental care to elderly residents in NHs (Lee et al., 2020, South Korea). However, only four out of the five studies

(Yoneyama et al., 2002, Samson et al., 2009, Seleskog et al., 2018, Lee et al., 2020) report RDHs as providing POHC in NHs with the policy means for implementation.

These four on-site POHC programs provided by RDHs seem to be the most clinically effective showing strong to moderate evidence from the content of POHC programs delivered in NHs. The recommended policy options for program components include:

1) Once per week, on-site POHC is provided by RDHs to remove the plaque and calculus from the natural teeth and to clean dentures using a denture cleanser. Daily denture cleaning is provided with a denture brush. After each meal, caregivers brush the residents' teeth for 5 minutes and/or swab the oropharynx with povidone iodine, if required. (Yoneyama et al., 2002).

2) At 1-week intervals, POHC is provided by 4 RDHs for 6 minutes per resident to clean the dentures using a suction device, to clean the teeth and tongue using rolling, Watanabe & Bass brushing, interdental brushes. Have the resident rinse with water, remove debris, and wipe the tongue using a chlorhexidine-soaked sponge brush. Provide the resident with an interdental brush, sponge brush and denture cleanser (Lee et al., 2020).

3) Once per week, 2 RDHs provide nursing staff support by participating in staff meetings, individualizing theoretical hands-on support per resident, and customizing written oral hygiene prescriptions for specialized oral care devices and routines (Seleskog et al., 2018).

4) At 3-month screening intervals, an RDH provides regular mucosal plaque score (MPS) index measuring routines, records the level of oral hygiene, and provides feedback to the ward for improvements. A RDH provides education/motivation of nursing staff, oral care cards for guidelines, distribution of adequate oral hygiene aids for standards (e.g. electric tooth brush), and implements new routines with the 'oral-care contact person' (Samson et al., 2009).

Policy decision makers may implement all or a combination of the components from these four public health programs to encompass one on-site POHC program in NHs. Successful implementation of this program in Alberta would require the Ministry of Health to develop policies that 1) expand oral health benefits for older adults, 2) establish relevant oral health care guidelines requiring daily oral hygiene care and regular dental hygiene care to elderly residents in NHs, 3) use an oral health care programme as an instrument to measure nursing staff oral health work in relation to defined standards, and 4) organize long-term presence and guidance by dental hygienists.

The evidence and content of different kinds of POHC programs that did not include any policy actions, but were provided to residents by RDHs, are as follows. High clinical evidence was found when POHC was provided by dental hygienists to elderly persons needing daily nursing care (Adachi et al., 2002). Once per week POHC included hand scaling, electric tooth brushing with automatic water supply, and interdental brush and swabbing with a sponge brush to clean teeth and dentures. The authors stated that this POHC was associated with a reduction in prevalence of fever and fatal pneumonia (Adachi et al., 2002).

High quality evidence was also found when a combination of monthly professional oral care and individual oral health care instructions were provided by RDHs to NH residents (Girestram et al., 2020). Once per month, for 30 minutes, 3 RDHs provided tooth brushing, interproximal cleaning and scaling of supragingival calculus, individual oral hygiene instructions, information and fluoridated toothpaste, soft toothbrush, and interproximal cleaning aids. The authors stated that this combination would likely show an improvement in oral hygiene and reduction in root caries among NH residents as well as contribute to a more positive attitude among NH staff (Girestram et al., 2020).

The study by Adachi et al. (2007) found moderate clinical evidence when POHC was provided by dental hygienists to elderly residents needing daily nursing care. Daily POHC included brushing the natural dentition using an electric brush with automatic water supply, interdental brush, and sponge brush. The teeth, buccal mucosa, tongue, and dentures were cleaned. The authors stated that this POHC was associated with a reduction in prevalence of fever and fatal pneumonia and was effective in preventing respiratory infections (Adachi et al., 2007).

All on-site POHC programs provided in NHs by RDHs are not the same. When evaluating 13 studies, the follow-up period varied from 3 months to 24 months. The 3-month POHC programs (Lee et al., 2020; Seleskog et al., 2018; Samson et al., 2009) may not provide long enough follow up time to measure all elements of clinical outcomes from receiving the intervention.

The length of POHC in NHs also varied. When RDH(s) provided the POHC intervention, the number of RDHs and length of the intervention from POHC service was: one RDH, once a day, but without a reported time frame nor time of day (Yoneyama et al., 1996); two RDHs once per week after breakfast but without a reported time frame (Morino et al., 2014); four RDHs at 1-week intervals for 6 minutes per resident (Lee et al., 2020); Number of RDHs not specified (Adachi et al., 2002) and one RDH (Adachi et al., 2007) once per week for an unspecified time frame nor time of day (Adachi et al., 2002, 2007); and an unspecified number of RDHs, once per week for an unspecified time frame (Yoneyama et al., 2002).

When POHC services were combined with education of NS staff, the number of RDHs and length of the intervention was: three RDHs, once per month, provided POHC services and education for 30 minutes without the time of day specified (Girestam et al., 2020); one RDH

provided oral health prevention education to groups of 8-10 healthcare providers for 45 minutes and two RDHs provided POHC without the length of time specified, once every 6 months (Mojon et al., 1998); and two RDHs provided oral health care education to health carers and a preventive OHC program without specifying the length of the intervention nor time of day, every six months (Budtz-Jorgensen et al., 2000).

The clinical practice of on-site POHC services and education have been inconsistent when studying follow-up periods for older adults residing in NHs. However, in recent studies, provision of services and education have consistently changed over time by increasing the number of RDHs, the frequency of the intervention, and timing the length of the intervention. Current POHC programs with services only, report an increase of 1 to 4 RDHs with 1-week intervals during the specified time frame of six minutes per resident (Lee et al., 2020). Similarly, the programs with combined POHC service and educational interventions also increased the number of RDHs from 1 to 3 RDHs (Mojon et al., 1998), the duration of the intervention from zero to 30-minutes (Zenthöfer et al., 2013), and the frequency of the intervention from every 6 months to once per month (Schou et al., 1989).

To implement the current frequency and duration of clinically effective POHC services and education mentioned above, RDHs will require a full-time presence as a regulated member who works within nursing homes as part of the interdisciplinary team. This will help RDHs meet the daily and weekly requirements for successful implementation of the services and educational components of a best practice POHC program.

My thesis results determine what is required to implement best practice POHC programs for all residents in NHs in Canadian provinces like Alberta. The success of this oral care intervention also requires nurse-led interdisciplinary collaboration (Quinn et al., 2014; McNally

et al., 2019; Robertson & Carter, 2013; Mitchell et al., 2019). In addition, a bedside dysphagia screen by a nurse and a rapid clinical swallow screen by a speech pathologist is suggested as a quality improvement initiative to reduce aspiration pneumonia (Titsworth et al., 2013).

It should be noted that in current studies, in most intervention groups, only about half of the residents were provided POHC services and education. Therefore, future implementation of the POHC in NHs will likely require multiple RDHs working full time so they can provide daily oral care and weekly POHC to all the residents. For example, if there are 100 residents and each of them requires 30 minutes of POHC per week, in a seven-hour workday, one RDH could provide POHC to 14 residents per day taking more than seven days per week to serve all residents. It is likely that the RDH would work 4 days per week therefore two RDHs would likely be required to provide weekly POHC. There would also need to be another two RDHs to provide daily denture cleaning, case management, education, and support to the staff, suggesting a need for four RDHs in this NH scenario.

