Professional oral health care prevents mouth–lung infection in long-term care homes: a systematic review

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PRACTICAL IMPLICATIONS OF THIS RESEARCH

- Bacterial plaque and debris removal from LTC home residents' teeth, gums, and dentures is effective in reducing oral infections and related pneumonia/aspiration pneumonia.
- Dental hygienists can provide clinically effective onsite oral health care, once per week, and caregiver/health care aids can provide mouth care, twice per day, to reduce the risk of oral and lung infection among all dependent LTC home residents.

ABSTRACT

Background: Nursing home-acquired pneumonia (NHAP) is the leading cause of mortality among residents in long-term care (LTC) homes. Aspiration pneumonia (AP) is one cause of NHAP. Professional oral health care (POHC) and daily mouth care can be effective in decreasing AP risk. **Aim**: To identify, appraise, synthesize, analyze, and interpret results on the effectiveness of onsite POHC interventions/programs delivered to LTC home residents in reducing oral disease and NHAP. To summarize the findings and provide recommendations for clinical work and future research. **Methods**: The PICO question addressed was, "In LTC home residents with oral health needs (P), is onsite POHC (I), compared to usual care (C), clinically effective in reducing dental disease and pneumonia/AP (O)?" Databases searched were PubMed, EMBASE (Ovid), CINAHL (Ebsco), Cochrane Library (Wiley), Web of Science, and the databases of the Centre for Reviews and Dissemination. Included were randomized controlled trials (RCTs), non-RCTs, and cross-sectional studies. PRISMA guidelines were followed and GRADE was used to assess the quality of studies. **Results**: Thirteen clinical effectiveness studies were included: 10 RCTs, 1 non-RCT, and 2 cross-sectional studies. **Discussion:** Better oral health and respiratory infection outcomes were found in the experimental groups who received an onsite POHC intervention compared to the control groups. **Conclusion**: There is moderate-to-strong evidence that onsite POHC in LTC homes, provided mostly by dental hygienists, is effective in preventing bacterial mouth infection, pneumonia, and AP.

RÉSUMÉ

Contexte : La pneumonie nosocomiale des foyers de soins est la principale cause de mortalité chez les résidents des foyers de soins de longue durée (SLD). La pneumonie par aspiration (PA) est l'une des causes de la pneumonie nosocomiale des foyers de soins. Les soins buccodentaires professionnels et les soins quotidiens d'hygiène buccale peuvent permettre de réduire efficacement le risque de PA. **Objectif** : Définir, évaluer, résumer, analyser et interpréter les résultats relatifs à l'efficacité des interventions et des programmes de soins buccodentaires professionnels offerts sur place aux résidents des foyers de SLD pour réduire l'incidence des affections buccales et de la pneumonie nosocomiale des foyers de soins. Résumer les constatations et formuler des recommandations pour les travaux cliniques et les études à venir. **Méthodes** : La question relative aux patients, aux interventions, aux comparaisons et aux résultats était la suivante : « Chez les résidents des foyers de SLD ayant des besoins en santé buccodentaire (patients), les soins buccodentaires professionnels sur place (interventions) sont-ils cliniquement efficaces par rapport aux soins ordinaires (comparaisons) pour réduire l'incidence des affections dentaires et de la pneumonie/de la PA (résultats)? » Les bases de données concernées par les recherches étaient PubMed, EMBASE (Ovid), CINAHL (Ebsco), la Bibliothèque Cochrane (Wiley), la plateforme Web of Science et les bases de données du Centre for Reviews and Dissemination (« Centre des examens et de la dissémination »). Des essais cliniques randomisés (ECR), des essais cliniques non randomisés et des études transversales étaient inclus. On a suivi les lignes directrices PRISMA et on s'est appuyé sur le cadre GRADE pour évaluer la qualité des études. **Résultats** : On a inclus 13 études sur l'efficacité clinique : 10 ECR, 1 étude clinique non randomisée et 2 études transversales. Les membres des groupes expérimentaux qui bénéficiaient d'interventions de soins buccodentaires professionnels sur place avaient de meilleurs résultats en matière de santé buccodentaire et d'incidence des infections respiratoires que ceux des groupes témoins. **Conclusion** : On constate l'existence de preuves modérées à solides que les soins buccodentaires professionnels offerts sur place dans les foyers de SLD, assurés principalement par des hygiénistes dentaires, sont efficaces pour prévenir les infections bactériennes buccales, la pneumonie et la PA.

Keywords: daily mouth care; daily oral hygiene; dental hygiene care; fluoride varnish; long-term care; oral health exam; prophylaxis; root planing; scaling
CDHA Research Agenda category: access to care and unmet needs

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INTRODUCTION

Longer life expectancy means older adults are retaining their natural dentition into their dependent years, contributing to increasingly complex oral health care needs.[1] Adding to these oral health complexities is a 60% incidence of dementia among long-term care (LTC) home residents in Canada,[2] which has been shown to negatively impact oral health, resulting in a high level of oral disease in this population.[3-5]

A national study of oral health in Canadian LTC homes (N = 559) showed a prevalence of oral conditions, including lip problems (69.8%), thick saliva (39%), bad breath (31.1%), edentulism (42.4%), angular chelitis (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 dentures (44.6%), and broken teeth, infection, severe decay, and ulcers requiring urgent dental treatment (8.6%). This study also found that the oral health status of 19.5% of participants most likely or significantly impacted their food intake (19.5%), and that 30% of study participants had oral conditions that made food intake potentially challenging.[2]

