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# Oral care measures for preventing nursing home-acquired pneumonia (Review)

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[Intervention Review]

# Oral care measures for preventing nursing home-acquired pneumonia

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## ABSTRACT

### Background

Pneumonia in residents of nursing homes can be termed nursing home-acquired pneumonia (NHAP). NHAP is one of the most common infections identified in nursing home residents and has the highest mortality of any infection in this population. NHAP is associated with poor oral hygiene and may be caused by aspiration of oropharyngeal flora into the lung. Oral care measures to remove or disrupt oral plaque might reduce the risk of NHAP. This is the first update of a review published in 2018.

### Objectives

To assess effects of oral care measures for preventing nursing home-acquired pneumonia in residents of nursing homes and other long-term care facilities.

### Search methods

An information specialist searched CENTRAL, MEDLINE, Embase, one other database and three trials registers up to 12 May 2022. We also used additional search methods to identify published, unpublished and ongoing studies.

### Selection criteria

We included randomised controlled trials (RCTs) that evaluated the effects of oral care measures (brushing, swabbing, denture cleaning mouthrinse, or combination) in residents of any age in nursing homes and other long-term care facilities.

### Data collection and analysis

At least two review authors independently assessed search results, extracted data, and assessed risk of bias in the included studies. We contacted study authors for additional information. We pooled data from studies with similar interventions and outcomes. We reported risk ratios (RRs) for dichotomous outcomes, mean differences (MDs) for continuous outcomes, and hazard ratios (HRs) or incidence rate ratio (IRR) for time-to-event outcomes, using random-effects models.

**Main results**

We included six RCTs (6244 participants), all of which were at high risk of bias. Three studies were carried out in Japan, two in the USA, and one in France. The studies evaluated one comparison: professional oral care versus usual oral care. We did not include the results from one study (834 participants) because it had been stopped at interim analysis.

Consistent results from five studies, with 5018 participants, provided insufficient evidence of a difference between professional oral care and usual (simple, self-administered) oral care in the incidence of pneumonia. Three studies reported HRs, one reported IRRs, and one reported RRs. Due to the variation in study design and follow-up duration, we decided not to pool the data. We downgraded the certainty of the evidence for this outcome by two levels to low: one level for study limitations (high risk of performance bias), and one level for imprecision.

There was low-certainty evidence from meta-analysis of two individually randomised studies that professional oral care may reduce the risk of pneumonia-associated mortality compared with usual oral care at 24 months' follow-up (RR 0.43, 95% CI 0.25 to 0.76, 454 participants). Another study (2513 participants) reported insufficient evidence of a difference for this outcome at 18 months' follow-up.

Three studies measured all-cause mortality and identified insufficient evidence of a difference between professional and usual oral care at 12 to 30 months' follow-up.

Only one study (834 participants) measured the adverse effects of the interventions. The study identified no serious events and 64 non-serious events, the most common of which were oral cavity disturbances (not defined) and dental staining.

No studies evaluated oral care versus no oral care.

**Authors' conclusions**

Although low-certainty evidence suggests that professional oral care may reduce mortality compared to usual care when measured at 24 months, the effect of professional oral care on preventing NHAP remains largely unclear. Low-certainty evidence was inconclusive about the effects of this intervention on incidence and number of first episodes of NHAP. Due to differences in study design, effect measures, follow-up duration, and composition of the interventions, we cannot determine the optimal oral care protocol from current evidence.

Future trials will require larger samples, robust methods that ensure low risk of bias, and more practicable interventions for nursing home residents.

## PLAIN LANGUAGE SUMMARY

### Mouth care for preventing pneumonia in nursing homes

#### What is nursing home-acquired pneumonia?

Nursing home-acquired pneumonia (NHAP) is a bacterial infection of the lung occurring in residents of long-term care facilities and nursing homes.

#### What measures can be taken to prevent nursing home-acquired pneumonia?

People with poor oral hygiene may be more likely to contract an infection. Professional oral care is a combination of brushing teeth and gums, cleaning false teeth, using mouthrinse, and attending check-up visits with a dentist. Usual oral care is self-administered or provided by nursing home staff without special training in oral hygiene.

#### What did we want to find out?

We wanted to find out whether oral care reduces NHAP. We also wanted to find out whether oral care reduces the number of deaths (from pneumonia and from any cause) among residents of care homes or other long-term care facilities.

#### What did we do?

We searched scientific databases and trials registers for randomised controlled trials on oral care in residents of care homes. Randomised controlled trials are considered to provide the most reliable scientific evidence because participants are randomly assigned to their treatment groups. We compared and summarised the results of the studies and rated our confidence in the evidence, based on factors such as study methods and sizes.

#### What did we find?

We found six relevant studies, with a total of 6244 participants, who were randomly assigned to professional or usual oral care. Three studies were carried out in Japan, two in the USA, and one in France. Participants were nursing home residents who did not have pneumonia at the beginning of the studies. Some participants had dementia or systemic diseases such as chronic lung diseases, stroke, or heart failure.

Usual care varied but was simple, self-administered care with no help from a dental professional or nursing home staff member trained in oral care. No studies compared oral care to no oral care.

From the limited evidence, we could not determine whether professional mouth care was better or worse than usual oral care for preventing pneumonia, death from pneumonia, or death from any cause. However, two studies suggested that professional mouth care may reduce the number of deaths caused by pneumonia after 24 months of observation.

Only one study measured negative side effects of professional oral care, and reported no serious events. The most common non-serious events were damage to the mouth and tooth staining.

**What are the limitations of the evidence?**

We found only a small number of studies that used varying methods (e.g. how and when results were measured and the type of professional oral care provided). Therefore, we are not confident about our findings, and further research is required.

**How up to date is this evidence?**

This evidence is up to date to 30 June 2022.

## Summary of findings 1. Professional oral care versus usual oral care

**Professional oral care versus usual oral care**

**Population:** older adults
**Setting:** nursing homes
**Intervention:** professional oral care
**Comparison:** usual oral care

| Outcomes | Illustrative comparative risks* (95% CI) | | Relative effect (95% CI) | Number of participants (studies) | Certainty of the evidence (GRADE) | Comments |
|---|---|---|---|---|---|---|
| | Assumed risk: usual oral care | Corresponding risk: professional oral care | | | | |
| **Incidence of NHAP**<br>Clinical and radiological assessment<br>Follow-up: 8–30 months | — | — | — | 5018<br>(5 studies) | ⊕⊕⊖⊖<br>**Low**[a] | Due to differences in the study design (individual and cluster-randomised), effect measures, and follow-up duration, we chose not to pool the results. However, the results of all studies were consistent, showing insufficient evidence of a difference in incidence of pneumonia between professional care and usual care. |
| **Mortality (pneumonia-associated)**<br>Clinical and radiological assessment<br>Follow-up: 24 months | 165 per 1000 | 71 per 1000<br>(41 to 126) | **RR 0.43**<br>(0.25 to 0.76) | 454<br>(2 studies) | ⊕⊕⊖⊖<br>**Low**[b] | 1 study (2513 participants) reported insufficient evidence of a difference for this outcome at 18 months' follow-up. Due to differences in the effect measures and follow-up duration, we decided not to include this study in the meta-analysis. |
| **Mortality (all-cause)**<br>Clinical assessment<br>Follow-up: 12-30 months | — | — | — | 3764<br>(3 studies) | ⊕⊖⊖⊖<br>**Very low**[c] | Due to differences in the effect measures and follow-up duration, we chose not to pool the results. However, the results of all studies were consistent, showing insufficient evidence of a difference in incidence of pneumonia between professional care and usual care. |
| **Adverse effects of interventions** | — | — | — | — | — | Measured in only 1 study (834 participants), which reported no serious events and 64 non-serious |

events, the most common of which were oral cavity disturbances (not defined) and dental staining.

*The basis for the **assumed risk** is the study incidence rate. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
**CI:** confidence interval; **IRR:** incidence rate ratio; **NHAP**: nursing home-acquired pneumonia; **RR:** risk ratio.

**GRADE Working Group grades of evidence**
**High certainty:** we are very confident that the true effect lies close to that of the estimate of the effect.
**Moderate certainty:** we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
**Low certainty:** our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
**Very low certainty:** we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

[a]Downgraded two levels due to risk of bias (performance bias and attrition bias) and imprecision.
[b]Downgraded two levels due to risk of bias (performance bias and attrition bias) and inconsistency.
[c]Downgraded three levels due to risk of bias (performance bias and attrition bias) and severe imprecision.

# BACKGROUND

## Description of the condition

Residents of nursing homes and long-term care facilities are predominantly older adults. Older adults in institutionalised care may have poor oral health as they have reduced access to professional dental care and are less able to maintain daily oral hygiene (Berg 2000; Gaszynska 2014). Many studies have emphasised the demanding nature of providing professional oral hygiene care and personal oral hygiene instruction in nursing homes (Frenkel 2000; Gaszynska 2014; Gluhak 2010; Petelin 2012).

Pneumonia occurring in nursing home residents can be termed nursing home-acquired pneumonia (NHAP). The rate of hospitalisation due to community-acquired pneumonia (CAP) is 1.96 to 10 times higher among nursing home residents than among community-dwelling older people (Marrie 2002; Ronald 2008; Ticinesi 2016), and the 30-day mortality rate is 2.29 times higher (Liapikou 2014). These findings can be ascribed to increased functional impairment, comorbidities, polypharmacy, and dependence upon caregivers in older nursing home residents (Dudas 2000; Martínez-Moragón 2004).

NHAP can be distinguished from CAP by the pathogenic microorganisms involved. A higher proportion of NHAP may be caused by multidrug-resistant bacteria, though the pathogens vary among reports (Craven 2006; Mylotte 2002). Multidrug resistant bacteria are implicated in data from the USA, Japan, and Italy (Falcone 2018; Kang 2017; Micek 2007; Nakagawa 2014; Russo 2020), whereas the isolation rate of multidrug-resistant bacteria was 5% or less in Germany and Spain (Ewig 2010; Polverino 2010). NHAP is one of the most common infections identified in nursing home residents, and it causes more deaths than any other infection in this setting (Braggion 2020; Cho 2011; Mylotte 2020). The reported incidence ranges from 0.7 to 1.2 per 1000 person-days (El-Solh 2010; Fassmer 2018; Zimmerman 2020), and the incidence proportion ranges from 0.26% to 12% with different follow-up durations (Hollaar 2016; Russo 2020).

In nursing home residents, it is impossible to distinguish pneumonia from aspiration pneumonia through clinical examination (Hollaar 2016). Aspiration pneumonia in the nursing home could be considered a type of NHAP. Oropharyngeal aspiration is an important aetiologic factor leading to pneumonia in older adults. Residents with dementia have a higher risk and incidence of pneumonia in the nursing home, especially those with end-stage dementia (Gozalo 2011; Zomer 2017). One study found that dysphagia was a risk factor for NHAP (Hollaar 2017). The incidence of cerebrovascular and degenerative neurologic diseases increase with ageing, and these disorders are associated with dysphagia and an impaired cough reflex, with the increased likelihood of oropharyngeal aspiration (Marik 2003; Scannapieco 2014). Therefore, decreasing bacterial aspiration might be a potential prophylactic measure for NHAP.

## Description of the intervention

Improved oral hygiene and frequent professional oral health care may be effective in reducing the incidence of respiratory infection in nursing home residents (Azarpazhooh 2006; Scannapieco 2003; Sjögren 2008; Watando 2004). One National Institute for Health and Care Excellence (NICE) guideline introduced detailed oral care measures and recommended that care home managers should set out plans and actions to promote residents' oral health (NICE guideline 2016). Oral care measures can be classified into several categories.

- Mechanical aids to remove plaque and debris from the oral cavity, for example:
  - toothbrushing with a manual or electric toothbrush;
  - interdental cleaning with dental floss, interdental brush, dental wood sticks, or oral irrigators; or
  - swabbing with water or saline.
- Topical (chemical) disinfection to reduce colonisation, for example:
  - mouthrinse;
  - sprays;
  - liquids; or
  - gels.
- Antiseptics (not antibiotics), for example:
  - chlorhexidine;
  - povidone-iodine; or
  - cetylpyridium (Shi 2013).
- Combination of mechanical plaque removal and topical disinfection, for example:
  - swabbing with antiseptic;
  - toothbrushing with antibacterial toothpaste; or
  - daily toothbrushing plus antiseptic rinse.
- Professional dental care, for example:
  - aided toothbrushing;
  - regular examinations and treatments by dentists or other professionals; or
  - regular oral hygiene instruction by dentists or other professionals.

Oral care measures can be delivered at any frequency, by caregivers, nurses, dental care professionals, or dentists (Ekstrand 2013; Zuluaga 2012).

## How the intervention might work

Increasing evidence suggests a link between oral bacterial colonisation and respiratory infection and pneumonia. Gram-negative bacilli, such as *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and *Enterobacter* species, may be causative pathogens of pneumonia (Craven 1992; Liapikou 2014). Research has shown increased colonisation of the oropharyngeal cavity by gram-negative bacteria in dependent and frail older adults (Leibovitz 2003; Mylotte 1994; Palmer 2001). In one study, the authors observed that a potential respiratory pathogen had colonised the dental plaque of 89/138 (64.5%) dependent older adults (Sumi 2007). Aspiration of oropharyngeal fluid may cause translocation of potential pulmonary pathogens into the lower respiratory tract and lungs (Gibbons 1989; Munro 2004; Whittaker 1996). Colonisation of the lungs by these pathogens may cause aspiration pneumonia (Van der Maarel-Wierink 2013). Poor oral hygiene and oral hygiene-related factors (e.g. denture use (O'Donnell 2016), being edentulous (Abe 2008)) may be additional risk factors for aspiration pneumonia among older adults, who have an increased rate of dental plaque colonisation as a possible reservoir for pathogenic organisms associated with CAP or NHAP (Bassim 2008; Janssens 2005; Scannapieco 2003).

For these reasons, reducing oral plaque buildup could substantially reduce pneumonia risk (Shi 2013; Van der Maarel-Wierink 2013). Oral care measures used to achieve this include mechanical disruption of the biofilm (e.g. through manual or electric toothbrushing), use of oral antiseptics (which may remain active on oral tissues for several hours after application), or both combined. For example, chlorhexidine (CHX) gluconate is a broad-spectrum antiseptic agent that reduces both gram-positive and gram-negative bacteria associated with respiratory tract infection; it can remain chemically active on tissue for up to six hours (Tantipong 2008). Research has shown that rinsing with 0.12% CHX solution daily or weekly for six weeks improves oral conditions in older adults (DeRiso 1996; Persseon 1991). Similarly, manual oral brushing improves oral hygiene by reducing bacterial pathogen colonisation, and improves the swallowing reflex by stimulating gums (Yamaya 2001; Yoshino 2001). Yoshida 2001 found that brushing teeth after each meal and rinsing daily with 1% povidone-iodine, in conjunction with weekly professional dental care, significantly decreased the incidence of pneumonia in nursing homes.

### Why it is important to do this review

Although good oral hygiene plays an important role in maintaining the oral health and well-being of institutionalised people, oral care measures remain insufficient in nursing homes (Saarela 2021), and guidance documents on CAP prevention (e.g. British Thoracic Society guidance on the prevention of CAP) do not always acknowledge the importance of oral hygiene (Lim 2009). Moreover, nurses have limited knowledge about providing mouth care in general (Frenkel 2000; Jablonski 2005; Pyle 2005). Chiba 2009 reported that 32.4% of caregivers hesitated to provide oral care measures, which indicated their lack of knowledge about oral hygiene. Oral health education has a positive effect on caregivers' knowledge and attitudes (Charteris 2001; Frenkel 2001; Frenkel 2002; Sjögren 2010). One 2015 systematic review found that mechanical oral cleaning significantly reduced the risk of fatal pneumonia in healthcare institutions, although it did not evaluate any other oral care measures (Kaneoka 2015). Another systematic review found fair evidence (II-2, grade B recommendation) of an association between pneumonia and oral health, and good evidence (I, grade A recommendation) that better oral health and frequent professional oral care reduced the occurrence or progression of respiratory disease among high-risk older adults living in nursing homes, and especially those in intensive care units (Azarpazhooh 2006). However, one randomised controlled trial (RCT) published in 2015 indicated that advanced oral care measures, compared with usual care, did not significantly reduce the incidence of radiographically confirmed pneumonia or lower respiratory tract infection in nursing home residents (Juthani-Mehta 2015). In addition, no Cochrane Systematic review has focused on this issue.