The gaps in practice when implementing the above POHC program within NHs are that only few studies provide the breakdown in care ratio of RDHs per resident. More data is required on the time spent providing the care, wages paid to the RDH, and the costs to implement the program to all residents who are not able to take care of their own teeth. This dependent cohort includes most of the residents residing in Alberta NHs.

POHC could be staged based on the needs of each subgroup in NHs. Future studies are required in economic evaluation to determine the most cost-effective way for RDHs to provide POHC for each subgroup, within NHs.

### **Preliminary Economic Cost-Effectiveness Analysis**

Two studies provide supporting evidence that POHC is cost-effective when provided by oral health professionals in NHs. The study by Münzenmayer et al. (2018) highlights the public health care payer perspective and the study by Schwendicke et al. (2017) highlights the mixed public-private payer perspective.

#### *Public health care payer perspective*

An Australian study using the health care system payer perspective, conducted a cost-effectiveness analysis (CEA) to measure the 'cost per pneumonia case averted' by providing POHC within Australian Residential Aged Care Facilities (RACF) (Münzenmayer et al., 2018). The authors built their model based on 6977 (15%) persons residing in 88 RACFs (Australian Government, 2016).

Four scenarios were compared to current practice (CP). In Scenario 1, non-POHC was provided twice per day; in scenario 2, POHC was provided once per week and non-POHC twice per day; in scenario 3, POHC once per week and CP the other days; and in scenario 4, POHC was provided once every two weeks and CP the other days. The authors chose Scenario 2 as the Gold Standard intervention because it offered the best achievable results, as determined by a Systematic Review in which the model simulations are based on (Kaneoka et al., 2015).

POHC included oral hygiene services provided by an oral hygienist/oral health therapist. Non-POHC included oral hygiene provided by trained nursing aids (NA). CP included care staff providing teeth brushing, and cleaning of the tongue, palate, gums, and oral mucosa using a bendable, soft mechanical toothbrush, high fluoride toothpaste (5000 ppm), and an interdental brush. Full dentures were cleaned using a denture brush. Partial dentures were cleaned using a soft, bendable, toothbrush (Lewis & Fricker, 2009).

### *Budget impact analysis in the Canadian and Albertan context*

In Canada, there are 1,360 continuing care (CC) NH facilities (residential care) with 207,424 residents. Alberta residential care comprises 175 facilities and 21,886 residents (Dobrescu, 2017). Using this number of Canadian and Albertan NH residents, the costing data from the Munzenmayer study was first converted from AU to CAD dollars (1 AU dollar equals 0.89 Canadian dollars, Xe Currency Converter, May 2020). Next, the converted CAD dollars were adjusted for the 2016 to 2020 inflation rates (average rate 1.97 over 4 years, Bank of Canada, 2020). As a result, the following costs were predicted for provision of onsite POHC.

Costs included once per week POHC costs by RDHs for training staff, salaries, a programme coordinator office, dental equipment, instruments, supplies and ambulance and hospitalization (Münzenmayer et al., 2018). When the total costs were converted per alternative of oral health professional (OHP; dental hygienist) the following costs were received. Compared to the total cost per alternative OHP of \$2948 per resident per year for current practice (CP), costs showed \$3056 per resident per year (Scenario 1), \$3477 per resident per year (Scenario 2), \$3366 per resident per year (Scenario 3), and \$3170 per resident per year (Scenario 4). In all four scenarios, cost of providing oral health care per resident are more cost-effective when compared to the significantly higher treatment costs of treating pneumonia in the hospital (\$13,289) or within residential aged care facilities (RACFs) (\$6891).

The most cost-effective and the most cost-saving alternate results from the Münzenmayer et al. (2018) study are aligned with my chapter 2 findings of program components and might predict the public health care payer perspective for providing POHC in the Alberta NHs. After costing all four scenarios in the study, Scenario 2 - POHC once per week by an RDH and non-

POHC, twice per day, by trained nursing aids (HCAs) is likely the best strategy because it may lead to the highest cases averted with high-direct-cost savings (Münzenmayer et al., 2018).

When providing the gold standard scenario 2, \$3,477 total cost of POHC per resident with 6779 pneumonia cases averted, there is a \$724 savings/resident. In Canada costs could potentially be \$3,477 cost of POHC per resident multiplied by 207,424 residents equals \$721,213,248 per year. Savings could translate to 207,424 NH residents multiplied by \$724 savings/resident for a total health care cost savings of \$150,174,976 per year.

In Alberta, costs could potentially be \$3,477 cost of POHC per resident multiplied by 21,886 residents equals \$76,097,622 per year. Savings could translate to 21,886 NH residents multiplied by \$724 savings/resident for a total cost savings of \$15,845,464 per year.

Scenario 2 combined with the most clinically effective program provided by RDHs in Alberta NHs would provide residents with access to POHC and HCAs, non-POHC oral care program. An estimated cost for this Alberta on-site POHC program will cost \$3477 per resident per year, to avert a pneumonia case and provide cost savings of \$724 per resident while saving pneumonia treatment costs of \$13,289 in hospital and \$6891 in NH related additional care, in one year.

Details of the cost adaptation in the Alberta context are shown in Appendix 1.1. The above cost analysis includes training and travel, OHP salaries, shared programme coordinator office, dental equipment, instruments, and supplies. Missing items that also require costing to provide the POHC program are denture cleanser, swabs, povidone iodine, a suction device to clean dentures, chlorhexidine, hand instruments (mouth mirror, probe, explorer, cotton pliers), and oral care cards. These costs were not included in the original study of Münzenmayer et al.

(2018). The cost of these supplies and devices is likely moderate so it would change the result of the above estimation.

The Canadian public health care system pneumonia cost burden could be reduced down from \$215.9 million to \$200,054,536 by providing direct access to onsite POHC in NHs, which will in turn reduce oral health inequity (Dobrescu, 2017). These cost savings do not include the reduction of risk of re-infection of pneumonia, which could introduce bias, as once affected by NHAP, residents might be at higher risk for re-infection (Schwendicke et al., 2017). Re-infection could amount to another two to six ambulatory transportation costs and an additional 7 to 42 hospital day costs. Considering in 2018-2019, Pneumonia was the first out of the top 20 main problems (admitted by volume) for reason of number of emergency department (ER) visits (35,376) and ED length of stay (LOS) (42.7 hours) in Canada (CIHI, 2017-2018 and 2018-2019). Preventing pneumonia/AP by providing universal onsite POHC for NH residents could translate to significant increase in health care cost savings not only in ambulatory costs and hospital costs for the first ER visit but also in additional consecutive ER readmission visits due to pneumonia re-infection (CIHI, 2012).

The above data means that all Canadian and Albertan NH residents would receive onsite POHC once per week and non-POHC twice per day. The preliminary results show that the cost benefit of providing onsite POHC in NHs outweighs the costs of treating preventable pneumonia cases alone and provides money left over to pay for other services required in NHs such as other complex specialty treatment needs.

*Mixed public-private payer perspective*

A German NH study referencing the mixed public-private payer perspective conducted a CEA of an RDH/Dentist providing once per week POHC for 1,000 residents, over 30 months. The study measured the health outcome, disability-adjusted life years (DALY), being the result of suffering or years of life lost from dying from pneumonia and the health benefits of providing POHC (Schwendicke et al., 2017).