In Canada, pneumonia was the leading cause of emergency department visits (65%) in 2017–2018 among older adults who were admitted to hospitals.[6] In LTC homes, nursing home-acquired pneumonia (NHAP) is the leading cause of mortality among residents.[7,8] NHAP risk factors include physical impairment, dementia, chronic obstructive pulmonary disease (COPD), mechanical ventilation, and older age.[9,10] For LTC home residents, additional risk factors for aspiration pneumonia (AP) are poor oral hygiene, denture use[11] or missing teeth[12]. Residents with an increased rate of dental plaque colonization, which may act as a reservoir for pathogenic organisms, have associated NHAP.[13-15] One proposed reason for fatal AP occurrence is the build-up of *C. albicans* in the resident's oral cavity.[16] This is an issue as most residents depend on LTC home staff to remove bacterial plaque from their oral cavity daily.[2] Yet most LTC homes do not consistently, if at all, administer oral health services as part of their daily care provision.[17] Alberta residents who need oral health care can arrange for an onsite visit from a dental hygienist, but they or their families are usually responsible for paying for some or all of the costs.[17] The current Alberta Continuing Care Act does not require LTC homes to 1) hire dental hygienists to perform weekly professional plaque and calculus control of residents' teeth and dentures or 2) hire caregivers to brush the residents' teeth or dentures or swab the oropharynx with povidone iodine after each meal.[18]

The COVID-19 pandemic highlighted the significant impact of pneumonia on LTC home residents when compared to community-dwelling older adults. Canada has been reported to have the highest number of COVID-related excess deaths in LTC homes when compared globally.[19] Suffering and pain related to pneumonia and AP in LTC home residents could potentially be reduced or prevented by providing daily mouth care and essential onsite professional oral health care (POHC). During the COVID-19 pandemic, the guidelines from the Centers for Disease Control and Prevention (CDC), Alberta Continuing Care, and the College of Registered Dental Hygienists of Alberta stated that non-aerosol-generating POHC was essential to reduce gum inflammation, especially among vulnerable older adults residing in LTC homes.[20]

Onsite POHC relies on portable clinics to provide high-quality, non-aerosol-generating, and non-invasive oral health care within the clinical treatment pathway. Onsite POHC is essential for vulnerable or dependent LTC home residents who are bedridden, medically compromised, mobility challenged, have dementia, are fearful of oral health care, and cannot be moved easily or transported to conventional dental or dental hygiene clinics. The design of onsite POHC programs facilitates systematic, interdisciplinary oral health care for LTC home residents that could include the following standardized preventive measures: 1) a daily oral care system and dental hygiene therapy; 2) training of nursing assistants by dental hygienists to provide daily mouth care; 3) direct and indirect supervision of daily mouth care by dental hygienists; 4) oral assessments; 5) education for nursing staff; and 6) participation in the medical–dental management of medically compromised and vulnerable or dependent residents.[21]

A systematic review was conducted to assess the evidence of the clinical effectiveness of onsite POHC program components in LTC homes in reducing oral disease as a primary outcome and pneumonia or AP as a secondary outcome.

METHODOLOGY

Protocol and registration

The authors followed standard procedures for a systematic review and reported results according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[22] The project protocol was not publicly posted prior to data extraction.

A preliminary literature search of randomized controlled trials (RCTs) and other peer-reviewed studies of relevant clinical outcomes helped define the population, intervention, comparator, outcome, and study design (PICOS).

Search strategy

A comprehensive literature search was conducted to identify studies on the effectiveness of onsite POHC interventions in LTC home residents. An expert medical information specialist developed and tested the search strategy in PubMed using an iterative process in consultation with the lead author (MM). The lead author (MM) then translated and executed the strategy in the following databases: Embase (Ovid), CINAHL (Ebsco), Cochrane Library (Wiley),

Table 1. PICOS inclusion and exclusion criteria

PICOS	Inclusion criteria	Exclusion criteria
Population	LTC home residents with oral disease	Non-LTC home residents
Intervention	POHC services delivered in LTC homes	Independent-living or assisted-living environments and non-program delivery
Comparator	Usual care as current practice	POHC services delivered in independent or supportive/ assisted living environments
Outcomes	Primary outcomes: oral disease-specific assessment tools measuring plaque levels, gum inflammation, bone levels, and decayed teeth Secondary outcomes: pneumonia rates, AP ratios, oral health-related quality of life (OHRQoL) tools that target older adults	Studies without any defined or relevant clinical outcomes
Study design	RCTs, non-RCTs, single-arm trials, cohort studies, case–control studies, and case series studies	Non-English language, single case reports, expert reviews, editorials, and opinion pieces

Web of Science, and the databases of the Centre for Reviews and Dissemination (DARE, NHS EED, HTA). The authors used a combination of controlled vocabulary (e.g., "long term care," "dental prophylaxis," "pit and fissure sealants") and keywords (e.g., LTC, oral health exam, dental care). ClincalTrials.gov was searched for ongoing trials. A grey literature search of key websites and databases (e.g., National Institute for Health and Clinical Evidence, PROSPERO, select dental associations) was also undertaken. All searches were executed between March 27 and March 30, 2020. An update of the search was completed in March 2021. Inclusion and exclusion criteria are shown in Table 1; the PubMed search strategy is found in Supplementary Table S1.