We believe it is important to synthesise the evidence from RCTs of oral care interventions for reducing NHAP. Identifying effective oral care interventions is an essential step towards improving oral health and quality of life for care home residents.

This is the first update of a review published in 2018 (Liu 2018). The protocol for the review was published in 2016 (Li 2016).

## OBJECTIVES

To assess the effects of oral care measures for preventing nursing home-acquired pneumonia in residents of nursing homes and other long-term care facilities.

## METHODS

### Criteria for considering studies for this review

#### Types of studies

Eligible studies included parallel RCTs assessing the effects of oral care measures in residents of nursing homes and other long-term care facilities. Cluster-RCTs (where the unit of randomisation was the care facility) were also eligible for inclusion. We excluded cross-over trials.

Wu 2009 showed that trials carried out in China often used the terminology of randomisation in a broader way than in other countries such as the UK. Therefore, we contacted the authors of studies written in Chinese to request a description of the randomisation method used, and included only those trials where participants' allocation to treatment was truly random.

We included all studies of oral care that aimed to reduce the incidence of pneumonia. We excluded studies that reported only intermediate outcomes, such as dental plaque and gingivitis, without providing data on pneumonia.

We did not include studies reported as an abstract, with no record of a full-text publication, as there would have been insufficient information for a full risk of bias assessment.

#### Types of participants

Residents of any age in nursing homes and other long-term care facilities (e.g. rehabilitation units, medical care facilities), regardless of oral health status (e.g. edentulous or dentate, with or without dentures, with or without physical or intellectual disabilities, with or without mechanical ventilation, with or without alternative feeding route). We excluded participants with pneumonia or respiratory infection at baseline.

#### Types of interventions

We included studies that examined oral care measures versus no treatment, placebo, usual care, or any other oral care measure (head-to-head trials) for prevention of NHAP.

- Intervention group: participants receiving one or more clearly defined oral care measures, such as professional oral care (dentists, dental hygienists, nurse-assisted tooth brushing), oral rinse, or swab and topical decontamination with antiseptics, regardless of frequency, dosage, or formulation.
- Control group: participants receiving placebo, no treatment, usual care (including self-care), or any other oral care measure (or combination or oral care measures).

We excluded studies in which only the intervention group received topical antibiotics.

### Types of outcome measures

#### *Primary outcomes*

- Incidence, incidence proportion, or prevalence of NHAP of any severity (diagnosis of NHAP based on radiological results, clinical signs and symptoms, bacterial culture, or some synthetic criteria (American Thoracic Society 2005))
- Mortality (pneumonia-associated)
- Mortality (all-cause)

#### *Secondary outcomes*

- Change in systemic antibiotic use: this parameter included both the number of participants who had used systemic antibiotics and the duration of antibiotic use
- Adverse reactions to interventions (both local and systemic): this parameter referred to both the number of participants who had adverse reactions and the number of adverse reactions
- Incidence or prevalence of fever: this included the proportion of participants with a fever higher than 37.8 °C and a prolonged number of febrile days
- Change in data on economics (costs or cost-effectiveness) and quality of life
- Oral health indices, such as gingival index, plaque index, bleeding index, or periodontal index

## Search methods for identification of studies

### Electronic searches

Cochrane Oral Health's Information Specialist conducted systematic searches in the following databases for RCTs and controlled clinical trials:

- Cochrane Oral Health's Trials Register (searched 12 May 2022; see Appendix 1);
- Cochrane Central Register of Controlled Trials (CENTRAL; in the Cochrane Register of Studies, searched 12 May 2022; see Appendix 2);
- MEDLINE Ovid (1946 to 12 May 2022; see Appendix 3);
- Embase Ovid (1980 to 12 May 2022; see Appendix 4); and
- CINAHL EBSCO (Cumulative Index to Nursing and Allied Health Literature; 1937 to 12 May 2022; see Appendix 5).

There were no language, publication year or publication status restrictions. We adapted the search strategy designed for MEDLINE Ovid to the remaining databases. Where appropriate, we combined subject strategies with adaptations of the Cochrane Highly Sensitive Search Strategies for identifying RCTs and controlled clinical trials, as described in the *Cochrane Handbook for Systematic Reviews of Interventions* (Lefebvre 2022).

### Searching other resources

Cochrane Oral Health's Information Specialist searched the following trials registers for ongoing trials:

- US National Institutes of Health Ongoing Trials Register ClinicalTrials.gov (clinicaltrials.gov; searched 12 May 2022; see Appendix 6); and
- World Health Organization (WHO) International Clinical Trials Registry Platform (ICTRP; apps.who.int/trialsearch; searched 12 May 2022; see Appendix 7).

We searched the reference lists of included studies and relevant review articles for additional papers.

We did not perform a separate search for adverse effects of interventions. We considered adverse effects described in included studies only.

## Data collection and analysis

### Selection of studies

Two review authors independently screened the titles and abstracts of the reports retrieved by the searches. The search was designed to be sensitive and include controlled clinical trials, but we filtered out all non-randomised trials early in the selection process. We obtained full-text copies of all studies that appeared to meet the inclusion criteria, or where information in the title and abstract was insufficient to make a clear judgement of eligibility. We resolved disagreements by discussion within the review author team.

From the retrieved full-text articles, we discarded studies that did not meet the inclusion criteria, and recorded the reasons for exclusion in the Characteristics of excluded studies table.

### Data extraction and management

We created a data extraction form and piloted it on three of the included studies. Two review authors independently extracted the following data, and recorded them in the Characteristics of included studies tables:

- trial design, with inclusion and exclusion criteria, duration, setting, and location of the study;
- demographic data of participants and risk factors for NHAP, including non-oral feeding, dysphagia, xerostomia, tongue coating, mechanical ventilation, and methicillin-resistant *Staphylococcus aureus* (MRSA);
- diagnostic criteria of CAP or NHAP;
- outcomes (with timing of measurement), such as incidence of NHAP and mortality; oral, dental, and respiratory health status before and after treatment; any adverse reactions potentially relevant to the interventions;
- management and intensity of specific interventions.

We resolved any disagreements by discussion. We contacted study authors to request any important missing data. We collated and analysed data from multiple reports of a single trial under a unique identifier.

### Assessment of risk of bias in included studies

Two review authors independently assessed risk of bias in the included studies, resolving disagreements by discussion. We used the Cochrane tool for assessing risk of bias (RoB 1; Higgins 2011a). This tool includes the following seven domains; for each domain, we provided information from the trial report on measures taken to address possible bias, and arrived at a judgement of 'low risk', 'unclear risk' or 'high risk'.

- Random sequence generation: selection bias (biased allocation to interventions) due to inadequate generation of a randomised sequence. We considered a study at low risk of bias only if the publication clearly described the generation of random

numbers. We considered the phases 'stratified randomisation', 'block randomisation scheme', or 'randomisation completed by statistician or nurse' indicative of unclear risk of bias. Studies with severe baseline imbalance were at high risk of selection bias.

- Allocation concealment: selection bias (biased allocation to interventions) due to inadequate concealment of allocation.
- Blinding of participants and personnel: performance bias due to knowledge of the allocated interventions by participants and personnel during the trial. We judged trials with completely different treatment arms that would be impossible to blind as having high risk of performance bias.
- Blinding of outcome assessment: detection bias due to knowledge of allocated interventions by outcome assessors.
- Incomplete outcome data: attrition bias due to quantity, nature, or handling of incomplete outcome data.
- Selective reporting: reporting bias due to selective outcome reporting.
- Other bias: bias due to problems not covered by the other domains, such as contamination or co-intervention.

We classified the overall risk of bias in included studies as follows.

| Risk of bias | Interpretation | Judgement |
|---|---|---|
| Low risk of bias | Plausible bias unlikely to seriously alter the results | Low risk of bias for all key domains |
| Unclear risk of bias | Plausible bias that raises some doubt about the results | Unclear risk of bias for 1 or more key domains |
| High risk of bias | Plausible bias that seriously weakens confidence in the results | High risk of bias for 1 or more key domains |

We summarised the risk of bias information graphically.

### Measures of treatment effect

For dichotomous outcomes, we calculated the effect estimate as a risk ratio (RR) with a 95% confidence interval (CI).

For time-to-event data, we expressed the treatment effect as a hazard ratio (HR). Where studies did not report HRs for time-to-event findings, we calculated the log HR and the standard error from available summary statistics or Kaplan-Meier curves, according to the methods proposed in Parmar 1998, or we requested the data from study authors. For incidence rate data we used the rate ratio or incidence rate ratio (IRR).

For continuous outcomes, when studies used the same scale, we used mean values and standard deviations (SDs) to express the estimate of effect as a mean difference (MD) with a 95% CI. When studies used different scales to measure the same outcome, we used the standardised mean difference (SMD) with a 95% CI.

### Unit of analysis issues

We used the individual as the unit of analysis in this review, and we analysed only participant-level data. For cluster-RCTs analysed and reported with statistical measures that took clustering into account, we used the reported effect estimate and the standard error. When the study authors did not take clustering into consideration in their analyses, we attempted to re-analyse trial data using approximate analyses with an effective sample size. We calculated and used external estimates of the intracluster correlation coefficient (ICC) from similar trials (when available) to calculate the design effect (Deeks 2011).

### Dealing with missing data

We contacted the first and corresponding authors of the trials to request missing details and summary statistics. When we received no response, we used standard methods provided in the *Cochrane Handbook for Systematic Reviews of Interventions* to extract approximate summary statistics (Higgins 2011b).

### Assessment of heterogeneity

For each meta-analysis, we assessed clinical heterogeneity by examining characteristics of studies and similarities between types of participants, interventions, and outcomes. We used Cochran's Q test to determine the presence of statistical heterogeneity at a significance level of 0.1. We used the $I^2$ statistic (plus 95% CI) to quantify the degree of statistical heterogeneity as follows (Deeks 2011):

- 0% to 40%: may indicate slight heterogeneity;
- 30% to 60%: may indicate moderate heterogeneity;
- 50% to 90%: may indicate substantial heterogeneity; and
- 75% to 100%: may indicate very substantial heterogeneity.

If substantial or very substantial heterogeneity existed, we provided a narrative description of the results rather than pooling data.

### Assessment of reporting biases

To assess whether results were influenced by publication bias, we had planned to construct a funnel plot (assuming we had at least 10 trials). We had planned to use tests for funnel plot asymmetry, such as Egger's methods for continuous data (Egger 1997), and Begg's methods for dichotomous and time-to-event data (Begg 1994).

### Data synthesis

We undertook meta-analysis only when studies of similar comparisons reported the same outcomes. Our general approach to data synthesis was to use a random-effects model. With this approach, the CI for the pooled average intervention effect is wider

than would be obtained with a fixed-effect approach, leading to a more conservative interpretation.

#### Subgroup analysis and investigation of heterogeneity

Had we collected sufficient data, we would have considered the following subgroup analyses:

- types of oral care measures;
- trial design (cluster or parallel);
- length of follow-up;
- characteristics of participants (e.g. dentate or edentulous, with or without physical or intellectual disabilities);
- characteristics of oral care measures (e.g. concentrations of the solutions used, mechanical or topical intervention); and
- diagnostic criteria of the outcome (clinical or radiological).

#### Sensitivity analysis

To test the stability of the judgements we made during the review process, if necessary, we would have undertaken sensitivity analyses that included only trials at low risk of bias or only trials using intention-to-treat (ITT) analysis.

If any meta-analyses had included several small trials and one very large trial, we would have undertaken a sensitivity analysis comparing the effect estimates from random-effects and fixed-effect models. If these were different, we would have reported the results of both analyses and considered possible interpretations.

#### Summary of findings and assessment of the certainty of the evidence

We assessed the certainty of the body of evidence for comparisons of clinical importance. At least two of the review authors, with no conflicts of interest, used GRADE criteria and GRADE profiler software to independently judge the certainty of the evidence for our only comparison (Atkins 2004; Guyatt 2008; Schünemann 2011). With the GRADE approach, evidence from RCTs is considered high-certainty initially, but can be downgraded due to study limitations (risk of bias), indirectness of the evidence, inconsistency, imprecision of effect estimates, and risk of publication bias (see Assessment of reporting biases). Based on this assessment, we classified the certainty of each body of evidence into one of four categories: high, moderate, low, or very low (Guyatt 2008).

We presented the key comparison and outcomes (pneumonia, mortality, and adverse effects) in a summary of findings table, together with illustrative comparative risks, relative effect, numbers of participants and studies involved, certainty of the evidence, and related comments. We used GRADEpro GDT to develop the summary of findings table (GRADEpro GDT).

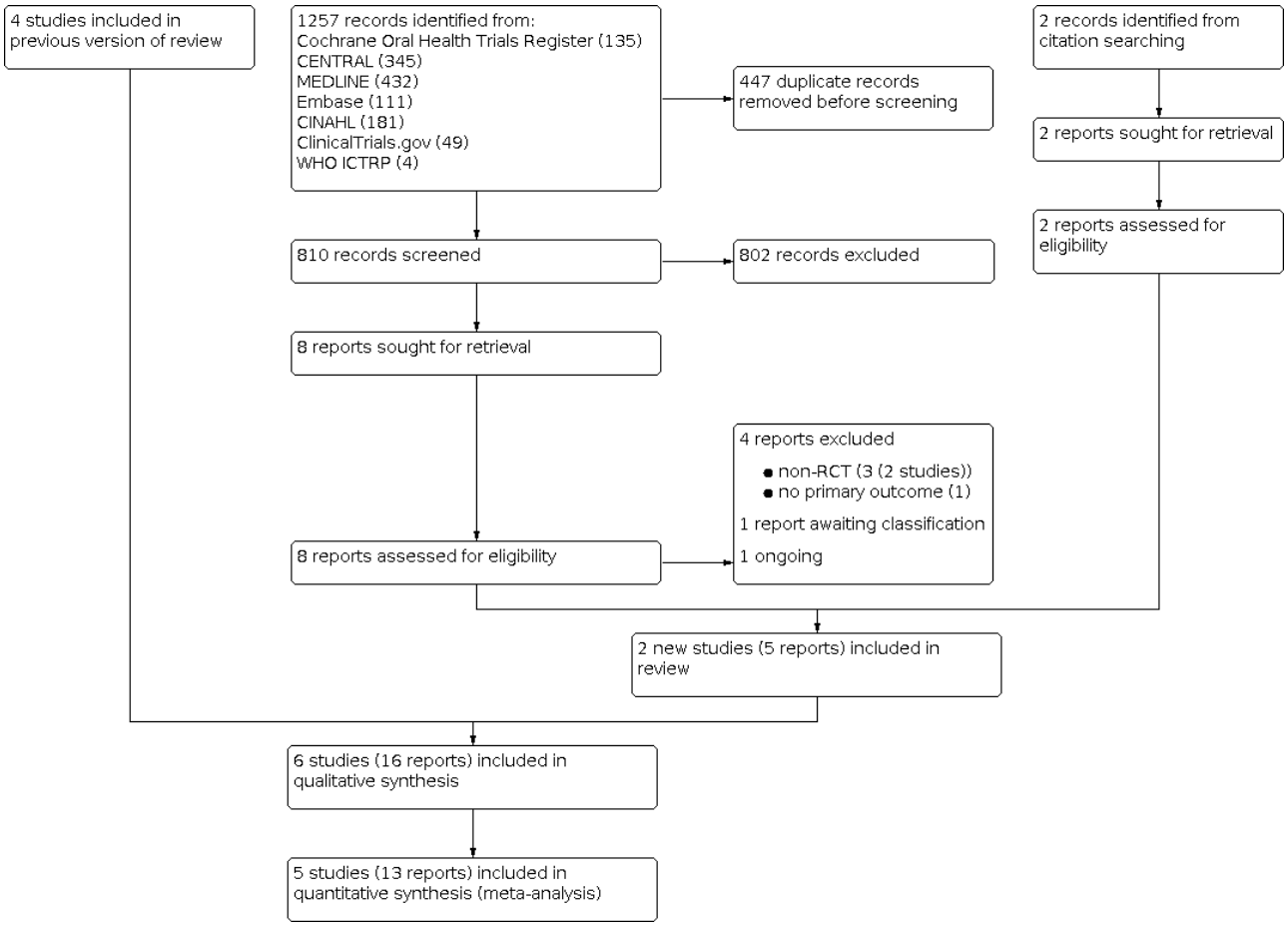
## RESULTS

### Description of studies

#### Results of the search

Our electronic searches and handsearches recovered 1257 records (810 records after deduplication). After scanning the titles and abstracts, we considered 10 records to be potentially eligible, and obtained the full-text reports for further review. We added two new studies (five reports) in this update (Higashiguchi 2017; Zimmerman 2020), resulting in six studies (16 reports) in total. We excluded three studies in this update (Chen 2021; Chiang 2020; Sunakawa 2022). Two studies were awaiting classification (JPRN-UMIN000020694; NCT03533335), and one was ongoing (NCT03892200). Figure 1 shows the flow of studies.