Calculations for resources and costs were based on mandatory statutory medical insurance which includes some dental treatment and the private tariff for professional biofilm and calculus removal, representing out-of-pocket costs (Schwendicke et al., 2017). The costs for POHC include first patient and subsequent patient visits and per patient visiting costs of a fixed fee and a distance-charge per km driven. Additional costs may be charged for treating dependent patients including first and further patients. Costs for oral health assessments were conducted by a dentist every 6 months, assuming weekly visits by a dentist. Professional teeth cleaning is charged per tooth with the assumption of six teeth to be present. The total minimum to maximum cost per POHC is provided and the total cost of treating pneumonia is shown to be cost-effective in Germany (Schwendicke et al., 2017). The above costs would be required to determine the operating costs for an Alberta on-site POHC program in NHs for dependent older adults with complex needs.

## **Conclusions**

Based on the review of the two published economic studies, and current clinical practice the following conclusions can be made:

- I. Assuming that the costs and benefits of the POHC programme reflect those demonstrated in the most recent Munzenmayer study, the potential value of the POHC programme weighs heavily on reducing transportation and hospitalization costs and the price point set by the programme planner. This includes charging an on-site fee and increasing the current Alberta wages for RDHs by about 25% to treat complex dependent NH residents.
- II. Based on the robust clinical effectiveness data from on-site POHC programs provided within NHs, the systematic review and preliminary economic analysis suggests that a weekly POHC programme provided by a registered dental hygienist and twice daily mouth care by caregivers/HCAs is clinically effective and cost-effective when provided on-site to all dependent NH residents.

The Alberta Government Dental Benefits is partially subsidized for low-income seniors aged 65+, and seniors are required to pay for out-of-pocket costs such as the on-site visit fee. The out-of-pocket costs, including the on-site fee, and inadequate frequency of plaque and calculus removal provides a financial barrier for many low-income seniors to receiving once per week on-site POHC by RDHs within NHs. Future programs require an economic evaluation to determine the cost-effectiveness of the clinically effective on-site POHC within Alberta NHs provided by full-time RDHs for all dependent NH residents.

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## Appendices

Table 2.1: Exemplary search strategy

Only the searches which produced hits are listed

Pubmed ([www.pubmed.gov](http://www.pubmed.gov); searched 26 March 2020 by Becky Skidmore, Librarian)

Final Search = 537 hits

LTC – Oral Health Care

PubMed Strategy

2020 Mar 26

#	Search Terms	# of Hits
68	57 OR 59 OR 61 OR 63 OR 67	537
67	55 AND 66	54
66	64 OR 65	503062
65	clinical path*[tw] OR clinical protocol*[tw] OR critical path*[tw] OR critical protocol*[tw] OR practice path*[tw] OR practice protocol*[tw]	57059
64	Clinical pathway[MESH] OR Clinical protocol[MESH] OR Consensus[MESH] OR Consensus development conferences as topic[MESH] OR Critical pathways[MESH] OR Guidelines as topic [Mesh:NoExp] OR Practice guidelines as topic[MESH] OR Health planning guidelines[MESH] OR guideline[pt] OR practice guideline[pt] OR consensus development conference[pt] OR consensus development conference, NIH[pt] OR position statement*[tiab] OR policy statement*[tiab] OR practice parameter*[tiab] OR best practice*[tiab] OR standards[ti] OR guideline[ti] OR guidelines[ti] OR CPGs[ti] OR consensus[ti] OR recommendat*[ti]	481476
63	55 AND 62	372
62	Cohort Studies[mh] OR cohort[tw] OR cohorts[tw] OR Retrospective Studies[mh] OR longitudinal[tw] OR prospective[tw] OR retrospective[tw] OR follow-up study[tw] OR followup study[tw] OR Observational Study[pt] OR observational study[tw] OR population study[tw] OR population analys*[tw] OR population-based study[tw] OR population-based analys*[tw] OR multidimensional study[tw] OR multi-dimensional study[tw] OR Comparative Study[pt] OR comparative study[tw] OR comparison study[tw] OR Case-Control Studies[mh] OR case-control study[tw] OR case-controlled study[tw] OR case-based comparison*[tw] OR case-comparison study[tw] OR Cross-Sectional Studies[mesh] OR cross-sectional study[tw] OR crosssectional study[tw]	4635030
61	55 AND 60	157
60	Controlled Clinical Trial[pt] OR Controlled Clinical Trials as Topic[mh] OR controlled trial*[tw] OR controlled clinical trial*[tw] OR Non-Randomized	1387764

	Controlled Trials as Topic[mh] OR nonrandom*[tw] OR non-random*[tw] OR quasi-random*[tw] OR quasi-experiment*[tw] OR nRCT[tw] OR non-RCT[tw] OR Controlled Before-After Studies[mh] OR (control*[tw] AND (“before and after”[tw])) OR Interrupted Time Series Analysis[mh] OR time series[tw] OR (pretest[tw] AND posttest[tw]) OR (pre-test[tw] AND post-test[tw]) OR Historically Controlled Study[mh] OR control study[tw] OR controlled study[tw] OR Control Groups[mh] OR control group*[tw] OR controlled groups[tw]	
59	55 AND 58	155
58	Controlled Clinical Trial[pt] OR Randomized Controlled Trial[pt] OR Pragmatic Clinical Trial[pt] OR Equivalence Trial[pt] OR Randomized Controlled Trials as Topic[mh] OR Clinical Trials as Topic [mesh:noexp] OR randomized[tw] OR randomized[tw] OR randomization*[tw] OR randomization*[tw] OR randomly[tw] OR RCT[tw] OR Placebo*[tw] OR ((singl*[tw] OR doubl*[tw] OR trebl*[tw]) AND (mask*[tw] OR blind*[tw] OR dumm*[tw])) or trial[ti]	1416870
57	55 AND 56	31
56	systematic review[pt] OR meta-analysis[pt] OR meta-analysis as topic[mh] OR meta analy*[tw] OR metanaly*[tw] OR metaanaly*[tw] OR met analy*[tw] OR integrative research[tw] OR integrative review*[tw] OR integrative overview*[tiab] OR research integration*[tw] OR research overview*[tw] OR collaborative review*[tw] OR collaborative overview*[tw] OR systematic review*[tw] OR systematic overview*[tw] OR evidence-based review*[tw] OR evidence-based overview*[tw] OR meta-review*[tw] OR meta-overview*[tw] OR meta-synthes*[tw] OR rapid review*[tw] OR “review of reviews”[tw] OR “Technology Assessment, Biomedical”[mh] OR technology assessment*[tw] OR HTA[tw] OR HTAs[tw] OR “Cochrane Database Syst Rev”[Journal:_jrid21711] OR “health technology assessment winchester, england”[Journal] OR “Evid Rep Technol Assess (Full Rep)”[Journal] OR “Evid Rep Technol Assess (Summ)”[Journal] OR “Health Technol Assess (Rockv)”[Journal] OR “Health Technol Assess Rep”[Journal] OR Network MA[tw] OR Network Mas[tw] OR indirect comparison*[tw] OR indirect treatment comparison*[tw] OR indirect treatments comparison[tw] OR multiple treatment comparison*[tw] OR multiple treatments comparison*[tw] OR mixed treatment comparison*[tw] OR mixed treatments comparison[tw] OR multi-treatment comparison*[tw] OR multi-treatments comparison*[tw] OR simultaneous comparison*[tw] OR mixed comparison*[tw]	319282
55	53 NOT 54	1467
54	comment[pt] OR editorial[pt] OR letter[pt] OR news[pt] OR newspaper article[pt]	2019909
53	51 NOT 52	1515
52	Animals[mesh] NOT Humans[mesh]	4682411
51	25 AND 50	1517
50	26 OR 27 OR 28 OR 29 OR 30 OR 31 OR 32 OR 33 OR 34 OR 35 OR 36 OR 37 OR 38 OR 39 OR 40 OR 41 OR 42 OR 43 OR 44 OR 45 OR 46 OR 47 OR 48 OR 49	85459
49	daily mouth care[tw] OR daily mouth healthcare[tw] OR daily mouth hygiene[tw]	65
48	daily oral health[tw] OR daily oral healthcare[tw] OR daily oral hygiene[tw]	234
47	dental health assessment*[tw] OR oral health assessment*[tw]	558