Study selection

The PRISMA flow diagram (Figure 1) describes the review process and shows the number of records identified, screened, eligible, and included for review. Two individuals (TS and MM) independently reviewed the titles and abstracts from the search results. Reference lists of included studies were also reviewed.

Two authors (AO and MM) independently reviewed manually searched titles and abstracts retrieved from the reference lists of included studies and a Google search. Two authors of articles were contacted once for a copy of their article, but no response was received. One author was contacted for the included number of LTC homes and responded.

Data collection process

The lead author (MM) extracted the following data from the included studies using a standardized extraction table: type of POHC program, author, date, study design, population, intervention, comparison group, primary and secondary outcome measures, major findings, and conclusions (Supplementary Table S2). Data were extracted by adhering to the PICOS inclusion criteria of study characteristics. MM and AO compared results and discussed and resolved any disagreements. Because there was a 100% inter-rater reliability, an independent arbitrator was not required.

Assessment of heterogeneity between included studies showed 1) clinical variation where the true intervention effect was different in the specific studies; 2) differences in methodological factors (use of blinding and concealment of allocation sequence) that lead to differences in the observed intervention effects; and 3) lack of reporting confidence intervals. A meta-analysis was not conducted because the included studies were not sufficiently homogeneous in types of interventions and outcomes measured to provide a meaningful summary.

Risk of bias and study quality

Quality assessment of the methodologies of the included studies was undertaken using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) (Table 2) checklist, a validated method for evaluating studies on their reporting, internal validity (bias and confounding), external validity, and power.[23] The studies were ranked based on their design and methodological rigour from highest (RCTs) to lowest (cross-sectional study).

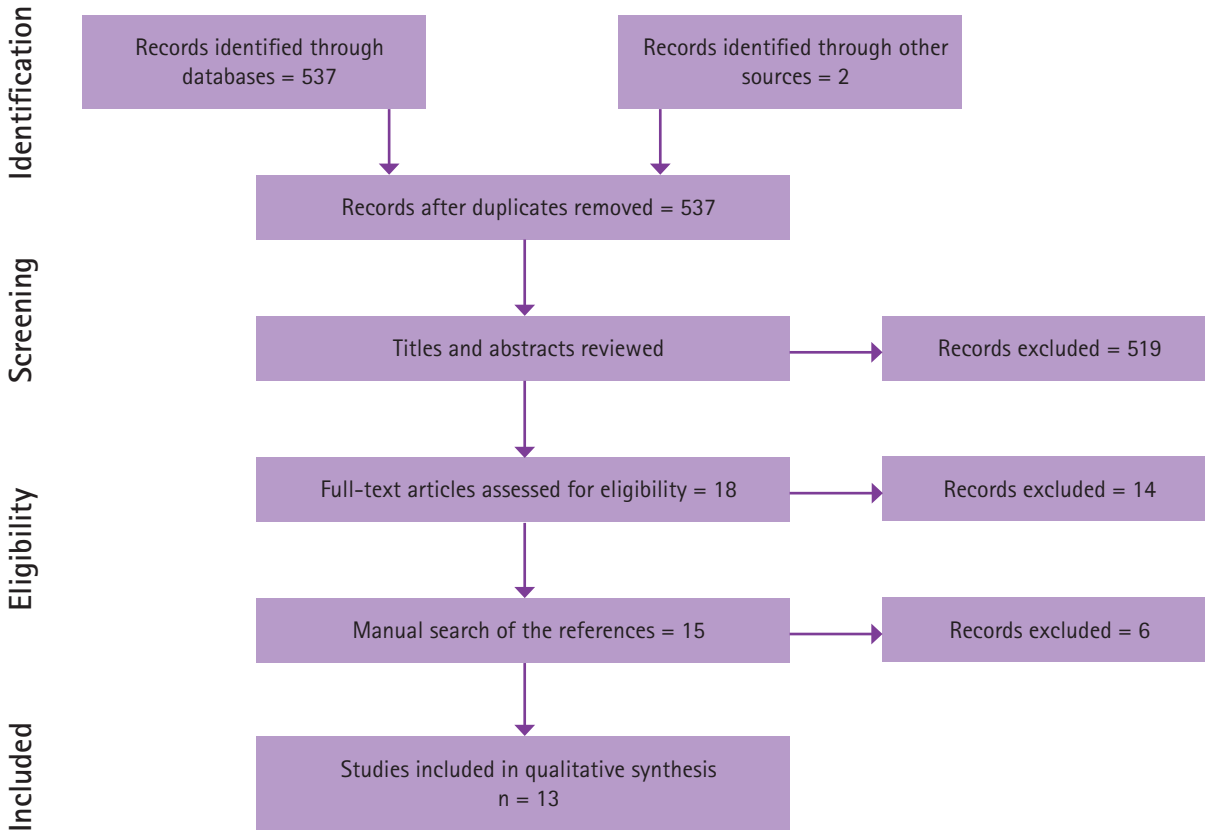
Summary measures

A qualitative thematic analysis was used to summarize the data. The principal summary measures of outcomes were severity and change in oral hygiene state after the POHC program intervention. Changes were measured as mean or median numbers (percentages) and the significance level set to $p \leq 0.05$. Primary outcome measures were abnormal pathogens of sputum, *C. albicans*, debris indices, dental plaque index or levels, maxillary denture plaque, mucosal-plaque score, and/or mucosal score. Secondary outcome measures were AP by number of deaths, febrile days, the change in mortality rate measured by the number of patients who received the POHC intervention, and oral health-related quality of life (OHRQoL) (Supplementary Table S2).