**Figure 1. Study flow diagram. RCT: randomised controlled trial.**




### Included studies

This review included six RCTs published between 2002 and 2020 (Adachi 2002; Bourigault 2011; Higashiguchi 2017; Juthani-Mehta 2015; Yoneyama 2002; Zimmerman 2020). The Characteristics of included studies table presents the details of each.

#### *Trial designs and settings*

Two studies used a two-arm parallel design and randomised individual participants (Adachi 2002; Yoneyama 2002), while four studies randomised care homes in a cluster-randomised design (Bourigault 2011; Higashiguchi 2017; Juthani-Mehta 2015; Zimmerman 2020). The setting for five studies was nursing homes, while Higashiguchi 2017 also included other long-term care facilities.

Follow-up duration was 24 months in Adachi 2002, Yoneyama 2002, and Zimmerman 2020; 18 months in Bourigault 2011; and eight months in Higashiguchi 2017. The intended follow-up duration in Juthani-Mehta 2015 was 30 months, but the real follow-up period varied among participants, with a mean of 1.13 years when the trial was terminated at the interim analysis.

Three studies were conducted in Japan (Adachi 2002; Higashiguchi 2017; Yoneyama 2002), two in the USA (Juthani-Mehta 2015; Zimmerman 2020), and one in France (Bourigault 2011).

Two studies reported sample size calculation (Juthani-Mehta 2015; Zimmerman 2020).

#### *Participants*

This review involved 6244 randomised participants (not including 14 participants in Higashiguchi 2017 who were excluded as not meeting eligibility criteria after cluster randomisation of facilities). In Juthani-Mehta 2015, 259 participants were lost to follow-up but were included in ITT analysis. Zimmerman 2020 excluded 217 participants from analysis due to a lack of information, and Yoneyama 2002 excluded 51 participants from analysis because they died from causes other than pneumonia during follow-up. Hence, data from 5976 participants was available for analysis.

Bourigault 2011 and Yoneyama 2002 did not describe age and sex distribution of randomised participants. In the remaining four studies, the mean age ranged from 79 to 88 years, and the proportion of males ranged from 21% to 40%. The inclusion criteria for participants in the included studies generally specified long-term care residents of nursing homes, with no clinical pneumonia at baseline. In Adachi 2002, several participants had febrile days at the beginning of the trial, which suggested susceptibility to pneumonia. Higashiguchi 2017 also included rehabilitation hospitals and other care facilities other than nursing homes, and only people with dysphagia were eligible. In Zimmerman 2020,

133 participants had asthma or chronic obstructive pulmonary diseases, with no clinical pneumonia at baseline.

### *Interventions*

We classified the identified interventions into two broad groups.

- Professional oral care: oral health care with instruction or assistance from dental practitioners (dentists, dental hygienists, dental nurses), or caregivers with professional oral health-related knowledge. The interventions included brushing teeth, mucosa, tongue, and dentures; using an interdental brush; using an electric brush; using mouthrinse; and regular dental visits.
- Usual oral care: basic oral health care by the nursing-home resident themselves, without instruction or assistance from dental practitioners (dentists, dental hygienists, dental nurses) or caregivers with professional oral health-related knowledge. The interventions included brushing teeth, mucosa, tongue, and dentures.

We evaluated the comparison between professional oral care and usual oral care, dividing the studies into subgroups according to the duration of follow-up as follows:

- 8-month follow-up (Higashiguchi 2017);
- 18-month follow-up (Bourigault 2011);
- 24-month follow-up (Adachi 2002; Yoneyama 2002; Zimmerman 2020); and
- variable follow-up (intended maximum of 30 months, with a mean follow-up of 1.13 years at the early termination of the trial; Juthani-Mehta 2015).

We found no studies that compared oral care with no oral care.

### *Measures of primary outcomes*

#### Incidence of nursing home-acquired pneumonia

Five studies reported the incidence of NHAP. Zimmerman 2020 reported the ratio of the number of new cases of pneumonia over the summed person-years/days of follow-up (IRR); Bourigault 2011, Higashiguchi 2017, and Juthani-Mehta 2015 used the HR of the first episode of pneumonia; and Yoneyama 2002 reported the incidence proportion (RR) only (participants with a new case of pneumonia occurring at any point during the study follow-up).

#### Mortality (pneumonia-associated)

Three studies reported pneumonia-associated mortality during follow-up (Adachi 2002; Bourigault 2011; Yoneyama 2002). The specific outcomes were death due to aspiration pneumonia (Adachi 2002), due to pneumopathy (Bourigault 2011), and due to pneumonia (Yoneyama 2002).

#### Mortality (all-cause)

Three studies reported the outcome of all-cause mortality during follow-up (Adachi 2002; Juthani-Mehta 2015; Zimmerman 2020). Adachi 2002 reported both the number and cause of deaths, while Juthani-Mehta 2015 and Zimmerman 2020 did not report the cause. Yoneyama 2002 stated that 51 participants died from causes other than pneumonia, but did not present these data by group.

### *Measures of secondary outcomes*

#### Change in systemic antibiotic use

No study reported change in systemic antibiotic use.

#### Adverse reactions to the interventions

Only Juthani-Mehta 2015 reported adverse events.

#### Incidence or prevalence of fever

No study reported time-to-event data for incidence of fever. Two studies reported fever as an outcome (Adachi 2002; Yoneyama 2002). Adachi 2002 described monthly proportions of participants with fever and the average prevalence of participants with fever, but we could not extract the number participants with febrile days during the 24-month follow-up. Yoneyama 2002 defined participants with fever as those who had more than seven cumulative febrile days over two years. Both studies considered a temperature of 37.8 °C or more to represent a feverish condition.

#### Change in data on economics (costs or cost-effectiveness) and quality of life

No study reported change in economics as an outcome. Only Yoneyama 2002 reported quality of life at several time points. This study also assessed cognitive impairment and activities of daily living (ADLs).

#### Oral health indices

Yoneyama 2002 reported the change of debris index. Zimmerman 2020 reported the change of plaque index, gingival index, and denture plaque index. No studies examined any other oral health indices.

## Studies awaiting classification

We identified three studies awaiting classification (JPRN-UMIN000020694; NCT00841074; NCT03533335). All three studies were completed, but we were unable to retrieve any published articles or useful data. We tried to contact the study authors for the data we needed. The author of NCT00841074 replied "The study is finished but we did not obtain any significant results and they have not been published". When we asked for more information, we received no further reply. We contacted the authors of JPRN-UMIN000020694 and NCT03533335 via email, using addresses provided on their website or that we found though electronic searching, but received no reply. See Characteristics of studies awaiting classification.

## Excluded studies

We excluded nine studies, reported in 13 publications. Five of these nine studies were not RCTS: Bassim 2008 was a retrospective cohort study, Sunakawa 2022 was a prospective cohort study, Hollaar 2017 and Chiang 2020 used a non-randomised controlled design, and Morino 2010 was a quasi-RCT. Four studies did not assess pneumonia incidence or mortality (Chen 2021; Izumi 2016; Quagliarello 2009; Watando 2004).

See the Characteristics of excluded studies table for details.

### Risk of bias in included studies

All included studies were at high risk of bias overall, as the study authors could not blind participants and their caregivers from the intervention they received. See Figure 2 and Figure 3.

**Figure 2. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.**

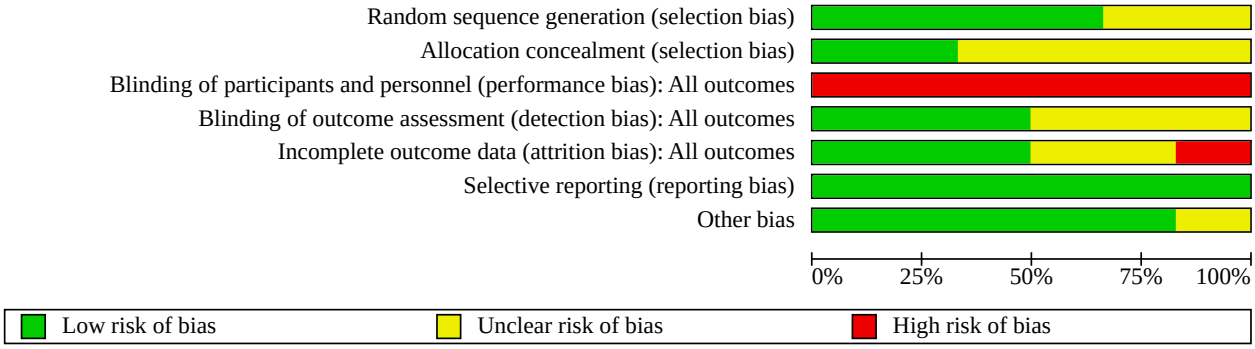
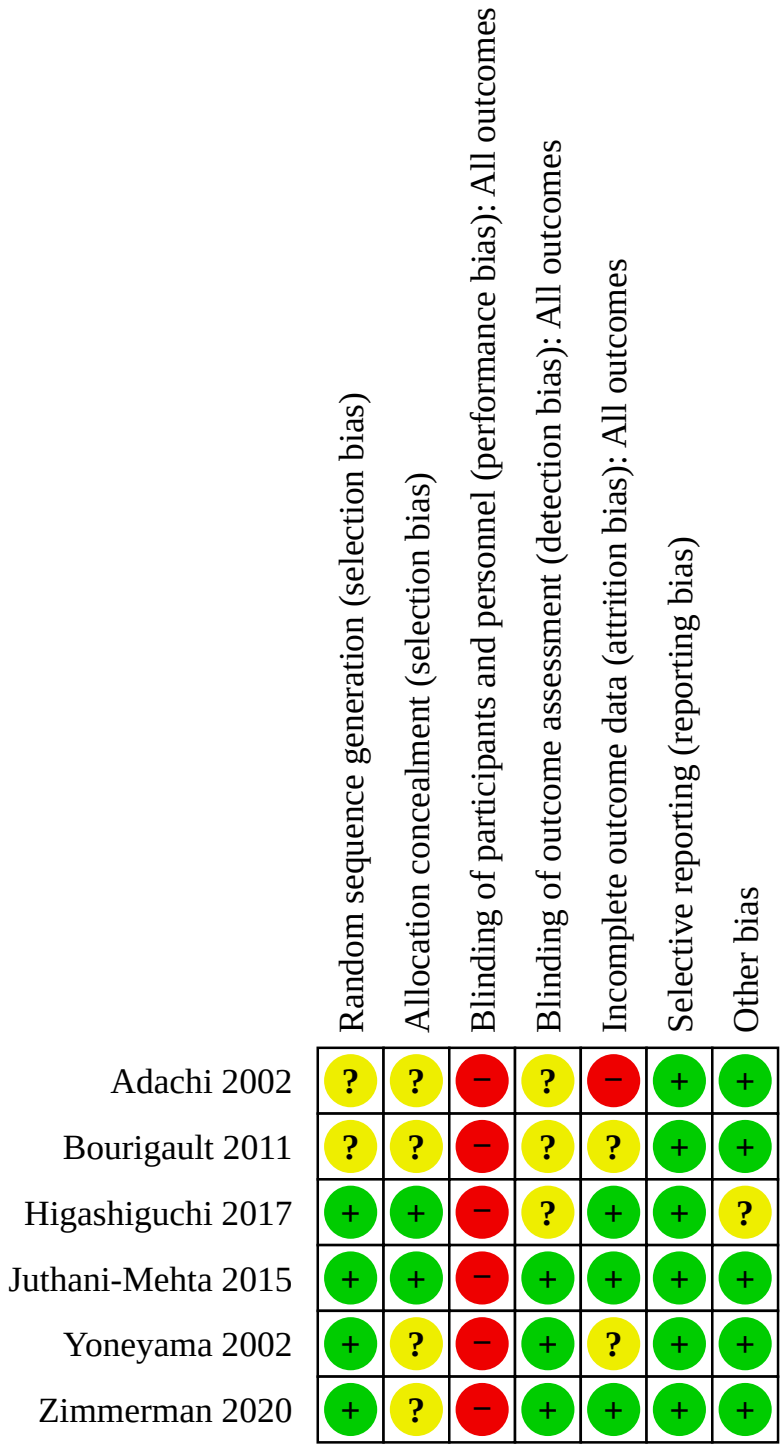


**Figure 3. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.**



### Allocation

#### *Sequence generation*

We considered four studies at low risk of bias for random sequence generation: Juthani-Mehta 2015 and Higashiguchi 2017 adopted a permuted block randomisation, Yoneyama 2002 used a random number table, and the project statistician in Zimmerman 2020 conducted the random number generation. Adachi 2002 and Bourigault 2011 stated that allocation was random but provided no further details; we therefore considered these studies at unclear risk of bias for this domain.

#### *Allocation concealment*

Adachi 2002, Bourigault 2011, Yoneyama 2002, and Zimmerman 2020 did not describe allocation concealment in sufficient detail to determine the risk of bias, and we rated these studies at unclear risk of bias. We considered Juthani-Mehta 2015 and Higashiguchi 2017 at low risk of bias because the randomisation status of the home was revealed after enrolment in the trial.

### Blinding

#### *Performance bias*

Blinding of the participants and their caregivers to the allocated treatment was not possible in any study. Professional oral care was instructed, assisted, or delivered by dental practitioners or caregivers with professional knowledge, while the participants themselves performed usual oral care. We assessed all studies at high risk of performance bias in this domain.

#### *Detection bias*

Blinding of outcome assessment was possible in all studies. Juthani-Mehta 2015, Yoneyama 2002, and Zimmerman 2020 described how this was achieved, and we therefore considered them at low risk of detection bias. Adachi 2002, Bourigault 2011, and Higashiguchi 2017 provided insufficient information, and we judged the risk of detection bias to be unclear.