46	(dental[tw] OR tooth[tw] OR teeth) AND (restorative treatment*[tw] AND restoration[tw])	939
45	Dental Atraumatic Restorative Treatment[mesh]	233
44	dental pulp test*[tw] OR pulp vitality test*[tw] OR PVT[tw]	3500
43	Dental Pulp Test[mesh]	1013
42	Fluoride varnish*[tw]	1060
41	Sealant*[tw] AND (dental* OR dentist*[tw] OR fissure*[tw] OR tooth[tw] OR teeth[tw])	4515
40	cariostatic*[tw] AND (dental* OR dentist*[tw] OR fissure*[tw] OR tooth[tw] OR teeth[tw])	5279
39	“Pit and Fissure Sealants”[mesh]	3404
38	Cariostatic Agents[mesh]	14766
37	“dental caries/prevention and control”[MESH Terms]	13950
36	root planing[tw]	3353
35	root scaling[tw]	42
34	scaling[tw] AND (dental OR dentist* OR subgingival*[tw] OR sub-gingival*[tw] OR supragingival[tw] OR supra-gingival[tw])	5786
33	dental prophyla*[tw] OR dental preventi*[tw] OR cavity prophyla*[tw] OR cavity preventi*[tw] OR caries prophyla*[tw] OR caries preventi*[tw]	9551
32	Dental Prophylaxis[mesh]	7637
31	oral health exam*[tw] OR dental exam*[tw]	2988
30	Oral Health[mesh] AND Physical Examination[tw]	87
29	oral hygiene care[tw] OR oral hygiene healthcare[tw] OR oral hygiene health care[tw]	2204
28	oral healthcare[tw] OR oral health care[tw]	4042
27	dental care[tw] OR dental healthcare[tw] OR dental health care[tw]	40255
26	Dental care [mesh]	32834
25	2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24	142058
24	“nursing facility”[tw] OR ‘nursing facilities”[tw]	6975
23	nursing home[tw] OR nursing homes[tw]	45552
22	Nursing Homes[mesh]	38741
21	(“gerontological care”[tw] OR “gerontological healthcare”[tw] OR “gerontological health care”[tw]) AND (facility[tw] OR facilities[tw] OR home[tw] OR homes[tw] OR institution*[tw] OR residence*[tw])	17
20	(“gerontologic care”[tw] OR “gerontologic healthcare”[tw] or “gerontologic health care”[tw]) AND (facility[tw] OR facilities[tw] OR home[tw] OR homes[tw] OR institution*[tw] OR residence*[tw])	2
19	(“psycho-geriatric care”[tw] OR “psycho-geriatric healthcare”[tw] or “psycho-geriatric health care”[tw]) AND (facility[tw] OR facilities[tw] OR home[tw] OR homes[tw] OR institution*[tw] OR residence*[tw])	10
18	(“psychogeriatric care”[tw] OR “psychogeriatric healthcare”[tw] or “psychogeriatric health care”[tw]) AND (facility[tw] OR facilities[tw] OR home[tw] OR homes[tw] OR institution*[tw] OR institution*[tw] OR residence*[tw])	36

17	("geriatric care"[tw] OR "geriatric healthcare"[tw] or "geriatric health care"[tw]) AND (facility[tw] OR facilities[tw] OR home[tw] OR homes[tw] OR institution*[tw] OR residence*[tw])	751
16	("elderly care"[tw] OR "elderly healthcare"[tw] or "elderly health care"[tw]) AND (facility[tw] OR facilities[tw] OR home[tw] OR homes[tw] OR institution*[tw] OR residence*[tw])	671
15	("elder care"[tw] OR "elder healthcare"[tw] or "elder health care"[tw]) AND (facility[tw] OR Facilities[tw] OR home[tw] OR homes[tw] OR institution*[tw] OR residence*[tw])	312
14	("aged care"[tw] OR "aged healthcare"[tw] or "aged health care"[tw]) AND (facility[tw] OR facilities[tw] OR home[tw] OR homes[tw] OR institution*[tw] OR residence*[tw])	1898
13	"old age home"[tw] OR "old age homes"[tw] OR "old age facility"[tw] OR "old age facilities"[tw]	424
12	"home for the aged"[tw] OR "homes for the aged"[tw] OR facility for the aged"[tw] OR "facilities for the aged"[tw] OR "institution for the aged"[tw] OR "institution for the aged"[tw]	13963
11	"Homes for the Aged"[mesh]	13710
10	institutionalization*[tw] OR institutionalisation*[tw]	9257
9	SNF[tw] OR SNFs[tw]	4281
8	"residential care"[tw] OR "residential facility"[tw] OR "residential facilities"[tw] OR "residential healthcare"[tw] or "residential health care"[tw]	8757
7	"care facility"[tw] OR "care facilities"[tw]	46553
6	"care home"[tw] OR "care homes"[tw]	3475
5	LTC[tw]	3625
4	"longterm care"[tw] OR "longterm facility"[tw] OR "longterm facilities"[tw] OR "longterm healthcare"[tw] OR "longterm health care"[tw] OR "longterm institution"[tw] OR "longterm institutions"[tw]	96
3	"long-term care"[tw] OR "long-term facility"[tw] OR "long-term facilities"[tw] OR "long-term healthcare"[tw] OR "long-term health care"[tw] OR "long-term institution"[tw] OR "long-term institutions"[tw]	37942
2	Long-Term Care[mesh]	25651

Table 2.2: Excluded studies during abstract and full text review

<b>Study author</b>	<b>Reason for exclusion</b>
Cobban, (2012)	Thesis not providing data on professional oral health care (POHC) programme
Cruz Gonzalez et al. (2016)	Abstract did not state a POHC programme
da Mata et al. (2014)	Abstract providing data in wrong setting (not in NHs)
da Mata et al. (2015)	Abstract providing data in wrong setting (not in NHs)
Gerritsen et al. (2014)	Abstract did not state supervision by an OHP and was not a POHC programme
Liu et al. (2018)	Abstract reported a systematic review
Miremadi et al. (2017)	Abstract did not state a POHC programme
Naito et al. (2010)	Abstract did not state a POHC programme
Rech et al. (2017)	Abstract stated independent elderly residents (not population of study)
Ueda et al. (2003)	Abstract stated elderly residents required long-term care, not resided in long-term care (not in NHs but in hospitals)
Mohammadi et al. (2015)	Abstract reported a systematic review protocol
Yoon, (2013)	Abstract did not state a POHC programme
Zenthöfer et al. (2014)	Abstract did not state a POHC programme
Nicol et al. (2005)	Full text reported on some residents from long-stay hospital wards not only NHs
Frenkel et al. (2001)	Full text does not report POHC by OHP
Shoajei, (2016)	Full text does not report POHC by OHP
Persson et al. (1991)	Full text reported elderly residents self- rinsing; not suitable for dependent population
Nawata et al. (2019)	Full text reported a systematic review
Abe et al. (2001)	Full text reported young healthy people as comparator; not population of study