RESULTS

The database search strategy identified 539 records. After duplicates were removed, the titles and abstracts of 537 articles were reviewed. Eighteen articles were included for full-text screening. Of these, 4 studies retrieved from databases were included along with 9 studies retrieved from manual searches, yielding 13 studies for the qualitative synthesis (Figure 1).

Figure 1. PRISMA flow diagram



The included studies were published between 1989 and 2020 and were undertaken in Japan,[24-28] Korea,[29] Scotland,[30] Switzerland,[31] Belgium,[32] Norway,[33] Germany,[34] and Sweden.[35-36] Study methodologies are summarized in Table 2, which organizes POHC programs by type, from least extensive (service provision only) to most extensive (service provision plus education). Major findings and odds ratio (OR) or risk ratio (RR) are presented and conclusions drawn.

Quality of included studies

The 13 studies were rated based on study design, limits (risk of bias), inconsistent, indirect, imprecise, publication bias, magnitude of effect, dose–response, residual confounding, and quality level (Table 2). Ten studies were RCTs[24-26,28-31,34-36] and were considered to offer high-quality evidence.[20] The 1 non-RCT[32] and the 2 cross-sectional studies[27,33] were considered to be of low-to-medium evidence quality (level 2 to 3)[23]. The total number of patients in these studies was 1666.

Assessment of the studies using the GRADE guidelines[23] (Table 2) for rating the quality of evidence allowed for certain weaknesses to be identified. Failure to report conflicts of interest was identified in 8 studies,[24-27,30-32,34] and 1 study had a potential conflict of interest[33]. In the Mojon et al.[31] study, the controls were likely "contaminated" after receiving dental treatment during the study.

Failure to report confidence intervals (CI) was identified in 10 studies.[24,25,27,29-33,35,36] The study by Zenthöfer et al.[34] had a small sample size with very low statistical power. The study by Seleskog et al.[35] had a small sample size and was underpowered. Certain strengths were also identified using the GRADE guidelines.[23] The RCTs by Mojon et al.[31] and Girestam Croonquist et al.[36] were of highest methodological quality.

Professional oral health care programs

The POHC programs were divided into 5 categories: service provision only, education only, both service provision and education, POHC and education/motivation/remotivation, and staff evaluation and POHC (Supplementary Table S2).

Service provision only

The interventions in the service provision only category included 1) POHC by a dentist and dental hygienist once per day for 6 months and mouth cleansing after each meal by nurses[32]; 2) POHC by dental hygienists and denture cleaning once per week for 6 months[25]; 3) POHC by dentists or dental hygienists, denture cleaning daily, and

Table 2. GRADE for rating the quality of evidence (N = 13)

Studies (design)	Limits (risk of bias)	Inconsistent	Indirect	Imprecise	Publication bias	Magnitude of effect	Dose–response	Residual confounding	Quality of evidence
Yoneyama et al. 1996[24] (RCT)	COI NR	N	N	N	N	No CI Yes Mean SD	N	N	High
Adachi et al. 2002[25] (RCT)	COI NR	N	N	N	N	No CI	N	N	High
Yoneyama et al. 2002[26] (RCT)	COI NR	N	N	N	N	Yes CI	N	N	Higher
Adachi et al. 2007[27] (Cross-sectional)	COI NR	N	N	N	N	No CI	N	N	Moderate
Morino et al. 2014[28] (RCT)	No COI	N	N	N	N	Yes CI	N	N	Highest
Lee et al. 2020[29] (RCT)	No COI	N	N	N	N	No CI	N	N	High
Schou et al. 1989[30] (RCT)	COI NR	Y; Change in diagnostic criteria between Time 1 & Time 2	N	Y; Low response; some unreliable answers	N	No CI	N	N	High
Mojon et al. 1998[31] (RCT)	COI NR	Y; Controls likely contaminated	N	N	N	No CI	N	N	High
Budtz-Jorgensen et al. 2000[32] (Non-RCT)	COI NR	N	N	N	N	No CI	N	N	Moderate
Samson et al. 2009[33] (Repeated Cross-Sectional)	Potential COI	N	N	N	N	No CI	N	N	Moderate
Zenthöfer et al. 2013[34] (RCT)	COI NR	N	N	N	N	Yes CI Low power	N	N	Higher
Seleskog et al. 2018[35] (RCT)	No COI	Study was only 3 months	N	N	N	No CI Underpowered	N	N	Moderate
Girestam Croonquist et al. 2020[36] (RCT)	No COI	N	N	N	N	No CI	N	N	High