### Incomplete outcome data

We judged three studies at low risk of attrition bias: Juthani-Mehta 2015 (ITT analysis), Higashiguchi 2017 and Zimmerman 2020. We judged two studies at unclear risk of bias: Yoneyama 2002 excluded 12.2% of participants from the analysis due to fatal causes other than pneumonia, and Bourigault 2011 provided insufficient information for us to determine the risk of attrition bias. We judged Adachi 2002 at high risk of attrition bias as only 88/141 participants had pneumonia-related outcomes.

### Selective reporting

All studies reported the outcomes specified in their methods section in full, and we judged them at low risk of reporting bias.

### Other potential sources of bias

We considered all included studies except Higashiguchi 2017 at low risk of other bias. Higashiguchi 2017 adopted different nutritional protocols for intervention and control groups, which may have biased the results, and thus we judged it at unclear risk of bias.

## Effects of interventions

See: **Summary of findings 1** Professional oral care versus usual oral care

### Professional oral care versus usual oral care

All six studies evaluated professional versus usual oral care (Adachi 2002; Bourigault 2011; Higashiguchi 2017; Juthani-Mehta 2015; Yoneyama 2002; Zimmerman 2020). See Summary of findings 1.

#### *Incidence of nursing home-acquired pneumonia*

Five studies reported the incidence of NHAP, measuring the IRR (Zimmerman 2020), HR (Bourigault 2011; Higashiguchi 2017; Juthani-Mehta 2015), or RR (Yoneyama 2002). Where a study reported incidence rates or time-to-event outcomes and the incidence proportion, we extracted the incidence rates or time-to-event outcomes, as these measures take into account the duration of follow-up. Due to differences in the study design (individual and cluster-randomised), reported effect measures, and follow-up duration, we decided not to pool the data.

We downgraded the certainty of the evidence for this comparison by two levels to low for risk of bias (performance and attrition bias) and imprecision.

##### Incidence rate ratio

Zimmerman 2020 reported the results of unadjusted, adjusted and model-based analyses up to 24 months' follow-up. In all instances, the results were reported for one-sided significance and an upper CI limit. At 24 months' follow-up, there were 213 cases of pneumonia among the 1219 participants randomised to the intervention arm (seven clusters), and 182 cases in the 933 participants randomised to the control arm (seven clusters). The study authors reported the incidence rate per 1000 resident-days and IRR of NHAP as follows:

| Follow-up | Incidence rate per 1000 resident-days | | Unadjusted IRR | | Covariate-adjusted IRR | |
|---|---|---|---|---|---|---|
| | Control | Intervention | RR (1-sided 95% CI) | P value | RR (1-sided 95% CI) | P value |
| Years 1 and 2 | 0.72 | 0.67 | 0.90 (1.24) | 0.27 | 0.92 (1.27) | 0.30 |
| Year 1 | 0.91 | 0.68 | 0.73 (1.08) | 0.09 | 0.74 (0.99) | 0.04 |
| Year 2 | 0.51 | 0.65 | 1.19 (1.90) | 0.78 | 1.19 (1.98) | 0.75 |

Results based on an adjusted negative binomial regression model analysing at the individual level were similar to the results above from statistical tests based on the permutation distribution of the paired t statistics for the paired differences in log rates. The study authors reported that there was insufficient evidence of a difference between professional oral care and usual oral care on the incidence of NHAP for years 1 and 2 (adjusted IRR 0.84, 1-sided 95% CI 1.12; 1921 participants in 14 clusters).

#### Hazard ratio

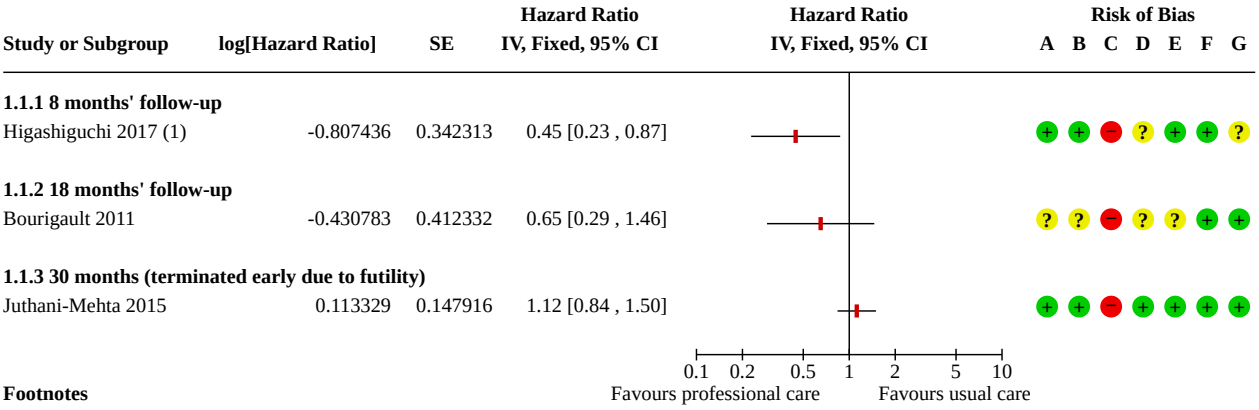
Bourigault 2011 reported the number of participants experiencing at least one episode of pneumonia over the study period. Of the 868 people (nine clusters) analysed in the intervention trial arm, 93 experienced at least one episode of pneumonia; of the 1645 people (eight clusters) in the control arm, 203 people experienced at least one episode of pneumonia (no effect estimate reported). The crude incidence rate of the first pneumonia episode was 3.3 (95% CI 2.7 to 4.1) per 10,000 resident-days in the experimental group and 5.1 (95% CI 4.5 to 5.9) per 10,000 resident-days in the control group. The probability of a first episode of pneumonia occurring in the experimental group at 18 months' follow-up was 15.2% (95% CI 12.5 to 18.3) versus 22.6% in the control group (95% CI 19.7 to 25.8). The study authors reported that there was insufficient evidence of a difference between professional oral care and usual oral care on the incidence of NHAP at 18 months (HR 0.65, 95% CI 0.29 to 1.46; 2513 participants in 17 clusters).

Higashiguchi 2017 reported the cumulative incidence of pneumonia at eight months' follow-up based on 252 participants in 75 healthcare facilities. The rates were 7.8% in the intervention group and 17.7% in the control group. Higashiguchi 2017 reported an HR of 0.446 (no CI reported) in favour of the intervention group (P = 0.056 log-rank test). It is not clear from the reporting whether the analysis accounted for the dependency of the data arising from the cluster randomisation. We used the methods of Parmar 1998 to calculate a standard error and CI; however, the analysis does not take the dependency of the data into account and consequently, the resulting CIs will be artificially narrow for this outcome.

In Juthani-Mehta 2015, 119 participants (27.4%) recorded a first pneumonia in the intervention group compared with 94 (23.5%) in the control group. The study authors reported a first pneumonia episode rate per person-year of 0.28 (95% CI 0.22 to 0.37) in the intervention group and 0.26 (95% CI 0.19 to 0.36) in the control group. They also reported an adjusted HR of 1.12 (95% CI 0.84 to 1.50; 834 participants in 33 clusters) from a Cox regression model when the study was stopped due to futility.

See Analysis 1.1 and Figure 4.

**Figure 4.**




**Footnotes**

(1) SE calculated using Parmar methods. Unadjusted effect estimate; resulting CI may be artificially narrow.

**Risk of bias legend**

(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias

#### Risk ratio

Yoneyama 2002 followed participants for 24 months and found fewer participants with pneumonia in the professional oral care group (21/184, 11.4%) than in the usual oral care group (34/182, 18.7%). The RR for this comparison was 0.61 (95% CI 0.37 to 1.01, 366 participants). No reported analysis accounted for variability in follow-up duration.

### *Mortality (pneumonia-associated)*

Three studies reported pneumonia-associated mortality (Adachi 2002; Bourigault 2011; Yoneyama 2002).

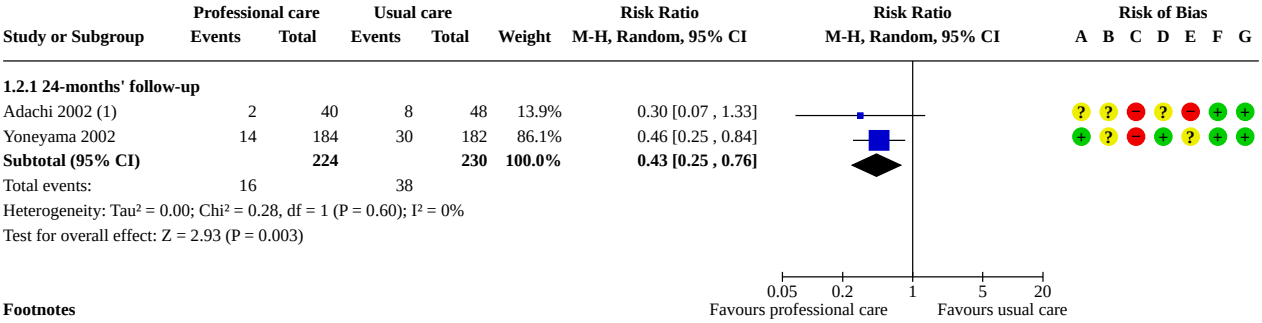
Bourigault 2011 reported pneumopathy-related deaths among residents experiencing pneumonia episodes of 12.2% for the intervention group (15 deaths arising from 123 episodes in 93

residents) and 10.8% for the control group (26 deaths arising from 241 episodes in 203 residents) during an 18-month follow-up period. The study authors reported no effect estimates but did report insufficient evidence of a difference between the intervention and control groups (P = 0.30). We were unable to re-analyse the data because there was insufficient information to calculate a design effect.

At 24 months' follow-up, there was evidence from two individually randomised trials that professional oral care may reduce pneumonia-associated mortality (RR 0.43, 95% CI 0.25 to 0.76; two studies, 454 participants; Analysis 1.2; Adachi 2002; Yoneyama 2002). However, in Adachi 2002, there was considerable attrition (38%) for the mortality outcome.

See Figure 5.

**Figure 5.**




**Footnotes**

(1) Analysis based on subset of participants (88/141; 62%) who were compliant with professional oral health care or who had died at 24 months' follow-up.

**Risk of bias legend**

(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias

We downgraded the certainty of the evidence for this outcome by two levels to low for risk of bias (performance and attrition bias) and inconsistency.

### *Mortality (all-cause)*

Three studies reported all-cause mortality (Adachi 2002; Juthani-Mehta 2015; Zimmerman 2020).

Adachi 2002 reported all-cause mortality at 24 months' follow-up. There was insufficient evidence of a difference in this outcome between the intervention and control group (RR 0.80, 95% CI 0.40 to 1.58; 88 participants; Analysis 1.3). Juthani-Mehta 2015 reported an all-cause mortality incidence of 0.24 (95% CI 0.20 to 0.28) per person-year in the intervention group compared with 0.20 (95% CI 0.16 to 0.27) per person-year in the control group. The HR for this comparison was 1.16 (95% CI 0.88 to 1.53; 834 participants in 33 clusters) when the study was stopped. Zimmerman 2020 reported a mortality rate of 0.56 per 1000 resident-days (122 deaths) in the intervention group and 0.71 per 1000 resident-days (120 deaths) in the control group at 12 months. The adjusted IRR for this comparison was 0.83 (95% CI 0.61 to 1.12; 1606 participants in 14 clusters).

Due to the different study designs (individual and cluster-randomised, reporting of different effect measures, and different follow-up periods), we decided not to pool the data. Results in all three studies were compatible with an increase or a decrease or no difference in the outcome as a result of professional oral care. We downgraded the certainty of the evidence for this comparison by three levels to very low for risk of bias (performance and attrition bias) and severe imprecision.

### *Change in systemic antibiotic use*

No studies measured change in systemic antibiotic use.

### *Adverse reactions to the interventions*

Only Juthani-Mehta 2015 reported adverse events. The study authors found no protocol-related serious adverse events, and 64 protocol-related non-serious adverse events, the most common of which were oral cavity disturbances and dental staining. Oral cavity disturbances included anything that could have been related to the oral care intervention (e.g. gum bleeding or mouth sores). All of these adverse events were anticipated.

### *Incidence or prevalence of fever*

Two studies reported prevalence of fever (Adachi 2002; Yoneyama 2002). No studies reported fever with time-to-event data. Adachi 2002 found a significantly lower occurrence of fever (37.8 °C or more) in the professional oral health care group than in the usual care group (P < 0.05). The study authors provided figures only, with no supporting data. Yoneyama 2002 reported the number of participants who had more than seven consecutive febrile days during the two-year period of follow-up, and found that the risk of fever was 51% lower in the professional oral care group (RR 0.49, 95% CI 0.33 to 0.75; 366 participants; Analysis 1.4).

#### *Change in data on economics (costs or cost-effectiveness) and quality of life*

No studies measured the costs or cost-effectiveness of oral care.

No studies measured quality of life directly. Yoneyama 2002 evaluated cognitive impairment with the Mini-Mental State Examination (MMSE), and ADLs with the modified Barthel Index. MMSE scores tend to reduce with age, but at the end of the 24-month follow-up, the study authors noted that professional oral care mitigated this reduction in comparison to usual oral care: the score in the intervention group (170 participants) was −1.5 (SD 4.9), versus −3.0 (SD 5.9) in the control group (152 participants). The MD for this comparison was 1.5 (95% CI 0.32 to 2.68). These results may reflect quality of life indirectly.

#### *Oral health indices*

Yoneyama 2002 found a debris index of 2.6 (SD 0.8) in the professional care group (109 participants) versus 2.5 (SD 0.8) in the usual care group (90 participants). The study authors dichotomised this outcome (improved or deteriorated) and concluded that professional oral care significantly reduced the debris index compared to usual care (RR 2.81, 95% CI 1.39 to 5.69, P = 0.004). Zimmerman 2020 reported oral health outcomes at 24 months' follow-up: plaque index 1.2 (SD 0.81) in the professional care group and 1.5 (SD 0.85) in the usual care group; gingival index 1.12 (SD 0.99) in the professional care group and 1.45 (SD 1.07) in the usual care group; and dental probing index 1.64 (SD 1.12) in the professional care group and 1.93 (SD 1.18) in the usual care group. The study authors did not report MDs or P values. Results were based on an analysis of 236 participants in seven clusters in the professional care group and 208 participants in seven clusters in the usual care group.

### Oral care versus no oral care

No studies evaluated oral care versus no care.

## DISCUSSION

### Summary of main results

This review aimed to assess the effects of oral care measures on preventing NHAP in residents of nursing homes and other long-term care facilities. We identified six eligible RCTs for the review. Key results are as follows.

- We were unable to establish the effects of professional oral care on the incidence rate of NHAP compared with usual oral care over an 18-month period (low-certainty evidence).
- We were unable to establish whether professional oral care can lower the number of first episodes of pneumonia compared with usual care over a 24-month period (low-certainty evidence).
- Professional oral care may reduce pneumonia-associated mortality compared with usual oral care at 24 months' follow-up (low-certainty evidence).
- We could not draw any conclusions about the effect of professional oral care compared with usual care on all-cause mortality (very low-certainty evidence).
- Only one study, which was stopped early, measured adverse reactions to interventions. It identified no serious events.

We did not identify any studies that compared oral care to no oral care.

Due to the limited quantity of included studies and low certainty of the evidence, we should treat the results cautiously.

### Overall completeness and applicability of evidence

The review recruited nursing home residents who were dentate or edentulous, able to care for themselves or not, and possibly suffering from systemic diseases (e.g. dementia, stroke, hypertension, or diabetes). However, the effects of professional oral care measures in individuals with systemic diseases remain unclear. We also noted that systemic diseases might be confounding factors that could influence the mortality measures. Adachi 2002 and Zimmerman 2020 reported all causes of death, but did not attempt to analyse potential effects of confounding factors.