Table 2.3: Included studies – Description of POHC Programs Based on Level of Extensiveness

POHC Program	Author Date, Study Design	Population (N)	Intervention	Comparison (Control Group)	Primary & Secondary Outcome Measures
Service provision only	Yoneyama et al., (Japan, 1996) RCT	46 NH residents in one NH. Intervention Group A: 21 residents with mean age 77 years (70-84), and Intervention Group B: 25 residents with mean age 79 years (70-88)	During period II (Group A) and during period III (Group B) residents received POC by a DDS & RDH once/day for 6 months; mouth cleansed after each meal by gargling/swabbing pharynx with povidone iodine (1%) by nurses	Period I (first six months): Usual care only to group A and group B residents Period II Group A: No POC in Period III, only usual care Group B: No POC in Period II, only usual care	<b>Primary:</b> Oral care improved febrile days to a limited extent; <b>Secondary:</b> Little difference in improved febrile days between group A and group B.
Service provision only	Adachi et al. (Japan, 2002) RCT	88 dependent elderly in two NHs requiring daily care over 24 months Intervention Group: 40 residents Control Group: 48 residents	RDHs performed POHC with hand scaling, electric brush with automatic water supply, interdental brush, sponge brush to clean teeth & dentures once/week	Usual care by self-oral care or staff using swabbing with sponge brush & denture cleaning.	<b>Primary:</b> C. albicans decreased significantly in the treatment group at 6 months <b>Secondary:</b> Prevalence of fevers & fatal AP ratio decreased significantly in the treatment group
Service provision only	Yoneyama et al., (Japan, 2002) RCT	366 elderly residents in 11 NHs investigated for two years. Intervention Group: 184 residents Mean age: 82.0 (74.2-89.8) Control Group: 182 residents Mean age: 82.1 (74.6-89.6)	Caregivers tooth brushed the residents' teeth for ~5 minutes. If tooth brushing was ineffective, the oropharynx was swabbed with povidone iodine after each meal; Plus weekly POHC of plaque & calculus control by DDSs or RDHs. Dentures cleaned with a denture brush daily & denture cleanser once/week	Some residents performed self-toothbrushing once a day or irregularly & none asked for oral care from caregivers; Dentures cleaned with a denture brush daily & denture cleanser once/week	<b>Primary:</b> Oral care significantly reduced plaque & debris; was beneficial in edentate and dentate residents <b>Secondary:</b> Residents receiving oral care had significantly decreased pneumonia rates, febrile days, & deaths from pneumonia compared to control group
Service Provision Only	Adachi et al., (Japan, 2007) Cross-sectional; First study only	88 residents in two NHs Intervention Group: 40 residents Control Group: 48 residents	A RDH brushed teeth using an electric brush with automatic water supply, interdental brush, & sponge brush; cleaned teeth, buccal mucosa, tongue & dentures	Usual care by resident self-oral care, staff, or helper swabbing with sponge brush & denture cleaning.	<b>Primary:</b> C. albicans were significantly lower in the POHC group compared to non-POHC group, after 6 months. <b>Secondary:</b> Fatal AP ratio and prevalence of fever were significantly lower in POHC residents compared to non-POHC; over 24-months

Service Provision Only (intervals, duration & short-term POHC)	Morino et al., (Japan, 2014) RCT	30 dentate elderly in one NH; follow-up at baseline to 5 months Intervention group: 14 residents Mean age: 86.2 (84.7-87.7) Control group: 16 residents Mean age: 84.8 (83.1-86.5)	2 RDHs provided manual toothbrushing only, after breakfast once/week for 1 month. Plus, residents received usual care	All Residents received usual care by self-care or staff-assisted, at baseline to 5 months using same products of a manual toothbrush, end-tufted brush, & interdental brush only. Toothbrush, denture cleaner tablet, & ultrasonic cleaner was provided for dentures.	<b>Primary:</b> DPI significantly improved in the intervention group & was retained for 3 months after the intervention, when compared to baseline <b>Secondary:</b> DPI of elderly with functional dependence (FIM $\leq 5$ ) was significantly decreased
Service Provision Only (intervals And duration)	Lee et al., (Korea, 2020) RCT	135 residents in three NHs. Intervention groups for 12 weeks: 38 residents, 1-week intervals Mean age: 82.63 (73.37-91.89). 43 residents, 2-week intervals Mean age: 83.14 (75.01-91.27). Control group: 44 residents Mean age: 85.02 (79.26-90.78).	POHC provided for 6 minutes/resident, 4 RDHs provided denture cleaning using a suction device; teeth & tongue cleaning using rolling, Watanabe & Bass brushing, interdental brushes, & resident rinsing with water, debris removal, & tongue wiped using chlorhexidine-soaked sponge brush; resident received an interdental brush, sponge brush & denture cleanser.	No POHC	<b>Primary:</b> POHC at 1-week intervals most significantly, decreased, by 2-fold greater, plaque, tongue coating, & gingival indices & increased saliva flow when compared to the 2-week interval group, relative to the control group <b>Secondary:</b> N/A
Education Only	Schou et al., (Scotland, 1989) RCT	187 "well elderly" residents from four different institutions Intervention group: 142 residents Control group: 45 residents Mean age: 82	1. Residents taught only 2. Staff taught only 3. Staff & residents taught Provision of dental health education (DHE) programme comprised of three 1-hour sessions at monthly intervals in groups of five to six residents &/or staff, provided by three RDHs with staff in each institution.	No DHE Programme Clinical examinations & questionnaire were completed in each group before DHE programme (Time 1: Jan 1985) & 2 months after (Time 2: Sept 1985) DHE programme was terminated, at 8 months.	<b>Primary:</b> Results showed poor oral health & oral hygiene, high objective need for oral care but low perceived need. Overall prevalence of denture stomatitis was significantly higher at Time 2. <b>Secondary:</b> N/A
Service Provision And Education	Mojon et al., (Switzerland, 1998) RCT	116 dentate residents in a LTCF Intervention group: 58 residents (5 wards) Mean age: 83.5 (76.3-90.7) Control group: 58 residents (7 wards) Mean age: 84.6 (77.4-91.8)	<i>Education:</i> For 45 minutes, 1 RDH provided oral health prevention education to groups of 8-10 healthcare providers. <i>POHC:</i> 2 RDHs provided prophylaxis, scaling, resident brief oral hygiene instruction, instruction to nurse/nurse aide on extent resident could do self-oral care, & adapted recall system to the needs of the resident with maximum 6 months between visits.	Residents were treated by 1 dentist with mobile equipment if the resident, family, or home care-givers requested it. Residents who needed dental treatment were treated on-site. Tooth extraction & denture repair were provided when residents health did not permit comprehensive procedures.	<b>Primary:</b> Root caries prevalence decreased significantly in experimental group; Secondary caries prevalence increased significantly in the control group. Mutans Streptococci counts decreased significantly in the experimental group <b>Secondary:</b> N/A