The quality of evidence determination is based on Balshem.[23] Rating is for primary outcomes only. COI: conflict of interest; CI: confidence interval; SD: standard deviation; NR: not reported; Y: Yes; N: No

daily cleanser once per week for 2 years, with caregivers brushing teeth or swabbing the oropharynx after each meal[26]; 4) POHC by dental hygienists, who brushed teeth, buccal mucosa, and tongue for 2 years[27]; 5) POHC by 2 dental hygienists, who manually brushed teeth only after breakfast, once per week, for 1 month plus residents received usual care; and 6) POHC by 4 dental hygienists, who provided denture cleaning, manual tooth brushing, resident mouth rinsing, debris removal, and tongue wiping for 6 minutes per resident at 1-week intervals for 12 weeks or 2-week intervals for 12 weeks.[29]

Education only

The 1 study in the education-only category involved an oral health education program comprising 3 one-hour sessions led by 3 dental hygienists at monthly intervals in groups of 5 to 6 residents and/or staff in each institution for 8 months.[30]

Service provision and education

The combined service provision and education category included 1) preventive oral health education provided by 1 dental hygienist to groups of 8 to 10 health care providers for 45 minutes over 18 months and POHC provided by 2 dental hygienists, consisting 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 6 months between visits over 18 months[31]; 2) POHC provided by 2 dental hygienists, consisting of examination, treatment planning, scaling,

and recall system. Dentate residents received a maximum 6-month frequency and edentulous residents received a once per year frequency between visits over 18 months. Oral health education was provided to health caregivers.[32]

Education/motivation/remotivation and professional oral health care

In this program category, education/motivation was provided to nursing staff, along with oral care guidelines on cards and oral hygiene aids. An oral care contact person oversaw the implementation of new routines.[33] In addition, remotivation was provided by a dentist after 4 and 8 weeks. At baseline, staff completed a 2-hour oral hygiene lesson and then provided remotivation to older adults twice per week. POHC was provided by a dentist and dentures were cleaned. Dentists tailored oral hygiene plans for each resident, and all 3 therapy groups had teeth and dentures cleaned professionally and received individual oral hygiene instruction.[34]

Staff evaluation and professional oral health care

In this category, a dentist performed dental examinations of all residents in 2 LTC homes. Two dental hygienists supported nursing staff once per week over 3 months.[35] POHC was delivered by 3 dental hygienists; 30-minute individual oral hygiene instruction and products were given once per month for 6 months.[36]

Clinical outcomes

Primary and secondary clinical outcomes for the 13 intervention studies varied based on the extensiveness of the POHC program. Primary outcomes for major findings or odds ratios (OR) or risk ratio (RR) results and conclusions are shown in Supplementary Table S2. All 13 studies found a significant reduction of bacterial infections in the oral cavity from a significant decrease in abnormal sputum[32]; *C. albicans* incidence[25,34] and its prevalence[27,32]; debris incidence[26;] plaque[29,34,35]; positive correlation of the plaque index[31] and prevalence[33]; incidence of mucosal disease[36]; and risk of poor maxillary denture plaque.[30] Four (31%) of 13 studies showed a significant reduction in fever,[24-27] its incidence,[26] and its prevalence[27]. One (8%) study showed a significant decrease in the number and proportion of deaths due to pneumonia and/or risk of getting pneumonia.[26] Three (23%) studies showed a significant reduction in number and proportion of deaths due to AP[24,25,27] and fatal AP ratio.[27] None of the studies measured the HRQoL (secondary outcome) of residents.

The studies were rated for quality of evidence (Table 2). Ten studies showed strong associations[24-26,28-31,34-36] and 3 studies reported moderate associations[27,32,33] between onsite POHC programs and clinical outcomes.

DISCUSSION

The purpose of this systematic review was to identify, appraise, synthesize, analyze, and interpret results and to summarize the findings and provide recommendations for clinical work and future research on the effectiveness of onsite POHC interventions in reducing oral disease and NHAP among LTC home residents. This systematic review identified 13 studies, with the majority showing positive outcomes from the programs delivered by dental hygienists and/or dentists. The main types of POHC programs were mostly provided by dental hygienists onsite in LTC homes and included a combination of components and services. Five studies included programs with mostly POHC service provision,[25-29] whereas only 2 studies provided both POHC services for residents and education for residents, staff, and caregivers.[31,32] Most of the studies reported that POHC services should be included in LTC homes mainly due to their positive impact on oral infection rates and reduction of pneumonia/AP. Studies concluded that providing POHC either prevented[24,26,31,32,34-36] or reduced disease[25,27-30] or provided protection.[33]

All of the studies, except for the 1996 study by Yoneyama et al.,[24] showed significant outcomes from the POHC intervention. Three studies showed significant reductions in latent bacterial mouth infections following provision of oral care by dental hygienists targeted to reduce the incidence of lower respiratory tract infections and to prevent pneumonia.[25-27] These 3 studies all reported reductions in the incidence of fever and fatal pneumonia, demonstrating that POHC was an effective intervention for the prevention of respiratory infections.[25-27]