The included studies were conducted in high-income countries: three in Japan (Adachi 2002; Higashiguchi 2017; Yoneyama 2002), two in the USA (Juthani-Mehta 2015; Zimmerman 2020), and one in France (Bourigault 2011). The ability to provide professional oral care will vary in lower-income countries.

The review grouped oral care measures into professional oral care and usual oral care, but oral care protocols varied in both groups across studies. It is beyond the remit of this systematic review to make suggestions regarding the best professional oral care protocol. The unpublished data of NCT00841074 implied that single use of mouthrinses might be not adequate to impede the oral, dental, or periodontal colonisation by pathogens. Current evidence does not provide adequate information about the best protocol of professional oral care.

We assessed only the effect of oral care measures on new incidences of NHAP, not the incidence or frequency of recurrent pneumonia.

We had planned to investigate the relationship between oral care measures and administration of antibiotics in nursing homes, but we found no relevant information in this regard. Nor was there adequate information about expenses.

### Quality of the evidence

We judged all the included studies at overall high risk of bias due to the lack of blinding of participants. However, the effect of lack of blinding of participants may be minimal in the cluster-designed studies, as participants in the usual oral care group will not be aware that other participants are receiving professional instruction or assistance. One study was at high risk of bias owing to incomplete outcome data, and reporting was incomplete across the domains for most studies, leading to judgements of unclear risk of bias. Future research should follow CONSORT reporting guidelines to ensure that a complete risk of bias appraisal can be undertaken. We downgraded the certainty of evidence for all outcomes due to the unclear or high risk of selection, detection, attrition, and other bias in the studies.

The number of studies providing information on the predefined outcomes was small. Due to differences in study design (individual and cluster-randomised studies), choice of effect measure, and differences in follow-up duration, as well as the composition of

the interventions, we decided not to pool the studies. The number of events was relatively low, even in the more recent studies with larger sample sizes, leading to wide CIs. This imprecision affected our assessment of the certainty in the evidence, and was a source of downgrading for all primary outcomes except pneumonia-associated mortality. The low certainty of evidence suggests that further information is needed to draw a more definitive conclusion.

### Potential biases in the review process

To reduce the risk of publication bias in our review, we conducted a broad search for both published and unpublished studies, with no restrictions on language. We searched the reference lists of included studies and contacted many of the trial authors to obtain additional information. We also searched the reference lists of other published reviews concerning oral care for nursing home residents. However, we failed to acquire the data from a potentially eligible study, entitled 'Chlorhexidine & Pneumonia in Nursing Home Residents', registered in clinicaltrials.gov (NCT00841074), which concluded that use of 0.12% chlorhexidine mouthwash spray did not decrease the 12-month incidence of NHAP compared with placebo mouthwash spray.

We chose very broad inclusion criteria, which resulted in a clinically heterogeneous group of studies involving older adults who were either dentulous or edentulous, with or without cognitive impairment, and possibly with a variety of systemic diseases. Some studies provided an incomplete description of the methods, which made it difficult to assess the similarity between studies. There might have been variations in the assessment of outcomes, and we acknowledge the lack of a definitive 'gold standard' for diagnosis of NHAP. We observed that oral care measures were provided by different caregivers, or participants themselves, and discrepancy in the performance of operators might have influenced the results. Due to the limited studies and incomplete information, we were unable to explore these factors further.

### Agreements and disagreements with other studies or reviews

There are other published reviews on the effects of oral care measures on NHAP (El-Rabbany 2015; Kaneoka 2015; Satheeshkumar 2020; Sjögren 2016). El-Rabbany 2015 fConcluded that chlorhexidine might be an effective means of lowering the risk for hospital-acquired and ventilator-associated pneumonia, but the efficacy of other prophylactic oral care measures, such as tooth brushing or iodine swab, was uncertain. Kaneoka 2015 suggested a preventive effect of oral care measures on healthcare-associated pneumonia in participants without mechanical ventilation. Sjögren 2016 reported that oral care provided by dental personnel may reduce mortality from healthcare-associated pneumonia, whereas oral care provided by nursing personnel probably resulted in little or no difference from usual care. Satheeshkumar 2020 found that enhanced oral care had no or little effect on preventing non-ventilator-associated pneumonia, while the subgroup of dental professional involvement in enhanced oral care might have some effects.

However, results from these systematic reviews do not reflect the effects of professional oral care in nursing homes with updated evidence. First, all of them included participants in hospitals and nursing homes. Second, they did not identify Ohsawa 2003 as a report of partial data in Yoneyama 2002. Third, none included updated data from Higashiguchi 2017 and Zimmerman 2020, which indicated no difference between professional and usual oral care on NHAP. Overall, our review provides the most complete and up-to-date evidence about the effects of oral care measures on NHAP.

## AUTHORS' CONCLUSIONS

### Implications for practice

Low-certainty evidence suggests that professional oral care may reduce mortality compared to usual care when measured at 24 months. Low-certainty evidence is inconclusive about the effects of professional care compared to usual oral care on incidence and number of first episodes of nursing home-acquired pneumonia (NHAP). The only study to measure and report adverse effects observed no serious adverse effects. We found no high-certainty evidence to determine which oral care measures are most effective for reducing NHAP. Further trials are needed to draw reliable conclusions.

### Implications for research

In view of the limited research in this field, we consider there is a need for more trials focusing on the effect of oral care measures on NHAP prevention. We hope future studies can address the following issues.

- Participants: due to the low event rate, future studies will have to recruit a large number of participants and nursing homes, although this may be difficult in the post-COVID 19 pandemic environment. Smaller studies are likely to be underpowered, resulting in wide confidence intervals for the effect estimate, with imprecision impacting the certainty of the evidence. In addition, future studies could pay more attention to older participants with limited ability to perform daily activities and who are more susceptible to pneumonia.
- Intervention and comparisons: future RCTs should cover a range of oral care measures (e.g. electric toothbrush, interdental brush, and different mouthrinses) and explore diverse oral care protocols aimed at residents with different conditions (e.g. dementia).
- Outcomes: we recommend that incidence measures take into account the variable follow-up expected per participant. We also recommend that trials measure first and recurrent pneumonia. We suggest future studies include or analyse the participants based on stratification of NHAP risk factors (e.g. chronic obstructive pulmonary diseases, cardiovascular diseases, diabetes, and age). Future studies could also pay more attention to systemic antibiotic use, economics, quality of life, and oral health indices; or address COVID-19 NHAP.
- Risk of bias: future studies should find ways to reduce the risk of bias. Although blinding of participants and personnel may be difficult, blinding of outcome assessment should be achieved.

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Ronald LA, McGregor MJ, McGrail KM, Tate RB, Broemling AM. Hospitalization rates of nursing home residents and community-dwelling seniors in British Columbia. *Canadian Journal on Aging* 2008;**27**(1):109-15.

**Russo 2020**

Russo A, Picciarella A, Russo R, Sabetta F. Clinical features, therapy and outcome of patients hospitalized or not for nursing-home acquired pneumonia. *Journal of Infection and Chemotherapy* 2020;**26**(8):807-12.

**Saarela 2021**

Saarela RK, Hiltunen K, Kautiainen H, Roitto HM, Mäntylä P, Pitkälä KH. Oral hygiene and health-related quality of life in institutionalized older people. *European Geriatric Medicine* 2021;**13**(1):213-20. [DOI: 10.1007/s41999-021-00547-8]

**Satheeshkumar 2020**

Satheeshkumar PS, Papatheodorou S, Sonis S. Enhanced oral hygiene interventions as a risk mitigation strategy for the prevention of non-ventilator-associated pneumonia: a systematic review and meta-analysis. *British Dental Journal* 2020;**228**(8):615-22.

**Scannapieco 2003**

Scannapieco FA, Bush RB, Paju S. Associations between periodontal disease and risk for nosocomial bacterial pneumonia and chronic obstructive pulmonary disease. A systematic review. *Annals of Periodontology* 2003;**8**(1):54-69.

**Scannapieco 2014**

Scannapieco FA, Shay K. Oral health disparities in older adults: oral bacteria, inflammation, and aspiration pneumonia. *Dental Clinics of North America* 2014;**58**(4):771-82.

**Schünemann 2011**

Schünemann HJ, Oxman AD, Vist GE, Higgins JP, Deeks JJ, Glasziou P, et al. Chapter 12: Interpreting results and drawing conclusions. In: Higgins JP, Green S, editor(s). Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 (updated March 2011). The Cochrane Collaboration, 2011. Available from handbook.cochrane.org/archive/v5.1.

**Shi 2013**

Shi Z, Xie H, Wang P, Zhang Q, Wu Y, Chen E, et al. Oral hygiene care for critically ill patients to prevent ventilator-associated pneumonia. *Cochrane Database of Systematic Reviews* 2013, Issue 8. Art. No: CD008367. [DOI: 10.1002/14651858.CD008367.pub2]

**Sjögren 2008**

Sjögren P, Nilsson E, Forsell M, Johansson O, Hoogstraate J. A systematic review of the preventive effect of oral hygiene on pneumonia and respiratory tract infection in elderly people in hospitals and nursing homes: effect estimates and methodological quality of randomised controlled trials. *Journal of the American Geriatrics Society* 2008;**56**(11):2124-30.

**Sjögren 2010**

Sjögren P, Kullberg E, Hoogstraate J, Johansson O, Herbst B, Forsell M. Evaluation of dental hygiene education for nursing home staff. *Journal of Advanced Nursing* 2010;**66**(2):345-9.

**Sjögren 2016**

Sjögren P, Wardh I, Zimmerman M, Almstahl A, Wikstrom M. Oral care and mortality in older adults with pneumonia in hospitals or nursing homes: systematic review and meta-analysis. *Journal of the American Geriatrics Society* 2016;**64**(10):2109-15.

**Sumi 2007**

Sumi Y, Miura H, Michiwaki Y, Nagaosa S, Nagaya M. Colonization of dental plaque by respiratory pathogens in dependent elderly. *Archives of Gerontology and Geriatrics* 2007;**44**(2):119-24.

**Tantipong 2008**

Tantipong H, Morkchareonpong C, Jaiyindee S, Thamlikitkul V. Randomized controlled trial and meta-analysis of oral decontamination with 2% chlorhexidine solution for the prevention of ventilator-associated pneumonia. *Infection Control and Hospital Epidemiology* 2008;**29**(2):131-6.

**Ticinesi 2016**

Ticinesi A, Nouvenne A, Folesani G, Prati B, Morelli I, Guida L, et al. An investigation of multimorbidity measures as risk factors for pneumonia in elderly frail patients admitted to hospital. *European Journal of Internal Medicine* 2016;**28**:102-6.

**Van der Maarel-Wierink 2013**

Van der Maarel-Wierink CD, Vanobbergen JN, Bronkhorst EM, Schols JM, De Baat C. Oral health care and aspiration pneumonia in frail older people: a systematic literature review. *Gerodontology* 2013;**30**(1):3-9.

**Whittaker 1996**

Whittaker CJ, Lier CM, Kolenbrander PE. Mechanisms of adhesion by oral bacteria. *Annual Review of Microbiology* 1996;**50**:513-2.

**Wu 2009**

Wu T, Li Y, Bian Z, Liu G, Moher D. Randomized trials published in some Chinese journals: how many are randomized? *Trials* 2009;**10**:46.

**Yamaya 2001**

Yamaya M, Yanai M, Ohrui T, Arai H, Sasaki H. Interventions to prevent pneumonia among older adults. *Journal of the American Geriatrics Society* 2001;**49**(1):85-90.

**Yoshida 2001**

Yoshida M, Yoneyama T, Akagawa Y. Oral care reduces pneumonia of elderly patients in nursing homes, irrespective of dentate or edentate status. *Nippon Ronen Igakkai Zasshi* 2001;**38**(4):481-3.

**Yoshino 2001**

Yoshino A, Ebihara T, Ebihara S, Fuji H, Sasaki H. Daily oral care and risk factors for pneumonia among elderly nursing home patients. *JAMA* 2001;**286**(18):2235-6.

**Zomer 2017**

Zomer TP, Van Der Maaden T, Van Gageldonk-Lafeber AB, De Greeff SC, Van Der Steen JT, Verhoef L. Incidence of pneumonia in nursing home residents with dementia in the Netherlands: an estimation based on three differently designed studies. *Epidemiology & Infection* 2017;**145**(11):2400-8. [DOI: 10.1017/S0950268817001339]

**Zuluaga 2012**

Zuluaga DJ, Ferreira J, Montoya JA, Willumsen T. Oral health in institutionalised elderly people in Oslo, Norway and its relationship with dependence and cognitive impairment. *Gerodontology* 2012;**29**(2):e420-6.

## References to other published versions of this review

**Li 2016**

Li C, Zhang Q, Ng L, Needleman I, Jie L, Walsh T. Oral care measures for preventing nursing home-acquired pneumonia. *Cochrane Database of Systematic Reviews* 2016, Issue 10. Art. No: CD012416. [DOI: 10.1002/14651858.CD012416]

**Liu 2018**

Liu C, Cao Y, Lin J, Ng L, Needleman I, Walsh T, et al. Oral care measures for preventing nursing home-acquired pneumonia.

*Cochrane Database of Systematic Reviews* 2018, Issue 9. Art. No: CD012416. [DOI: 10.1002/14651858.CD012416.pub2]

* Indicates the major publication for the study

## CHARACTERISTICS OF STUDIES

### Characteristics of included studies *[ordered by study ID]*

#### Adachi 2002

| ***Study characteristics*** | |
|---|---|
| Methods | **Study design:** RCT, 2 parallel groups<br>**Location:** Tokyo, Japan<br>**Number of centres:** 2<br>**Study period:** not stated<br>**Funding source:** Grant from Tokyo Dental College to the Oral Health Science Center |
| Participants | **Setting:** nursing homes<br>**Inclusion criteria:** older adults in nursing homes, afflicted with a variety of medical problems, and under medication of some type<br>**Exclusion criteria:** not stated<br>**Number randomised:** 141 (female/male: 104/37, mean age: 84; intervention group: 77; control group: 64)<br>**Number evaluated:** 141 (intervention group: 77; control group: 64) |
| Interventions | **Comparison: caregiver-provided professional oral care versus caregiver-provided usual oral care**<br><br>**Intervention group (n = 77):** brushing teeth, buccal mucosa, and tongue (electric brush with an automatic water supply, interdental brush, sponge brush) + cleaning denture, by dental hygienists<br><br>**Control group (n = 64):** swabbing teeth, buccal mucosa, tongue (sponge brush) + cleaning denture, by either the participant or a member of nursing home staff<br><br>**Operators:** dental hygienists, number not stated<br><br>As for daily oral care, participants who were independent enough used the washing facilities in their rooms to rinse out their mouths after each meal, but the other participants were assisted to carry out oral cleansing once/day by the nursing home staff. |
| Outcomes | • Mortality (pneumonia-associated; 24 months' follow-up)<br>• Mortality (all-cause; 24 months' follow-up)<br>• Prevalence of fever (24 months' follow-up) |
| Notes | **Sample size calculation:** not reported |

| ***Risk of bias*** | | |
|---|---|---|
| **Bias** | **Authors' judgement** | **Support for judgement** |
| Random sequence generation (selection bias) | Unclear risk | **Quote:** "The experimental group consisted of 77 subjects who received POHC, and the control group of 64 subjects who did not receive POHC treatment; the subjects were divided randomly."<br><br>**Comment:** method of sequence generation not described. |
| Allocation concealment (selection bias) | Unclear risk | **Quote:** "The experimental group consisted of 77 subjects who received POHC, and the control group of 64 subjects who did not receive POHC treatment; the subjects were divided randomly."<br><br>**Comment:** method of allocation concealment not described. |