			Residents received a toothbrush & fluoridated tooth paste at first & following visits.		
Service Provision And Education	<a href="#">Budtz-Jorgensen et al. (Belgium, 2000)</a> Non-RCT	237 dependent /frail elderly in one LTCF; data collection at baseline and again at 18 months Intervention group: 122 residents (5 wards) Mean age: 85.1 (66-101) Control group: 115 residents (7 wards) Mean age: 86.2 (66-101)	2 RDHs provided preventive POHC program including examination, treatment plan, scaling & prophylaxis, toothbrushes & fluoridated toothpaste, & recall system for POHC (dentate max 6 months frequency; edentulous once/year b/w visits). Oral health education provided to health carers	No systematic OHC program; teeth cleaned only if requested by DDS using mobile equipment	<i>At 18 months:</i> <b>Primary:</b> Prevalence of glossitis, mucosal lesions, palatal inflammation, denture stomatitis, colony counts, and yeast counts decreased significantly <b>Secondary:</b> N/A
Service Provision (6-18month screening) And Education /Motivation And Guidelines New routines	<a href="#">Samson et al., Norway, 2009</a> Repeated Cross-Sectional non-randomized pretest & post-test design	88 residents in one NH; recorded level of oral hygiene before start of the study, after 3 months, & after 6 years after the intervention Intervention group: 88 residents Control group: inherent	1. educating/motivating nursing staff 2. Oral care cards for guidelines 3. Distribution of adequate oral hygiene aids for standard e.g. electric brush 4. Implementation of new routines using 'oral-care contact person 5. 6–18-month screening intervals by a RDH to provide regular MPS measuring routines & feedback to the ward for improvements	No control group	<b>Primary:</b> Statistically significant difference of improved oral hygiene after 3 months, and still significant after 6 years; Dentate residents had statistically significant higher mean MPS than edentate residents; Residents with dementia had significantly better oral hygiene than residents with uncertain cognitive impairment. Positive correlation between degree of mucosal inflammation and amount of plaque. <b>Secondary:</b> N/A
Service Provision And Remotivation Individual OH instruction And Education	<a href="#">Zenthöfer et al. (Germany, 2013)</a> RCT Prospective, Single-blinded (outcome evaluation),	102 residents in eight LTCFs within a 12-week follow-up period & 3-year long-term follow-up after end of study Intervention group: 79 residents 1: No re-motivation; N=26 no further intervention 2: DDS re-motivation; N=27 DDS re-instructed & re-motivated	All three therapy groups had professional teeth & denture cleaning & individual instruction. POHC provided by a DDS using portable ultrasonic unit and polishing; dentures cleaned using ultrasonic bath. DDS tailored oral hygiene according to oral hygiene needs, manual & cognitive ability, for 30 minutes	Usual oral hygiene care (not detailed)  Baseline & recall exam performed after 2, 6 & 12 weeks for all four groups. At baseline, staff completed 2-hour oral hygiene lesson & provided help to participants twice/week	<b>Primary:</b> Mean plaque, gingival bleeding & denture hygiene indices were significantly lower showing improved oral hygiene in the intervention group over 12-weeks. Indices were significantly worse than study recall at 3-year long-term follow-up meaning effect of POHC with individual instruction decreases over time and renewal is necessary to maintain improved oral hygiene <b>Secondary:</b> N/A

		elderly after 4 & 8 weeks 3: Staff remotivation; N=26 Elderly received help twice/week and were re-motivated by minimally educated staff Control group: 23 residents			
Dental Exams And Education And weekly hands-on support And Customized oral hygiene report And Staff Evaluation	<a href="#">Seleskog et al. (Sweden, 2018)</a> <b>Non-RCT</b> Controlled Clinical Trial; short-term study with longitudinal design	37 residents in two NHs, at baseline & after three month follow-up Intervention group: 13 residents Mean Age: 89 (83-95) Control group: 18 residents Mean Age: 88 (83-93)	2 RDHs gave once/week nursing staff support over three months by: 1. Participating in staff meetings at beginning of study, after 6 weeks & end of study 2. Individualizing theoretical hands-on support per resident once/week 3. Customizing written oral hygiene prescriptions per resident for specialized oral care devices & routines	Usual oral care  DDS did dental exams of all participating elderly in both NHs	<b>Primary:</b> Dental plaque levels decreased significantly after the 3-month intervention <b>Secondary:</b> <b>Questionnaire</b> from nursing staff did not show significance, just improvement
Service Provision (Frequency And Duration) And Education And Staff Evaluation	<a href="#">Girestam Croonquist et al., (Sweden, 2020)</a> <b>RCT</b> Evaluator-blinded open-ended	146 residents from nine NHs randomly assigned to the intervention or control group at the NH level, at baseline, 3 months & 6 months  At baseline, residents in the intervention and control group received professional cleaning, home care instruction, written information, and oral hygiene products. Oral exam performed at baseline, 3 & 6 months	N=72 Mean age: 89 (85-93) 56 (78%) female 16 (22%) male  3 RDHs provided POHC of tooth brushing, interproximal cleaning and scaling of supragingival calculus, individual oral hygiene instructions, information & fluoridated toothpaste, soft toothbrush, & interproximal cleaning aids, once/month, for 30 minutes, for 6 months N=35 nursing staff participated at baseline & N= 20 at 6-month follow-up, with N=12 staff followed from baseline to 6-month follow-up & designated as the identified group	N=74 Mean age: 88.7 (84.5-92.9) 52 (70.3%) female 22 (29.7%) male  Usual daily oral care was self-performed or nursing staff-assisted without any additional visits/instruction from an RDH  N=15 nursing staff participated at baseline & N=15 at 6-month follow-up, with N=2 staff followed from baseline to 6-month follow-up & designated as the identified group. Nursing staff completed 2 questionnaires to analyze nursing staff attitudes (priorities) & knowledge regarding oral health care & oral health care needs for care-dependent elderly.	<b>Primary:</b> Significant improvement in MS b/w period 3-and 6-month follow-ups when compared to the control group <b>Secondary:</b> At 6-month follow-up, the intervention group nursing staff working with residents showed statistically significant improvement in OHCB, external and internal locus of control, compared to the control group.

POC, professional oral care; POHC, professional oral health care; f, female; m, male; NH, nursing home; LTCF, long-term care facility; RDH, registered dental hygienist; OHCB, oral health care beliefs; RCT, randomized control trial; DDS, dentist; AP, aspiration pneumonia; fevers are 37.8°C+; DPI, Dental plaque index; MPS, mucosal plaque scores; MS, mucosal score index;

Table 2.4: On-site Professional Oral Health Care (POHC) Interventions: Results and Conclusions  
Primary Outcomes Only