Ten of the thirteen studies had some type of randomization and were considered RCTs. In the study by Mojon et al.,[31] the reliability was increased by using 2 calibrated dentists who were blinded to the ward in which each resident lived and to previous examination forms. Studies varied in the way randomization was done. For example, the Girestam Croonquist et al.[36] study randomly assigned residents to the intervention or control group at the LTC home level while other studies randomized the participants within one home.[24,28,31-33] There are advantages and disadvantages to both types of randomization when it comes to internal and external validity issues. In the Mojon et al.[31] study, the controls were likely contaminated by receiving dental treatment during the study, which may have threatened internal validity by introducing performance bias because the care provided to the controls differed from that offered to the experimental group. The study by Zenthöfer et al.[34] had a small sample size with very low statistical power and may likely have incurred statistical error because of the risk of random error due to outcome variability that may have arisen by chance alone. In both the Mojon et al. and Zenthöfer et al. studies, this threat to internal validity may have also decreased external validity when, for example, assessing intervention outcomes. Some studies had methodological limitations that decreased the quality of evidence. For example, in the RCTs by Yoneyama et al.[24,26] and Adachi

et al.[25], residents were randomly assigned to groups. However, there was no mention of blinding or calibration of evaluators. Although some studies had methodological limitations, all 10 RCTs[24-26,28-31,34-36] were assessed as having strong evidence, while the 3 non-RCT studies[27,32,33] were assessed as having moderate evidence.

Professional oral health care programs

Five POHC program categories were identified in this systematic review. The service-provision-only category included 6 studies in which POHC was provided by a dentist and a dental hygienist,[24] a dentist or dental hygienists,[26] and by 1 to 4 dental hygienists.[25,27-29] The services varied from once-daily mouth cleansing after each meal by nurses[24] or teeth and denture cleaning once per week for 6 months[25] to denture cleaning, manual tooth brushing, resident mouth rinsing, debris removal and tongue wiping for 6 minutes per resident at 1-week or 2-week intervals for 12 weeks.[29] The one study in the education-only category consisted of an oral health education program comprising 3 one-hour sessions provided by 3 dental hygienists at monthly intervals in groups of 5 to 6 residents and/or staff in each institution for 8 months.[30] This type of education alone, however, did not show any significant outcomes. Conversely, when both Budtz-Jorgensen et al.[32] and Mojon et al.[31], in separate studies, combined service provision and education in the same program, they found statistically significant clinical outcomes. This combined-program approach may be better than delivering educational programs alone.

Another example of this type of combination approach was explored in a study by Samson and colleagues[33] in which oral health education was provided by dental hygienists to groups of health care providers over 18 months. The dental hygienists also provided POHC services in LTC homes, including prophylaxis, scaling, examination, treatment planning, resident brief oral hygiene instruction, and instructions to the nurse or nurse aide. Education/motivation was provided to nursing staff, along with oral care guidelines on cards and oral hygiene aids. The implementation of new routines was overseen by an oral care contact person.[33] This combined intervention showed a statistically significant difference in improved oral hygiene after 3 months and was still significant after 6 years. This combination approach is likely better for improving short-term and long-term oral health care outcomes when compared to education and POHC service provision alone.

Another combination approach was used by Zenthöfer and colleagues,[34] in which a dentist provided remotivation for both the resident and staff groups. The intervention groups also had teeth and dentures cleaned professionally and received individual oral hygiene instruction. Compared to the education-only programs, these motivational programs improved oral health statistically significantly over a 12-week intervention. However, oral health was significantly worse at the 3-year study recall, indicating the effect of POHC with individual instruction decreases over time and renewal is necessary to maintain improved oral hygiene. When comparing the Samson et al.[33] and Zenthöfer et al.[34] studies, both showed significant improvement after 3 months but only the Samson et al.[33] study showed oral hygiene improvement after 6 years. The Zenthöfer et al.[34] study showed worse outcomes after 3 years. The Samson et al.[33] combination approach provided by dental hygienists is likely better for improving both short-term outcomes and maintaining improved long-term oral health care outcomes when compared to a combination approach provided by dentists.

The last program type included staff evaluation, education, and either dental exams by a dentist[35] or professional oral health care by 3 dental hygienists, which varied by the type of dental hygiene intervention.[36] In both studies, interventions resulted in significant improvements after 3 months to the oral health of older adults. However, the Seleskog et al.[35] study showed a significant decrease in plaque levels with 2 dental hygienists providing LTC staff support, once a week, over 3 months. In contrast, the Girestam Croonquist et al.[36] study showed significant improvement in mucosal score, and improvement in LTC staff oral health care beliefs and external and internal loci of control when 3 dental hygienists provided POHC for 30 minutes over 6 months. This type of intervention by dental hygienists is likely better for improving staff attitudes (priorities) and knowledge of oral health care needs for care-dependent elderly when compared to programs in which dental hygienists only provide staff support without providing POHC.

For policy makers and LTC home administrators considering POHC interventions and ways to improve staff attitudes, the Samson et al.[33] combination approach provided by a dental hygienist is likely better for improving both short-term outcomes and maintaining improved long-term oral health care outcomes. The Girestam Croonquist et al.[36] combination approach is likely better for improving staff attitudes (priorities) and knowledge of oral health care needs for care-dependent elderly. However, it is difficult to compare the 5 program categories because they all employed different approaches to care. More standardization is needed to ensure LTC home residents receive POHC programs that meet their oral health care needs.