**Adachi 2002** *(Continued)*

| | | |
|---|---|---|
| Blinding of participants and personnel (performance bias)<br>All outcomes | High risk | **Comment:** blinding not possible. |
| Blinding of outcome assessment (detection bias)<br>All outcomes | Unclear risk | **Comment:** unclear information about blinding of outcome assessors. |
| Incomplete outcome data (attrition bias)<br>All outcomes | High risk | **Comment:** no withdrawals but study authors did not report the pneumonia-related data from all participants (88/141 participants had pneumonia-related outcome). |
| Selective reporting (reporting bias) | Low risk | **Comment:** trial authors reported all planned outcomes. |
| Other bias | Low risk | **Comment:** no other sources of bias identified. |

**Bourigault 2011**

| | |
|---|---|
| ***Study characteristics*** | |
| Methods | **Study design:** cluster-RCT, 2 parallel groups<br>**Location:** France<br>**Number of centres:** 18<br>**Study period:** June 2005–December 2006<br>**Funding source:** Colgate-Palmolive and the 'Programme Hospitalier de Recherche Clinique' 2003 |
| Participants | **Setting:** nursing homes<br>**Inclusion criteria:** volunteer facilities with more than 30 beds and residents aged > 65 years<br>**Exclusion criteria:** not stated<br>**Number randomised:** not stated<br>**Number evaluated:** 2513 participants (intervention group: 868; control group: 1645) |
| Interventions | **Comparison: professional oral care versus usual oral care**<br>**Intervention group (n = 868):** brushing teeth, buccal mucosa, and tongue (3 times/day and after each meal) + mouthrinse (chlorhexidine) + annual dental visit<br>**Control group (n = 1645):** usual mouth care (not described in detail)<br>**Operators:** not stated |
| Outcomes | • Incidence of first NHAP (18 months' follow-up)<br>• Mortality (pneumonia-associated; 18 months' follow-up) |
| Notes | **Sample size calculation:** not reported |
| ***Risk of bias*** | |

| **Bias** | **Authors' judgement** | **Support for judgement** |
|---|---|---|
| Random sequence generation (selection bias) | Unclear risk | **Quote:** "The 18 facilities were allocated at random, nine to the experimental group and nine to the control group."<br>**Comment:** method of sequence generation not described. |

**Bourigault 2011** *(Continued)*

| | | |
|---|---|---|
| Allocation concealment (selection bias) | Unclear risk | **Quote:** "The 18 facilities were allocated at random, nine to the experimental group and nine to the control group."<br><br>**Comment:** method of allocation concealment not described. |
| Blinding of participants and personnel (performance bias)<br>All outcomes | High risk | **Comment:** blinding not possible. |
| Blinding of outcome assessment (detection bias)<br>All outcomes | Unclear risk | **Comment:** unclear information about blinding of outcome assessors. |
| Incomplete outcome data (attrition bias)<br>All outcomes | Unclear risk | **Quote:** "In the end, the analysis covered nine facilities in the experimental group (868 participants) and eight facilities in the control group (1645 participants)."<br><br>**Comment:** residents of a facility in control group were not included in analysis, but the number was not stated. |
| Selective reporting (reporting bias) | Low risk | **Comment:** trial authors reported all planned outcomes. |
| Other bias | Low risk | **Comment:** no other sources of bias identified. |

**Higashiguchi 2017**

| ***Study characteristics*** | |
|---|---|
| Methods | **Study design:** cluster-RCT, 2 parallel groups<br>**Location:** Japan<br>**Number of centres:** 75<br>**Study period:** December 2013–May 2015<br>**Funding source:** Grant-in-Aid for Scientific Research (FY2013) from the Ministry of Health, Labor and Welfare, Japan |
| Participants | **Setting:** nursing homes, rehabilitation hospitals, and other care facilities<br><br>**Inclusion criteria:** probable high risk for aspiration pneumonia; age ≥ 75 years at the time of consent; BMI < 18.5 kg/$m^2$; serum albumin level < 3.5 g/dL; with dysphagia but capacity for oral food intake, and needing a thickening agent for drinks for ≥ 30 min each meal; consent given<br><br>**Exclusion criteria:** life expectancy ≤ 1 year; use of feeding tube; onset of pneumonia (or symptoms suspected of pneumonia) within 1 month of enrolment; participation inappropriate as judged by the study director<br><br>**Number randomised:** 252 participants (intervention group: 109, female/male 89/20, mean age 88.3; control group: 143, female/male 109/34, mean age 87.9)<br><br>**Number evaluated:** 252 participants |
| Interventions | **Comparison: caregiver-provided professional oral care versus usual oral care**<br><br>**Intervention group (n = 109):** conventional oral care (every day in principle) + additional oral care (oral cleaning with wet wipes); conventional nutritional care (usual diet) + additional nutritional care (2 portions of oral nutritional supplements/day, approximately 80 kcal and 5 g–10 g protein per portion) |

**Higashiguchi 2017** *(Continued)*

| | |
|---|---|
| | **Control group (n = 143):** conventional oral care (every day in principle); conventional nutritional care (usual diet)<br><br>**Operators:** described in the intervention group only; number not stated: "The intervention included 3 in-service trainings provided by a specialist in dementia care and dental hygiene at study onset and monthly support visits over 2 years; at 12 months, a second in-service training was conducted. All nursing assistants, nurses, and administrative staff were invited to the training. In each NH, a nursing assistant was identified as a dedicated oral care aide; they provided staff support, trained new staff, and cared for residents who required the most time." |
| Outcomes | • Onset of complications, including incidence of first pneumonia (8 months' follow-up)<br>• Food intake (mean daily caloric intake)<br>• Secondary endpoints, including physical measurements, haematology, and blood biochemistry measurement |
| Notes | **Sample size calculation:** not reported |

***Risk of bias***

| Bias | Authors' judgement | Support for judgement |
|---|---|---|
| Random sequence generation (selection bias) | Low risk | **Quote:** "Participating facilities were publicly solicited and then randomly assigned to provide either wiping plus ONS (intervention group) or conventional oral care (control group) using the envelope method for block and randomization in a centralized registration system." |
| Allocation concealment (selection bias) | Low risk | **Quote:** "Participating facilities were publicly solicited and then randomly assigned to provide either wiping plus ONS (intervention group) or conventional oral care (control group) using the envelope method for block and randomization in a centralized registration system." |
| Blinding of participants and personnel (performance bias)<br>All outcomes | High risk | **Comment:** blinding not possible. |
| Blinding of outcome assessment (detection bias)<br>All outcomes | Unclear risk | **Comment:** unclear information about blinding of outcome assessors. |
| Incomplete outcome data (attrition bias)<br>All outcomes | Low risk | **Comment:** the trial authors reported that 10 people had been excluded before the start of the study and 4 found to be ineligible, but all trial participants were included in the analysis of the primary outcome. |
| Selective reporting (reporting bias) | Low risk | **Comment:** expected outcomes reported. |
| Other bias | Unclear risk | **Comment:** different nutritional care might have biased the results between groups. |

**Juthani-Mehta 2015**

***Study characteristics***

| | |
|---|---|
| Methods | **Study design:** cluster-RCT, 2 parallel groups<br>**Location:** New Haven, Connecticut, USA |

**Juthani-Mehta 2015** *(Continued)*

| | |
|---|---|
| | **Number of centres:** 36<br>**Study period:** not stated<br>**Funding source:** The National Institutes of Health, the National Institute on Aging (NIA) (K23AG028691, R01AG030575, K07AG030093, and P30AG021342) |
| Participants | **Setting:** nursing homes<br>**Inclusion criteria:** nursing home facilities housing ≥ 90 residents; long-term care residents aged > 65 years, resident at the nursing home for ≥ 1 month, with ≥ 1 of 2 modifiable risk factors for pneumonia (i.e. impaired oral hygiene, swallowing difficulty)<br><br>**Exclusion criteria**: housing for short-term rehabilitation; presence of a gastric tube (including percutaneous endoscopic gastrostomy or nasogastric tube) or jejunostomy tube; presence of a tracheostomy; life expectancy < 3 months; current use of chlorhexidine; pneumonia within the previous 6 weeks; previous enrolment in the study; unwillingness to give informed consent (from residents or designated surrogates); non-English speaking; inappropriateness for the study in the opinion of nursing home administration<br><br>**Number randomised:** 834 participants (female/male: 636/198, mean age: 86.3; intervention group: 434; control group: 400)<br><br>**Number evaluated:** 834 participants (259 participants lost to follow-up, but ITT analysis was used) |
| Interventions | **Comparison: professional oral care + upright feeding positioning versus usual oral care + usual feeding position**<br><br>**Intervention group (n = 434):** brushing teeth (twice/day) + cleaning denture + mouthrinse (0.12% chlorhexidine oral rinse, twice/day) by nurses (intervention protocol was tailored to participants who could either perform self-care or required assistance) + upright feeding positioning<br><br>**Control group (n = 400):** usual oral care + usual feeding position (not described in detail)<br><br>**Operators:** nursing home staff, number not stated |
| Outcomes | • Incidence of first NHAP (≤ 30 months' follow-up)<br>• Mortality (all-cause; (≤ 30 months' follow-up)<br>• Adverse reactions to the interventions (≤ 30 months' follow-up) |
| Notes | **Sample size calculation:** "The target sample size was 828 participants to detect a 25% reduction in the cumulative 2.5-year first pneumonia rate with intervention relative to control assuming a type I error of 0.05 (2-sided), 80% power, an annual loss to follow-up rate of 20% (death, transfer out of the nursing home), equal allocation and an intracluster correlation (ICC) of 0.005 from a previous study." |

***Risk of bias***

| Bias | Authors' judgement | Support for judgement |
|---|---|---|
| Random sequence generation (selection bias) | Low risk | **Quote:** "Homes were randomized within each stratum using a permuted block design with equal allocation to intervention or control arms." |
| Allocation concealment (selection bias) | Low risk | **Quote:** "After enrolment, the randomization status of the home was revealed." |
| Blinding of participants and personnel (performance bias)<br>All outcomes | High risk | **Comment:** blinding not possible. |
| Blinding of outcome assessment (detection bias)<br>All outcomes | Low risk | **Quote:** "Blinded study personnel performed screening assessments and approached eligible residents (or designated surrogates) for consent." |

**Juthani-Mehta 2015** *(Continued)*

| | | |
|---|---|---|
| Incomplete outcome data (attrition bias) All outcomes | Low risk | **Quote:** "Analyses of primary and secondary endpoints were by intent-to-treat." |
| Selective reporting (reporting bias) | Low risk | **Comment:** expected outcomes reported. |
| Other bias | Low risk | **Comment:** no other sources of bias identified. |

**Yoneyama 2002**

| ***Study characteristics*** | |
|---|---|
| Methods | **Study design:** RCT, 2 parallel groups<br>**Location:** Japan<br>**Number of centres:** 11<br>**Study period:** not stated<br>**Funding source:** Comprehensive Research on Aging and Health from 1999 to 2000 of the Japan Welfare Ministry |
| Participants | **Setting:** nursing homes<br><br>**Inclusion criteria:** physical symptoms and cognitive impairment must have been stable for the preceding 3 months. During this 3-month period, no participant had acute disorders (e.g. severe infection, heart failure, or stroke requiring special treatment and intensive care). Chronic diseases suffered by participants included previous stroke, hypertension, arrhythmia, previous myocardial infection, diabetes mellitus, and inactive gastric ulcer. Mental function varied from slight cognitive impairment to dementia.<br><br>**Exclusion criteria:** no participant had any chronic pulmonary disease, such as chronic obstructive pulmonary disease, bronchial asthma, or pulmonary fibrosis. No participant had feeding tubes.<br><br>**Number randomised:** 417 participants<br><br>**Number evaluated:** 366 participants (female/male: 293/73, mean age: 82.0; intervention group: 184; control group: 182). 51 participants were excluded from the analysis because they died from causes other than pneumonia during follow-up. |
| Interventions | **Comparison: caregiver-provided professional oral care versus usual oral care**<br><br>**Intervention group (n = 184):** brushing teeth, mucosa, and tongue (approximately 5 minutes after each meal without dentifrice) + swabbing mucosa (with 1% povidone iodine, used in some cases), by nurses or caregivers + dental visit (plaque and calculus control once/week) by dentists or dental hygienists + cleaning denture (every day)<br><br>**Control group (n = 182):** brushing teeth (once/day or irregularly) by themselves without caregivers + cleaning denture (every day)<br><br>**Operators:** nurses, caregivers, dentists, and dental hygienists. Number not stated. |
| Outcomes | • Incidence of first NHAP (24 months' follow-up)<br>• Mortality (pneumonia-associated; 24 months' follow-up)<br>• Prevalence of fever (24 months' follow-up)<br>• Change in data on quality of life (24 months' follow-up)<br>• Oral health indices (24 months' follow-up) |
| Notes | **Sample size calculation:** not reported |

**Yoneyama 2002** *(Continued)*

***Risk of bias***

| Bias | Authors' judgement | Support for judgement |
|---|---|---|
| Random sequence generation (selection bias) | Low risk | **Quote:** "The patients were randomly selected from the same floor and nursing team in each nursing home. Randomization was made from a random-numbers table, and the list was held independently of the investigators." |
| Allocation concealment (selection bias) | Unclear risk | **Comment:** method of allocation concealment not described. |
| Blinding of participants and personnel (performance bias)<br>All outcomes | High risk | **Comment:** blinding not possible. |
| Blinding of outcome assessment (detection bias)<br>All outcomes | Low risk | **Quote:** "Two radiologists who were not involved in the studies made the diagnosis of pneumonia." |
| Incomplete outcome data (attrition bias)<br>All outcomes | Unclear risk | **Quote:** "51 patients were excluded from the analysis because they died from causes other than pneumonia during follow-up."<br>**Comment:** the percentage of participants excluded from the analysis was 12.2%. |
| Selective reporting (reporting bias) | Low risk | **Comment:** expected outcomes reported. |
| Other bias | Low risk | **Comment:** no other sources of bias identified. |

**Zimmerman 2020**

***Study characteristics***

| | |
|---|---|
| Methods | **Study design:** matched-pairs cluster-RCT, 2 parallel groups<br>**Location:** North Carolina, USA<br>**Number of centres:** 14 (7 matched pairs)<br>**Study period:** September 2014–May 2017<br>**Funding source:** The Agency for Healthcare Research and Quality (R01HS022298) |
| Participants | **Setting:** nursing homes<br>**Inclusion criteria:** age ≥ 21 years<br>**Exclusion criteria:** no natural teeth or dentures; housing for short-term rehabilitation<br>**Number randomised:** 2152 participants (female/male: 1281/871, mean age: 79.4; intervention group: 1219; control group: 933)<br>**Number evaluated:** 2152 participants evaluated without adjustment (217 participants excluded from the adjusted analysis because of missing covariates, and 1935 participants evaluated with adjustment (adjustment for the following 7 resident-level covariates: age at baseline, no eating support, asthma or chronic obstructive pulmonary disease, feeding tube, antibiotic medication, flu vaccine documented this year, and pneumococcal vaccine up to date); 1921 participants evaluated in the resident-level negative binomial regressions with random-effects; one nursing home dropped out after 16 months). |