Major Findings or Odds Ratio (OR) or Risk Ratio (RR)	Conclusions
<p><i>Yoneyama 1996 (RCT - Incidence)</i> Patients (#) with abnormal sputum Group B, period II: 8 out of 25; one pneumonia death Group A, period III: 6 out of 21; no pneumonia deaths Abnormal sputum at 6 months Group A: RR: 0.66, AR: POHC once per day: 10%; NT: 10% Group B: RR: 0.88, AR: POHC Program: 4%; NNT: 25%</p>	<p>Assuming causality, the exposure to the POHC once per day by a DDS or RDH for six months with an RR &lt; 1 (RR is 0.66) in Group A and RR &lt; 1 (RR is 0.88) in Group B is preventing the disease number of sputum.</p>
<p><i>Adachi 2002 (RCT - Incidence)</i> C. albicans (#) after 6 months (P &lt; .01) POHC compared to non-POHC LTC residents who receive POHC by dental hygienists for 6 months showed a significant decrease in numbers of C. Albicans in samples without POHC (2000 CFU/ml) compared to after POHC (700 CFU/ml) (p &lt; .01).</p>	<p>Elderly residents who need daily nursing care and who receive POHC by dental hygienists for 6 months showed a significant decrease in C. Albicans (#) (p &lt; .01). This shows a 1,300 CFU/ml difference and 2.9 times difference of reduction in C. albicans when LTC residents receive POHC once per week by RDHs for 6 months when compared to going without POHC by RDHs.</p>
<p><i>Yoneyama 2002 (RCT - Incidence)</i> Debris Indices at 24 months Oral care compared to non-oral care RR: 0.94 AR: professional oral care once per week: 3% NNT: 33% (2.81, 95% CI = 1.39-5.69, P &lt; .01).</p>	<p>When categorizing each LTC resident into an improved or deteriorated group, there was a significant reduction in the Debris Index in oral care compared to non-oral care. Assuming causality, the exposure to the Professional oral care once per week by DDSs or RDHs for 24 months with an RR &lt; 1 (RR is 0.94) is preventing the disease mean debris indices compared to the unexposed who did not receive professional oral care.</p>
<p><i>Adachi 2007 (Cross-sectional - Prevalence)</i> <i>First study only.</i> C. albicans (Average #) for 6 months POHC compared to non-POHC Numbers of C. albicans in the POHC are 1,200 less in the POHC compared to the Non-POHC group.</p> <p>The relationship between total febrile days and oral hygiene in dentate elderly patients showed that poor oral hygiene groups had a higher DPI and significantly higher mean number of febrile days than the good oral hygiene groups (P &lt; .01) in one year.</p>	<p>After POHC, numbers of C. albicans were significantly lower when compared to the non-POHC group (P &lt; 0.001). This means that there is a relationship between LTC residents receiving POHC and reducing the number of C. albicans in the mouth.</p> <p>In the dentate group, the number of febrile days and patients who developed pneumonia were significantly higher in the DPI poor group compared to the DPI good group (P &lt; .01).</p>
<p><i>Morino 2014 (RCT)</i> DPI Effect of short-term POHC on the elderly residents at baseline and once/week for one month on DPI</p>	<p>The effect was retained for three months after the intervention period, with no differences observed in the control group (Wilcoxon test, P &lt; 0.05). The variable, POHC intervention, showed significant</p>

<p>Effect of POHC on the elderly residents in Dental Plaque Index (DPI) showed significant improvement in the intervention group (57%; 8/14) compared to the control group (13%; 2/16); Fisher's two-tailed test, <math>P &lt; 0.05</math>. (OR, 9.33; 95% CI, 1.74-75.66; <math>P &lt; 0.01</math>).</p>	<p>association in ability to predict the outcome of improvement in DPI</p>
<p><i>Lee 2020 (RCT)</i>          Plaque Index          Comparison of effects of the POHC program on Plaque Index after the intervention in the one-week and two-week interval groups          The plaque index decreased significantly by mean 0.90 in one-week and mean 0.47 in two-week interval groups (Paired t-test, <math>P &lt; 0.001</math>) after the intervention when compared to the control group.</p>	<p>The plaque index decreased most significantly in the one-week interval group, followed by the two-week interval group which was followed by the control group.</p>
<p><i>Schou 1989 (RCT) (Short-Term; Education only)</i>          Number of residents with maxillary denture plaque scores in control and experimental groups before (Time 1) and after (Time 2) dental health education (DHE)          Time 1 (Before DHE intervention): Maxillary denture plaque score</p> <p>RR          Group A: Staff taught DHE only  <i>Poor score</i>: RR: 1.12; Relative risk reduction: 12%          Group B: Residents taught DHE only  <i>Poor score</i>: RR: 0.64; Relative risk reduction: 36%          Group C: Both residents and staff taught DHE programme  <i>Poor score</i>: RR: 78%; Relative risk reduction: 22%          Group D: Control group; No DHE  <i>Poor score</i>: RR: 137%; Relative risk reduction: 37%.</p>	<p>There was no statistically significant reduction in maxillary denture plaque scores in the control and experiment group before (Time 1) and after (Time 2) dental health education (DHE). This means that denture hygiene instruction taught to both residents and staff did not improve oral hygiene habits.</p> <p>The risk of a poor outcome is 1.12 times the risk of a poor maxillary denture plaque score outcome in the staff taught DHE only (Group A).          The risk of a poor outcome poor maxillary denture plaque score in in the staff taught DHE only (Group A) is 1.12 times the risk; residents taught DHE only (Group B) is 0.64 times the risk; both residents and staff taught DHE (Group C) is 0.78 times the risk; and control group with no DHE (Group D) is 1.37 times the risk of poor maxillary denture plaque score outcome.</p>
<p><i>Mojon 1998 (RCT) (long-term; service provision and education; incidence)</i>          Plaque Index at 18 months          RR: 0.94          AR: POHC Program: 2%; NNT: 50%          We observed less disease in the exposed group to the POHC than in the unexposed group who did not receive the POHC. Assuming causality, the exposure to the POHC with an RR <math>&lt; 1</math> (RR is 0.94) is preventing the disease plaque index.</p>	<p>The difference in the median plaque index of 2.75 in the control group and 2.57 in the experiment group at baseline was not significant (Mann-Whitney, <math>P = 0.43</math>). There was no significant change in the plaque index over 18 months despite comparison of the increase in median score of 0.25 in the control group and 0.06 in the experimental group (Wilcoxon, <math>P = 0.26</math>; Wilcoxon, <math>P = 0.95</math>, respectively).          The correlation of plaque index was significant at 18 months (Spearman -0.31, <math>P = 0.006</math>) but not significant in the experimental group (Spearman -0.31, <math>P = 0.09</math>) but was significant in the control group (Spearman -0.46, <math>P = 0.003</math>). There was a positive correlation of the plaque index at 18 months with the plaque index at</p>

	baseline (Spearman rank correlation coefficient: 0.37, P < 0.01).
<p><i>Budtz-Jorgensen 2000</i> (Non-RCT) (long-term; prevalence)  <i>C. albicans</i> after 18 months  Experimental group compared to the control group  RR: POHC Program: 0.7  We observed less disease in the exposed group to the POHC program than in the unexposed group who did not receive the POHC program.  AR: POHC Program: 20%; NNT: 5%</p>	<p>There was a significant reduction in the numbers of <i>C. albicans</i> positive residents (P&lt;0.05) in the experimental group at 18-month follow-up. In both the experimental (90%) and control (90%) group, <i>C. albicans</i> was the predominant yeast species.</p> <p>Assuming causality, the exposure to the POHC program with an RR &lt; 1 (RR is 0.7) is preventing the disease <i>C. albicans</i>.</p>
<p><i>Samson 2009</i> (Repeated cross-sectional; Prevalence) (long-term – service provision screening, education/motivation)  Oral hygiene (MPS) 2-4, n (%)  Baseline, 3 months &amp; 6 years after intervention  Prevalence Ratio: 0.83  The exposure is less likely to have an outcome of poor MPS. Exposure to OHC programme is protective as the prevalence ratio is less than 1; is 0.83 times as likely.</p>	<p>Six years after implementing the oral healthcare programme, 70% of the residents had an MPS of 2-4 which is a good/acceptable oral hygiene state. There was a statistically significant difference of oral hygiene between baseline, 3 months after the intervention, and 6 years after the intervention (P &lt; 0.001). There was also a statistically significant improvement in oral hygiene after 3 months (P &lt; 0.001 and still significant after 6 years (P &lt; 0.001).</p>
<p><i>Zenthöfer 2013</i> (RCT) (long-term; Service provision and Education/motivation/remotivation; incidence).  Primary: Mean Plaque Index in 18 months  RR: POHC Program: 1.17  We observed less disease in the exposed group to the POHC program than in the unexposed group who did not receive the POHC program. Assuming causality, the exposure to the POHC program with an RR &gt; 1 (RR is 1.17) is preventing the disease <i>C. albicans</i>.  AR: POHC Program: 20%; NNT: 5%  (95% CI 29.1%/50.0%, P &lt; 0.001, n = 24)</p>	<p>For plaque indices, residents of all three therapy groups had significant improvement in the hygiene index over time compared to the control group (P &lt; 0.023). 3 years after the end of the study the plaque index was significantly worse (27.4%, P &lt; 0.001) when compared with baseline. However, when the results of the 3 years after assessment were compared with the last study recall results (Recall 3, after 12 weeks), all indices were significantly worse and the mean plaque index increased by 38.0%</p>
<p><i>Seleskog 2018</i> (Non-RCT) (short-term; Service provision and education, customized oral hygiene report; incidence)  Primary: Plaque levels after 3 months  RR: Oral Health educational Programme: 0.78  We observed less disease in the exposed group to the OHC educational programme than in the unexposed group who did not receive the OHC educational programme.  AR: OHC Educational Programme: 11%; NNT: 9%</p>	<p>Residents' plaque levels at the intervention NH at baseline were median 1.5 (0.5-2.7) and after 3 months at follow-up were significantly decreased to median 0.9 (0.3-2.7); P ≤ .05. Residents' plaque levels at the control NH at baseline were median 1.8 (0.8-2.7) and after 3 months at follow-up were 1.7 (0.9-2.8). Assuming causality, the exposure to the OHC educational program with an RR &lt; 1 (RR is 0.78) is preventing the disease plaque levels and improving oral health of residents in nursing homes.</p>
<p><i>Girestam 2020</i> (RCT) (short-term; Service provision (monthly frequency and duration: 30 minute visiting time) and education; incidence))</p>	<p>MPS improved from baseline to six-month follow-up in both the intervention group and control group. There was no significance in improved PS in both</p>