Residents, frequency, and duration

Of the 13 studies included in this review, 6 studies were short term (3 months to 8 months)[28-30,32,35,36] and 7 studies were long term (18 months to 6 years).[25-27,31-34] The sample sizes ranged from 13 to 184 per study making some studies too small to achieve statistical power. Six of the 13 studies reported POHC services by dental hygienists once per day for 6 months[32]; once per week from 1 month[28]; 1-week or 2-week intervals for 12 weeks[29]; once per week for 6

months[25,27]; and once per week for 2 years.[26] Three studies reported services and education by dental hygienists once per month for 6 months[36] and once every 6 months for 18 months.[31,32] In addition to educating LTC staff,[30,33] dental hygienists participated in one program[35] in staff meetings and provided hands-on theoretical support and individualized oral hygiene for residents. The tendency across all studies was for dental hygienists to provide POHC once every 3 to 6 months, instead of once per week or once per month, until the resident passed away. The reason for this low, inadequate frequency is that LTC homes do not include POHC in the cost of their services, government-subsidized dental coverage does not meet the needs of low-income LTC residents, and many residents or families cannot afford to pay out of pocket costs for more frequent POHC services.

Clinical effect and relationship

The essential components that seem to improve residents' oral and respiratory health are POHC services that include screening, oral examinations, scaling, prophylaxis, resident mouth rinsing with water, debris removal, wiping the tongue using a chlorhexidine-soaked sponge brush, and oral hygiene education by oral health professionals. Provision of essential mouth care for dependent LTC home residents includes tooth brushing twice per day and/or swabbing of the oropharynx with povidone iodine by nursing assistants. The study by Morino et al.[28] had the strongest evidence (OR, 9.33; 95% CI, 1.74 to 75.66; $p < 0.01$), showing better results for the intervention in which dental hygienists provided manual toothbrushing after breakfast once per week for 1 month.

The quality of the studies based on the indicators of improved oral health status, reduction in bacterial plaque, and decrease in pneumonia and AP varied from low to high. For example, Liu et al.[37] in their 2018 Cochrane Systematic Review included both Adachi et al.[25] and Yoneyama et al.[26] and rated them both as low-quality studies. Liu et al. recommended caution when suggesting that professional oral care could reduce mortality from pneumonia in LTC home residents when compared to usual care. They did not find any high-quality evidence to determine which oral care measures were most effective in reducing NHAP. In contrast, this current systematic review did identify a limited number of studies that found high-quality evidence to determine effective oral care measures.

In contrast to the Liu et al.[37] systematic review, an older 2006 systematic review[38] included Adachi et al.[25], Yoneyama et al.[24], and Yoneyama et al.[26] and graded the quality of evidence as good (I, grade A recommendation), supporting that frequent POHC and improved oral hygiene reduced the occurrence of respiratory diseases among high-risk older adults residing in LTC homes and intensive care units. The number needed to treat was low (NNT = 2 to 16) and there was a high relative risk reduction (RRR = 34% to 83%).[38] Azarpazhooh and Leake's evidence supports some of the findings in this systematic review of effective onsite POHC interventions in LTC homes.[38] Similarly, a 2003 systematic review by Scannapieco et al.[15] included Yoneyama et al.[24] in a meta-analysis of 5 RCTs with institutionalized persons showing several oral hygiene interventions reduced the incidence of nosocomial pneumonia by 40% (average) in high-risk clients. The Scannapieco et al.[15] evidence also supports some of the findings in this current review for the variety of onsite POHC interventions in LTC homes. However, both of these systematic reviews are very old, dating from 2003[15] and 2006,[38] and more recent systematic reviews evaluating newer studies have drawn different conclusions.

A position paper on the oral–systemic link from the Canadian Dental Hygienists Association (CDHA), published in 2007,[39] reported findings from 2 systematic reviews[15,38] consistent with 2 of the intervention studies (Adachi et al.[25] and Yoneyama et al.[26]) included in this current review. In the Adachi et al. study, residents who received weekly oral health care by dental hygienists for 24 months had a ratio of fatal AP significantly lower in the treatment group (2/40) than in the non-treatment control group (8/84) ($p < 0.05$).[39] Yoneyama and colleagues reported residents who had their teeth brushed by nurses or caregivers after each meal with no dentifrice, and plaque and calculus control as needed once per week by a dentist or dental hygienist had significantly lower pneumonia (RR = 1.67; 95% CI = 1.01 to 2.75, $p < 0.05$) and death from pneumonia (RR = 2.40; 95% CI = 1.54 to 3.74, $p < 0.01$) compared to the control group.[26] Similar results were found for both edentate and dentate residents.[39]

None of the 13 studies included all of the POHC components to establish best practice guidelines for an onsite POHC intervention for LTC home residents. However, the most clinically beneficial POHC program and its components is likely provided by full-time dental hygienists working onsite in LTC homes, providing POHC for residents[23-27] and oral health instruction and education for residents, staff, and caregivers[21,29]. The onsite POHC programs in LTC homes analyzed in this review consisted mainly of teeth cleaning services[24-29,32] or teeth cleaning services and education,[31,32] instead of just education alone.[30] None of these 13 studies measured causality, and several of them are quite dated. More current systematic reviews have included some of the older studies analyzed in this systematic review and pointed out their flaws concluding mixed results.