**Zimmerman 2020** *(Continued)*

| | |
|---|---|
| Interventions | **Comparison: caregiver-provided professional oral care versus usual oral care**<br><br>**Intervention group (n = 1219):** Mouth Care Without a Battle (MCWB), including: person-centred daily mouth care (cleaning the teeth, tongue, gums, and dentures), provided by caregivers who were trained by specialists in dementia care and dental hygiene; behavioural techniques to encourage resistant participants (e.g. who hit, bite, yell, spit), such as singing to encourage the mouth to open, providing hand-over-hand guidance, and gently massaging the cheek and jaw<br><br>**Control group (n = 933):** standard mouth care (usual mouth care)<br><br>**Operators:** described in the intervention group only: "The intervention included 3 in-service trainings provided by a specialist in dementia care and dental hygiene at study onset and monthly support visits over 2 years; at 12 months, a second in-service training was conducted. All nursing assistants, nurses, and administrative staff were invited to the training. In each NH, a nursing assistant was identified as a dedicated oral care aide; they provided staff support, trained new staff, and cared for residents who required the most time." Number of operators not stated. |
| Outcomes | • Incidence of first NHAP (24 months' follow-up)<br>• Mortality (all-cause; 24 months' follow-up)<br>• Oral health indices (24 months' follow-up) |
| Notes | **Sample size calculation:** "The estimate of statistical power was based on pneumonia incidence over 2 years of follow-up. Using previous research, it assumed a pneumonia rate of 2 cases per 1000 resident-days. With an average of 102 residents per NH, it was estimated that 74460 resident-days and 149 pneumonia cases would be observed per control site, resulting in 80% power to detect a pneumonia incidence reduction of 19% with a prespecified, 1-sided test for α = .05. Power calculations assumed an overdisperson factor for NH level rates of 3.0 to account for clustering; they were further based on an unmatched analysis, assuming they would be conservative and hence would provide justification for the planned matched analyses." |

***Risk of bias***

| Bias | Authors' judgement | Support for judgement |
|---|---|---|
| Random sequence generation (selection bias) | Low risk | Quote: "Within each pair, 1 NH was randomized to MCWB by random number generation conducted by the project statistician." |
| Allocation concealment (selection bias) | Unclear risk | Quote: "Within each pair, 1 NH was randomized to MCWB by random number generation conducted by the project statistician."<br><br>Comment: method of allocation concealment not described. |
| Blinding of participants and personnel (performance bias)<br>All outcomes | High risk | Quote: "Masking: None (Open Label)" (NCT03817450). |
| Blinding of outcome assessment (detection bias)<br>All outcomes | Low risk | Quote: "Data collection was conducted from September 2014 to May 2017 by research assistants masked to study group." |
| Incomplete outcome data (attrition bias)<br>All outcomes | Low risk | Comment: all 2152 participants were included in the unadjusted analysis. |
| Selective reporting (reporting bias) | Low risk | Comment: expected outcomes reported. |
| Other bias | Low risk | Comment: no other sources of bias identified. |

BMI: body mass index; g: grams; g/dL: grams/decilitre; ITT: intention-to-treat; kcal: kilocalorie; kg/m$^2$: kilograms per metre squared; MCWB: Mouth Care Without a Battle; NH: nursing home; NHAP: nursing home-acquired pneumonia; ONS: oral nutritional supplements; POHC: professional oral hygiene care; RCT: randomised controlled trial.

### Characteristics of excluded studies *[ordered by study ID]*

| Study | Reason for exclusion |
|---|---|
| Bassim 2008 | Retrospective cohort study. |
| Chen 2021 | Not conducted to assess pneumonia incidence or mortality. |
| Chiang 2020 | Non-RCT. |
| Hollaar 2017 | Non-RCT. |
| Izumi 2016 | Not conducted to assess pneumonia incidence or mortality. |
| Morino 2010 | Quasi-randomised trial. |
| Quagliarello 2009 | Not conducted to assess pneumonia incidence or mortality. |
| Sunakawa 2022 | Prospective cohort study. |
| Watando 2004 | Not conducted to assess pneumonia incidence or mortality. |

RCT: randomised controlled trial.

### Characteristics of studies awaiting classification *[ordered by study ID]*

**JPRN-UMIN000020694**

| | |
|---|---|
| Methods | **Study design:** RCT, 2 parallel groups<br>**Location:** Japan<br>**Number of centres:** 5<br>**Study period:** starting date 20 March 2015, completion date not stated<br>**Funding source:** Health, Labour and Welfare Ministry, Japan |
| Participants | **Setting:** nursing homes<br>**Inclusion criteria:** residents of the 5 nursing homes, aged 65–100 years<br>**Exclusion criteria:** "difficult person of oral function improvement services"<br>**Number randomised:** 400 participants<br>**Number evaluated:** unclear |
| Interventions | **Comparison: oral function improvement + oral hygiene programme versus oral hygiene programme**<br>Intervention group: weekly oral function improvement + oral hygiene programme for 15 months<br>Control group: weekly oral hygiene programme for 15 months |
| Outcomes | • Incidence of NHAP (15 months' follow-up) |

**JPRN-UMIN000020694** *(Continued)*

| | |
|---|---|
| Notes | It was stated that the trial was completed in April 2020 and "partially published", but we could retrieve no published articles or useful data.<br><br>We tried to contact Watanabe Yutaka (ywata@tmig.or.jp), but received no reply.<br><br>We will consider the study for inclusion once the trial authors provide the outcome data. |

**NCT00841074**

| | |
|---|---|
| Methods | **Study design:** RCT, 2 parallel groups<br>**Location:** USA<br>**Number of centres:** not stated<br>**Study period:** not stated<br>**Funding source:** not stated |
| Participants | **Setting:** nursing homes<br><br>**Inclusion criteria:** age ≥ 65 years; dependence in ≥ 2 ADLs, 1 of which must be personal hygiene; natural teeth or complete or partial dentures; expected residence in a nursing home for 2 years<br><br>**Exclusion criteria:** existing pneumonia; history of chlorhexidine reaction or allergy, multiple medication or substance allergies; receiving chlorhexidine oral application at enrolment as prescribed by physician or dentist<br><br>**Number randomised:** 75 participants<br><br>**Number evaluated:** unclear |
| Interventions | **Comparison: Peridex mouthwash versus placebo mouthwash**<br><br>**Intervention group:** 0.12% chlorhexidine mouthwash spray, ~1.3 mL, twice/day<br><br>**Control group:** placebo mouthwash spray, ~1.3 mL, twice/day |
| Outcomes | • Incidence of NHAP (12 months' follow-up)<br>• Oral health indices (12 months' follow-up) |
| Notes | It is stated that the trial was completed in July 2011, but we could retrieve no published articles or useful data. We tried to contact the study authors for the data we needed. One author replied "The study is finished but we did not obtain any significant results and they have not been published", but when we asked for further information, we received no further reply. We will consider the study for inclusion once the trial authors provide the outcome data. |

**NCT03533335**

| | |
|---|---|
| Methods | **Study design:** RCT, 3 parallel groups<br>**Location:** Hong Kong, China<br>**Number of centres:** not stated<br>**Study period:** June 2014–December 2017<br>**Funding source:** not stated |
| Participants | **Setting:** nursing homes |

**NCT03533335** *(Continued)*

| | |
|---|---|
| | **Inclusion criteria:** ≥ 6 natural teeth; no indwelling nasogastric tube<br><br>**Exclusion criteria:** not stated<br><br>**Number randomised:** 228 participants<br><br>**Number evaluated:** unclear |
| Interventions | **Comparison: chlorhexidine mouthwash versus chlorine dioxide mouthwash versus placebo mouthwash**<br><br>**Group 1:** 0.2% chlorhexidine oral spray, once daily<br><br>**Group 2:** 0.1% pH-balanced chlorine dioxide oral spray, once daily<br><br>**Group 3:** sterile water spray, once daily |
| Outcomes | Incidence of NHAP (over 6 months' follow-up)<br><br>• Oral health indices, including:<br>  ○ change in dental plaque (Silness and Löe Plaque Index) from baseline to 3 months and 6 months;<br>  ○ change in gingival bleeding (Silness and Löe Gingival Bleeding Index) from baseline to 3 months and 6 months;<br>  ○ change in OHIP (Oral health impact profile) scores from baseline to 3 months and 6 months; and<br>  ○ supragingival calculus, extrinsic staining from baseline to 6 months.<br>• Microbiological indices, including:<br>  ○ change in Staphylococcus aureus (cfu/mL), from baseline to 3 months and 6 months;<br>  ○ change in aerobic and facultative anaerobic gram-negative bacilli (cfu/mL), from baseline to 3 months and 6 months;<br>  ○ change in *Streptococcus pneumoniae* (cfu/mL), from baseline to 3 months and 6 months;<br>  ○ change in *Haemophilus influenza* (cfu/mL), from baseline to 3 months and 6 months; and<br>  ○ change in *Moraxella catarrhalis* (cfu/mL), from baseline to 3 months and 6 months. |
| Notes | It is stated that the trial was completed in 2017, but we could retrieve no published articles or useful data.<br><br>No contact information is available.<br><br>We will consider the study for inclusion once the trial authors provide the outcome data. |

ADL: activity of daily living; cfu/mL: colony-forming units per millilitre; NHAP: nursing home-acquired pneumonia; RCT: randomised controlled trial.

## Characteristics of ongoing studies *[ordered by study ID]*

**NCT03892200**

| | |
|---|---|
| Study name | Adapting an evidence-based program that improves oral hygiene and health for assisted living residents With dementia |
| Methods | **Study design:** RCT, 2 parallel groups<br>**Location:** USA<br>**Number of centres:** not stated<br>**Funding source:** National Institutes of Health Grant/Contract (R01AG061966) |
| Participants | **Setting:** nursing homes<br><br>**Inclusion criteria:** age ≥ 18 years; natural teeth or dentures; diagnosis of dementia |

| | |
|---|---|
| **NCT03892200** *(Continued)* | |
| | **Exclusion criteria:** requirement of antibiotic prophylaxis prior to oral hygiene examination; hospice or tube feeding; expected date of death or discharge within 6 months<br><br>**Number randomised:** 1780 participants (estimated) |
| Interventions | **Comparison: caregiver-provided professional oral care versus usual oral care**<br><br>**Intervention group:** daily mouth care. The intervention being tested is a standardised educational and skill-building programme for use in assisted living communities, which highlights that mouth care is infection control (e.g. can reduce pneumonia); includes techniques and products to clean and protect the teeth, tongue, gums, and dentures (e.g. the jiggle-sweep approach to remove plaque, use of an interdental brush instead of floss); provides strategies for care provision in special situations (e.g. broken teeth); and includes a toolkit of dementia-sensitive approaches for people who are resistant (e.g. who refuse to open the mouth). It also includes information about potential dental emergencies and issues that merit assessment.<br><br>**Control group:** standard mouth care. Assisted living communities will continue to provide standard mouth care to all residents. Staff will not receive training or supplies in the control condition. |
| Outcomes | • Change in Plaque Index Score for Long-Term Care (PI-LTC) over time (time frame: baseline and 8 months)<br>• Change in Gingival Index Score for Long-Term Care (GI-LTC) over time (time frame: baseline and 8 months)<br>• Change in Denture Plaque Index Score (DPI) over time (time frame: baseline and 8 months)<br>• Incidence of pneumonia over time (time frame: collected monthly during 8-month study period)<br>• Incidence of hospitalisations over time (time frame: collected monthly during 8-month study period)<br>• Staff self-efficacy to provide mouth care (time frame: baseline and 8 months)<br>• Dental hygienists' self-efficacy to train nursing assistants (time frame: baseline and 8 months)<br>• Average number of days mouth care was performed (time frame: collected during the 8-month study period)<br>• Acceptability of Intervention Measure (AIM; time frame: baseline and 8 months)<br>• Feasibility of Intervention Measure (FIM; time frame: baseline and 8 months)<br>• Intervention Appropriateness Measure (IAM; time frame: baseline and 8 months)<br>• Texas Christian University Workshop Evaluation (WEVAL; time frame: baseline)<br>• Texas Christian University Workshop Assessment Follow-up (WAFU; time frame: 4 months) |
| Starting date | 1 October 2019 |
| Contact information | Kimberly T Ward: kimberly_ward@unc.edu<br>Sheryl Zimmerman: sheryl_zimmerman@unc.edu<br>University of North Carolina at Chapel Hill<br>Chapel Hill, North Carolina, USA, 27599 |
| Notes | **Estimated completion date:** 31 May 2024 |

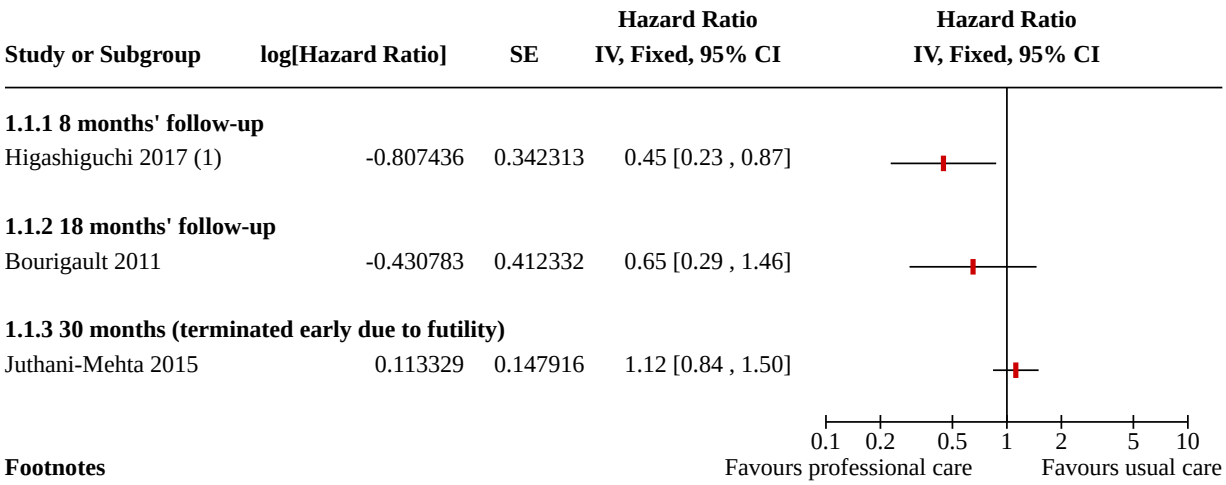
RCT: randomised controlled trial.

## DATA AND ANALYSES

**Comparison 1. Professional oral care versus usual oral care**

| Outcome or subgroup title | No. of studies | No. of participants | Statistical method | Effect size |
|---|---|---|---|---|
| 1.1 Incidence of nursing home-acquired pneumonia | 3 | | Hazard Ratio (IV, Fixed, 95% CI) | Totals not selected |
| 1.1.1 8 months' follow-up | 1 | | Hazard Ratio (IV, Fixed, 95% CI) | Totals not selected |
| 1.1.2 18 months' follow-up | 1 | | Hazard Ratio (IV, Fixed, 95% CI) | Totals not selected |
| 1.1.3 30 months (terminated early due to futility) | 1 | | Hazard Ratio (IV, Fixed, 95% CI) | Totals not selected |
| 1.2 Mortality (pneumonia-associated) | 2 | | Risk Ratio (M-H, Random, 95% CI) | Subtotals only |
| 1.2.1 24-months' follow-up | 2 | 454 | Risk Ratio (M-H, Random, 95% CI) | 0.43 [0.25, 0.76] |
| 1.3 Mortality (all-cause) | 1 | | Risk Ratio (M-H, Random, 95% CI) | Subtotals only |
| 1.3.1 24-months' follow-up | 1 | 88 | Risk Ratio (M-H, Random, 95% CI) | 0.80 [0.40, 1.58] |
| 1.4 Prevalence of fever | 1 | | Risk Ratio (M-H, Random, 95% CI) | Subtotals only |
| 1.4.1 24-months' follow-up | 1 | 366 | Risk Ratio (M-H, Random, 95% CI) | 0.49 [0.33, 0.75] |

**Analysis 1.1. Comparison 1: Professional oral care versus usual oral care, Outcome 1: Incidence of nursing home-acquired pneumonia**



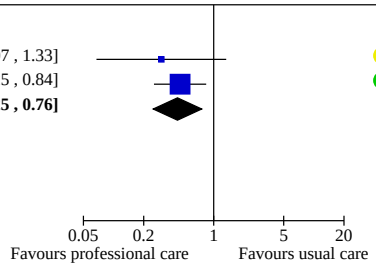

**Footnotes**

(1) SE calculated using Parmar methods. Unadjusted effect estimate; resulting CI may be artificially narrow.