<p>Mucosal Score (MS); from three-and Six-Month Follow-ups (P &lt; 0.04)  Intervention compared to the control group. Residents (N) who participated  RR: Professional cleaning and OHI: 0.92 at the 3–6-month follow-ups.  We observed less disease in the exposed group to the professional cleaning and individual OHI than in the unexposed group who did not receive the professional cleaning nor individual OHI.  AR: Professional cleaning and individual OHI: 7%  NNT: 14%</p>	<p>groups. However, there was a significant difference in mucosal scores (MS) between the intervention group and control group (p=0.04) within the period between three- and six-month follow-ups. Percentage of improvement in MS were 20% in the intervention group compared to 13% in the control group. Assuming causality, the exposure to the professional cleaning and individual OHI with an RR &lt; 1 (RR is 0.92) is preventing the disease mucosal scores and improving oral health of residents in nursing homes.</p>
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POHC, professional oral health care; POC, professional oral care; LTC, long-term care; RR, Risk Ratio/Relative Risk; AR, Risk Difference/Attributable Risk; NNT, Number Needed To Treat; OR, odds ratio; PYs (person-years); AP, aspiration pneumonia; DPI, dental plaque index; MP, mucosal plaque; MS, mucosal score; OHI, oral health instruction; \*Febrile days defined as body temperature above 37.5 °C.

Table 2.5: Quality of included studies: GRADE for rating the quality of evidence

No. of Studies (Design)	Limits (Risk of Bias)	Inconsistent	Indirect	Imprecise	Publication Bias	Magnitude Of Effect	Dose Response	Residual Confounding	Quality Level
Yoneyama (1996) RCT	COI NR					No CI Yes Mean SD			High
Adachi RCT	COI NR					No CI			High
Yoneyama (2002) RCT	COI NR					Yes CI			Higher
Adachi Cross-sectional	COI NR					No CI			Mod
Morino RCT	No COI					Yes CI			Highest
Kyeong Hee Lee RCT	No COI					No CI			High
Schou RCT	COI NR	Change in diagnostic criteria bw Time 1 and Time 2		Low response; half could understand; Some unreliable answers		No CI			High
Mojon RCT	COI NR	Contaminate Controls by treating residents in the control group				No CI			High
Budtz non:RCT	COI NR					No CI			High
Samson Repeated Cross-Sectional	Potential COI					No CI			Mod
Zenthöfer RCT	COI NR					Yes CI			Higher
Seleskog Non-RCT	No COI	Study was only 3 months				No CI Under powered			Mod
Girestam Croonquist RCT	No COI					No CI			High
Initial Quality of Body of Evidence	<b>Lower If</b>	<b>Lower If</b>	<b>Lower If</b>	<b>Lower If</b>	<b>Lower If</b>	<b>Higher If</b>	<b>Higher If</b>	<b>Higher If</b>	<b>Quality Level</b>

RCTs High	-1 serious -2 very serious	-1 likely -2 very likely	+1 large +2 very large	+1 evidence of a gradient, Reduce a demonstrated effect, suggest spurious effect if no effect was observed	High ++++ Moderate +++ Low ++ Very Low +				
Observational Studies Low									

Balshem, H., Helfand, M., & Schumemann, H. J. et al. GRADE guidelines 3: rating the quality of evidence. J Clin Epidemiol, 2011 Apr;64(4):401-6. Rating is for primary outcomes only. COI, conflict of interest; NR, not reported

## **Appendix 1. Detailed description of the adaptation of Munzenmayer et al., 2018 study costs for Provision of On-site Professional Oral Health Care within Alberta NHs.**

*Training and Travel:* Costs include the 90 minutes of time that it takes for an RDH to prepare the training session and the 90 minutes of time that it takes to provide a standardized training session in daily oral hygiene provision to two registered nurses (RNs) and two NA/HCAs per NH for every 20 residents. This includes retraining every six months. Costs also include the RNs and NA/HCAs training time costs to attend the training. It would take 38 RDHs to train the staff in 761 Alberta NHs in five business days, visiting four NHs per day (Münzenmayer et al., 2018). RDH travel costs to the NHs would be calculated in Google Maps (<http://maps.google.ca>) using cents per kilometre to quantify costs for distance traveled.

*Salaries:* Costs include the salary paid (CAD) per hour for time worked (including: \$45.40 for the programme coordinator/oral-care contact person (RN) for three hours per week, \$24.77 for the NA/HCAs provision of non-POHC, \$61.76 for the RDHs provision of POHC (Alberta Alis Occupation <https://alis.alberta.ca/occinfo/occupations-in-alberta/>)). Automobile allowance rates would pay the RDH 59 cents per km for the first 5,000 km driven, and 53 cents per km driven after that for RDH travel costs (*2021 automobile allowance rates* <https://www.canada.ca/en/revenue-agency/services/tax/businesses/topics/payroll/benefits-allowances/automobile/automobile-motor-vehicle-allowances/automobile-allowance-rates.html>)

*Programme coordinator office:* Costs include office rent and expenses including office furniture, computers, and office services. The POHC program would use the space, administration staff and office equipment from each NH based on a shared office, 3 hours per week (Münzenmayer et al., 2018).

*Dental equipment, instruments, and supplies:* At market value, costs for all dental equipment, instruments, and supplies would be calculated to provide teeth and denture cleaning. Pricing of manual and electric toothbrushes, interdental brushes, denture brushes, sponge brushes, portable dental unit and chair, ultrasonic scaler tips and trays, saliva ejectors, autoclave and sterilization, gloves, masks, gowns, shields, and safety glasses to follow COVID-19 guidelines (Münzenmayer et al., 2018). None of these cost categories were included in any calculations and need to be included in future cost effectiveness analysis.