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 of performing proper oral care.[35] In addition, the most effective implementation, with POHC interventions at 1-week intervals, will likely enhance the oral health and saliva production in older adults, showing that dental hygienists should monitor and manage the oral

health of older adults in LTC homes.[29] A combination of monthly POHC and individual oral health care instructions improves oral hygiene, reduces root caries among residents, and contributes to a more positive attitude among LTC home staff.[36]

In community-dwelling older adults, a systematic review of the literature found that mortality (24%) and mental health disorders (21%) were the most common outcomes associated with poor oral health.[40] A recent study of LTC residents in Canada found that 62.6% had a dementia diagnosis and the oral health of residents was poor, with inadequate denture hygiene (43.2%) and moderate-to-severe gingival inflammation (79.6%).[2] Vulnerable or dependent residents living in LTC homes require a higher level of care and are likely not capable of understanding oral health instructions. Therefore, LTC home residents should receive daily oral health care by caregivers, consistent POHC once per week by a dental hygienist or dentist, and their caregiver and staff should be evaluated in their education and provision of resident oral health instruction.

POHC in LTC homes is clinically beneficial because dental plaque levels were decreased significantly after once-per-week oral care[25,26,28,29] for a 1-month,[28] 3-month[29] or 6-month[25,27] intervention. However, educating residents and staff on proper oral health care techniques without also providing onsite POHC resulted in poor oral health outcomes.[30] Whereas, providing a combination of onsite POHC services to LTC home residents and education to health care providers significantly decreased root caries and *Mutans Streptococci*,[31] as well as prevalence of glossitis, mucosal lesions, palatal inflammation, denture stomatitis, and yeast counts.[32]

The results of this systematic review provide evidence of associations between bacterial plaque and respiratory diseases. Causation cannot be established because of the methodological and statistical limitations of the included studies. More longitudinal studies are required to provide evidence of causation in both LTC home residents and community-dwelling older adults. Determining causality is a rigorous process that requires the use of strict criteria such as the Bradford Hill criteria for causation.[41] The most recent CDHA position paper, published on this topic in 2020, investigated whether there was sufficient evidence for a causal relationship between oral microbes and respiratory illnesses such as aspiration pneumonia.[42] After applying the Bradford Hill criteria to the 10 included systematic reviews, 9 of which included meta-analyses, the results of the analysis did not provide sufficient evidence to support a causal relationship at this time.[42]

Pneumonia occurrence in LTC homes remains a major public health concern[42] and is one of the major causes of mortality among LTC residents.[43] Its high treatment costs place a heavy burden on Canada's health care system.[42,43] This systematic review provides evidence that dental hygienists could have a significant impact on reducing bacterial mouth infection in dependent LTC home residents, thereby reducing health care costs associated with treating respiratory illnesses. Health policies need to be improved to include regular, onsite POHC for vulnerable or dependent LTC home residents.

Strengths and limitations

Although 10 of the 13 studies were RCTs, most of the studies included in this review have flaws. Adachi et al.[25] reported all causes of death but neither Adachi et al.[25] nor Yoneyama et al.[26] analyzed potential effects of these systemic diseases as confounding factors. In both studies, not being able to blind participants and caregivers to the oral care measures may have led to a Hawthorne effect and influenced results.[44] Subsequently, both studies were assessed as having a high risk of bias by the authors of this review. The number of events was predominately insufficient, as demonstrated by the wide CIs, downgrading the quality of evidence to low on incidence rate, cumulative incidence of NHAP, and pneumonia-associated mortality and to very low on all-cause mortality. However, evidence from another systematic review by Liu et al.[37] should also be treated with caution because the authors only assessed the effect of oral care measures on new incidences of NHAP and did not provide evidence of the effect of oral care measures on the incidence or frequency of recurrent pneumonia which is a public health concern in LTC homes. In addition, potential biases in the review process for the Liu et al.[37] systematic review include risk of publication bias as the authors were not able to acquire data from a potentially relevant study reporting chlorhexidine and pneumonia in LTC home residents (clinical trials.gov; NCT00841074).[45]

Another limitation was that 12 studies had weaker statistical evidence (OR/RR under 2.0) showing poorer and thus mixed results for POHC interventions. In addition, over half of the studies did not report whether there was a conflict of interest, and a few studies were either underpowered or lower powered, thus reducing the quality of evidence. Future studies on this topic would need a better developed study plan to ensure high-quality evidence and statistical power that can better support clinical and policy decision making.

CONCLUSION

The 13 POHC programs identified and analyzed in this review were effective, to varying degrees. Although there was a positive impact on oral health and respiratory health, this improvement occurred following different types and extensiveness of POHC programs with varied oral health services, frequency, duration, and outcome measures. More research is needed to study the same POHC program intervention components and services and outcome measures to demonstrate a cause-effect relationship between bacterial mouth infections, pneumonia, and fatal AP for dependent LTC home residents. In addition,

provision of confidence intervals in all studies will enable a meta-analysis of results. At this time, direction for oral health care training and provision in LTC homes includes a combination of weekly onsite POHC services performed by dental hygienists, daily mouth care provided by caregivers and staff, and oral health education provided by dental hygienists to LTC home residents and staff.

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CONFLICTS OF INTEREST

The authors have declared no conflicts of interest.

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