## Analysis 1.2. Comparison 1: Professional oral care versus usual oral care, Outcome 2: Mortality (pneumonia-associated)

| Study or Subgroup | Professional care Events | Total | Usual care Events | Total | Weight | Risk Ratio M-H, Random, 95% CI | Risk of Bias A B C D E F G |
|---|---|---|---|---|---|---|---|
| **1.2.1 24-months' follow-up** | | | | | | | |
| Adachi 2002 (1) | 2 | 40 | 8 | 48 | 13.9% | 0.30 [0.07 , 1.33] | ? ? − ? − + + |
| Yoneyama 2002 | 14 | 184 | 30 | 182 | 86.1% | 0.46 [0.25 , 0.84] | + ? − + ? + + |
| **Subtotal (95% CI)** | | **224** | | **230** | **100.0%** | **0.43 [0.25 , 0.76]** | |
| Total events: | 16 | | 38 | | | | |

Heterogeneity: Tau² = 0.00; Chi² = 0.28, df = 1 (P = 0.60); I² = 0%
Test for overall effect: Z = 2.93 (P = 0.003)




**Footnotes**

(1) Analysis based on subset of participants (88/141; 62%) who were compliant with professional oral health care or who had died at 24 months' follow-up.

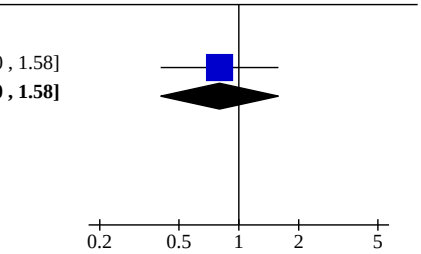
**Risk of bias legend**

(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias

## Analysis 1.3. Comparison 1: Professional oral care versus usual oral care, Outcome 3: Mortality (all-cause)

| Study or Subgroup | Professional care Events | Total | Usual care Events | Total | Weight | Risk Ratio M-H, Random, 95% CI |
|---|---|---|---|---|---|---|
| **1.3.1 24-months' follow-up** | | | | | | |
| Adachi 2002 (1) | 10 | 40 | 15 | 48 | 100.0% | 0.80 [0.40 , 1.58] |
| **Subtotal (95% CI)** | | **40** | | **48** | **100.0%** | **0.80 [0.40 , 1.58]** |
| Total events: | 10 | | 15 | | | |

Heterogeneity: Not applicable
Test for overall effect: Z = 0.64 (P = 0.52)



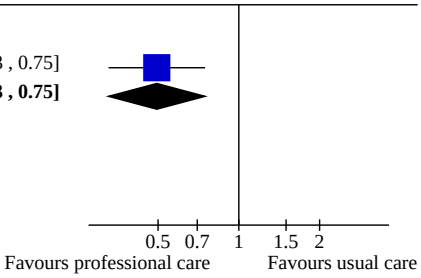

**Footnotes**

(1) Analysis based on subset of participants (88/141; 62%) who complied with professional oral health care or who had died at 24 months.

## Analysis 1.4. Comparison 1: Professional oral care versus usual oral care, Outcome 4: Prevalence of fever

| Study or Subgroup | Professional care Events | Total | Usual care Events | Total | Weight | Risk Ratio M-H, Random, 95% CI |
|---|---|---|---|---|---|---|
| **1.4.1 24-months' follow-up** | | | | | | |
| Yoneyama 2002 | 27 | 184 | 54 | 182 | 100.0% | 0.49 [0.33 , 0.75] |
| **Subtotal (95% CI)** | | **184** | | **182** | **100.0%** | **0.49 [0.33 , 0.75]** |
| Total events: | 27 | | 54 | | | |

Heterogeneity: Not applicable
Test for overall effect: Z = 3.33 (P = 0.0009)



# APPENDICES

## Appendix 1. Cochrane Oral Health Trials Register search strategy

Cochrane Oral Health's Trials Register is available via the Cochrane Register of Studies. For information on how the register is compiled, see oralhealth.cochrane.org/trials.

1 (((oral or mouth or dental) and (care or hygiene or health)):ti,ab) AND (INREGISTER)
2 ((care and teeth):ti,ab) AND (INREGISTER)
3 ((denture* and (clean* or clens*)):ti,ab) AND (INREGISTER)
4 ((plaque and (control* or remov*)):ti,ab) AND (INREGISTER)
5 ((mouthwash* or mouth-wash* or mouthrins* or mouth-rins* or oral-rins* or toothpaste* or "tooth paste*" or dentifrice* or toothbrush* or "tooth brush*" or fluorid* or chlorhexidine or betadine* or triclosan or cepacol or Corsodyl or Peridex or Hibident or Prexidine or Parodex or Chlorexil or Periodont or Eludril or Perioxidin or Chlorohex or Savacol or Periogard or Chlorhexamed or Nolvasan or Sebidin or Tubulicid or hibitane):ti,ab) AND (INREGISTER)
6 ((antiseptic* or antiiinfect* or "local microbicide*" or "topical microbicide"):ti,ab) AND (INREGISTER)
7 (((oral or mouth or dental) and (foam* or gel*)):ti,ab) AND (INREGISTER)
8 ((floss* or "interdental brush*" or (tooth and clean*) or (teeth and clean*) or (denture* and hygien*) or (tongue* and scrap*)):ti,ab) AND (INREGISTER)
9 ("professional oral health care":ti,ab) AND (INREGISTER)
10 (#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9) AND (INREGISTER)
11 (pneumonia:ti,ab) AND (INREGISTER)
12 (("gram negative bacilli" or "psuedomonas aeruginosa" or enterobacter* or pneumonitis or "pulmonary inflammation" or "lung inflammation"):ti,ab) AND (INREGISTER)
13 (#11 or #12) AND (INREGISTER)
14 (#10 and #13) AND (INREGISTER)

## Appendix 2. Cochrane Central Register of Controlled Trials (CENTRAL) search strategy

#1 [mh "preventive dentistry"]
#2 [mh dentifrices]
#3 [mh ^mouthwashes]
#4 [mh ^"oral health"]
#5 [mh ^"Anti-infective agents, local"]
#6 [mh ^Cetylpyridinium]
#7 [mh ^Chlorhexidine]
#8 [mh ^Povidine-iodine]
#9 ((oral or mouth or dental) near/3 (care or hygiene or health)):ti,ab
#10 (care near/3 teeth):ti,ab
#11 (denture* near/5 (clean* or clens*)):ti,ab
#12 (plaque near/3 (control* or remov*)):ti,ab
#13 (mouthwash* or mouth-wash* or mouthrins* or mouth-rins* or oral-rins* or toothpaste* or "tooth paste*" or dentifrice* or toothbrush* or "tooth brush*" or fluorid* or chlorhexidine or betadine* or triclosan or cepacol or Corsodyl or Peridex or Hibident or Prexidine or Parodex or Chlorexil or Periodont or Eludril or Perioxidin or Chlorohex or Savacol or Periogard or Chlorhexamed or Nolvasan or Sebidin or Tubulicid or hibitane):ti,ab
#14 (antiseptic* or antiiinfect* or "local microbicide*" or "topical microbicide"):ti,ab
#15 ((oral or mouth or dental) near/5 (foam* or gel*)):ti,ab
#16 (floss* or "interdental brush*" or (tooth near/5 clean*) or (teeth near/5 clean*) or (denture* near/5 hygien*) or (tongue* near/5 scrap*)):ti,ab
#17 "professional oral health care":ti,ab
#18 {or #1-#17}
#19 [mh pneumonia]
#20 pneumonia:ti,ab
#21 ("gram negative bacilli" or "psuedomonas aeruginosa" or enterobacter* or pneumonitis or "pulmonary inflammation" or "lung inflammation"):ti,ab
#22 {or #19-#21}
#23 #18 and #22

## Appendix 3. MEDLINE Ovid search strategy

1. exp Preventive dentistry/
2. exp Dentifrices/
3. Mouthwashes/
4. Oral health/

5. Anti-infective agents, local/
6. Cetylpyridinium/
7. Chlorhexidine/
8. Povidone-iodine/
9. ((oral or mouth or dental) adj3 (care or hygiene or health)).ti,ab.
10. (care adj3 teeth).ti,ab.
11. (denture$ adj5 (clean$ or clens$)).ti,ab.
12. (plaque adj3 (control$ or remov$)).ti,ab.
13. (mouthwash$ or mouth-wash$ or mouthrins$ or mouth-rins$ or oral-rins$ or toothpaste$ or "tooth paste$" or dentifrice$ or toothbrush $ or "tooth brush$" or fluorid$ or chlorhexidine or betadine$ or triclosan or cepacol or Corsodyl or Peridex or Hibident or Prexidine or Parodex or Chlorexil or Peridont or Eludril or Perioxidin or Chlorohex or Savacol or Periogard or Chlorhexamed or Nolvasan or Sebidin or Tubulicid or hibitane).ti,ab.
14. (antiseptic$ or antiinfect$ or "local microbicide$" or "topical microbicide$").ti,ab.
15. ((oral or mouth or dental) adj5 (foam$ or gel$)).ti,ab.
16. (floss$ or "interdental brush$" or (tooth adj5 clean$) or (teeth adj5 clean$) or (denture$ adj5 hygien$) or (tongue$ adj5 scrap$)).ti,ab.
17. "professional oral health care".ti,ab.
18. or/1-17
19. exp Pneumonia/
20. pneumonia.ti,ab.
21. ("gram negative bacilli" or "pseudomonas aeruginosa" or "pseudomonas aruginosa" or enterobacter$ or pneumonitis or "pulmonary inflammation" or "lung inflammation").ti,ab.
22. or/19-21
23. 18 and 22

The above subject search was linked with the highly sensitive search strategy designed by Cochrane for identifying randomised controlled trials and controlled clinical trials in MEDLINE (as described in Lefebvre 2022, box 3c).
1. randomized controlled trial.pt.
2. controlled clinical trial.pt.
3. randomized.ab.
4. placebo.ab.
5. drug therapy.fs.
6. randomly.ab.
7. trial.ab.
8. groups.ab.
9. or/1-8
10. exp animals/ not humans.sh.
11. 9 not 10

## Appendix 4. Embase Ovid search strategy

1. exp Preventive dentistry/
2. Toothpaste/
3. Mouthwash/
4. Mouth hygiene/
5. Anti-infective agent/
6. Cetylpyridinium salt/
7. Chlorhexidine/
8. Povidone iodine/
9. ((oral or mouth or dental) adj3 (care or hygiene or health)).ti,ab.
10. (care adj3 teeth).ti,ab.
11. (denture$ adj5 (clean$ or clens$)).ti,ab.
12. (plaque adj3 (control$ or remov$)).ti,ab.
13. (mouthwash$ or mouth-wash$ or mouthrins$ or mouth-rins$ or oral-rins$ or toothpaste$ or "tooth paste$" or dentifrice$ or toothbrush $ or "tooth brush$" or fluorid$ or chlorhexidine or betadine$ or triclosan or cepacol or Corsodyl or Peridex or Hibident or Prexidine or Parodex or Chlorexil or Peridont or Eludril or Perioxidin or Chlorohex or Savacol or Periogard or Chlorhexamed or Nolvasan or Sebidin or Tubulicid or hibitane).ti,ab.
14. (antiseptic$ or antiinfect$ or "local microbicide$" or "topical microbicide$").ti,ab.
15. ((oral or mouth or dental) adj5 (foam$ or gel$)).ti,ab.
16. (floss$ or "interdental brush$" or (tooth adj5 clean$) or (teeth adj5 clean$) or (denture$ adj5 hygien$) or (tongue$ adj5 scrap$)).ti,ab.
17. "professional oral health care".ti,ab.
18. or/1-17
19. exp Pneumonia/

20. pneumonia.ti,ab.
21. ("gram negative bacilli" or "pseudomonas aeruginosa" or "pseudomonas aruginosa" or enterobacter$ or pneumonitis or "pulmonary inflammation" or "lung inflammation").ti,ab.
22. or/19-21
23. 18 and 22

The above subject search was linked with the highly sensitive search strategy designed by Cochrane for identifying randomised controlled trials and controlled clinical trials in Embase (as described in Lefebvre 2022, box 3e).

1. Randomized controlled trial/
2. Controlled clinical study/
3. random$.ti,ab.
4. randomization/
5. intermethod comparison/
6. placebo.ti,ab.
7. (compare or compared or comparison).ti.
8. ((evaluated or evaluate or evaluating or assessed or assess) and (compare or compared or comparing or comparison)).ab.
9. (open adj label).ti,ab.
10. ((double or single or doubly or singly) adj (blind or blinded or blindly)).ti,ab.
11. double blind procedure/
12. parallel group$1.ti,ab.
13. (crossover or cross over).ti,ab.
14. ((assign$ or match or matched or allocation) adj5 (alternate or group$1 or intervention$1 or patient$1 or subject$1 or participant $1)).ti,ab.
15. (assigned or allocated).ti,ab.
16. (controlled adj7 (study or design or trial)).ti,ab.
17. (volunteer or volunteers).ti,ab.
18. human experiment/
19. trial.ti.
20. or/1-19
21. random$ adj sampl$ adj7 ("cross section$" or questionnaire$1 or survey$ or database$1)).ti,ab. not (comparative study/ or controlled study/ or randomi?ed controlled.ti,ab. or randomly assigned.ti,ab.)
22. Cross-sectional study/ not (randomized controlled trial/ or controlled clinical study/ or controlled study/ or randomi?ed controlled.ti,ab. or control group$1.ti,ab.)
23. (((case adj control$) and random$) not randomi?ed controlled).ti,ab.
24. (Systematic review not (trial or study)).ti.
25. (nonrandom$ not random$).ti,ab.
26. "Random field$".ti,ab.
27. (random cluster adj3 sampl$).ti,ab.
28. (review.ab. and review.pt.) not trial.ti.
29. "we searched".ab. and (review.ti. or review.pt.)
30. "update review".ab.
31. (databases adj4 searched).ab.
32. (rat or rats or mouse or mice or swine or porcine or murine or sheep or lambs or pigs or piglets or rabbit or rabbits or cat or cats or dog or dogs or cattle or bovine or monkey or monkeys or trout or marmoset$1).ti. and animal experiment/
33. Animal experiment/ not (human experiment/ or human/)
34. or/21-33
35. 20 not 34

## Appendix 5. CINAHL EBSCO (Cumulative Index to Nursing and Allied Health Literature) search strategy

S22 S17 and S21
S21 S18 or S19 or S20
S20 ("gram negative bacilli" or "psuedomonas aeruginosa" or enterobacter* or pneumonitis or "pulmonary inflammation" or "lung inflammation")
S19 pneumonia

S18 (mh pneumonia+)
S17 S1 or S2 or S3 or S4 or S5 or S6 or S7 or S8 or S9 or S10 or S11 or S12 or S13 or S14 or S15 or S16
S16 "professional oral health care"
S15 (floss* or "interdental brush*" or (tooth N5 clean*) or (teeth N5 clean*) or (denture* N5 hygien*) or (tongue* N5 scrap*))
S14 ((oral or mouth or dental) N5 (foam* or gel*))
S13 (antiseptic* or antiiinfect* or "local microbicide*" or "topical microbicide")
S12 (mouthwash* or mouth-wash* or mouthrins* or mouth-rins* or oral-rins* or toothpaste* or "tooth paste*" or dentifrice* or toothbrush* or "tooth brush*" or fluorid* or chlorhexidine or betadine* or triclosan or cepacol or Corsodyl or Peridex or Hibident or Prexidine or Parodex or Chlorexil or Periodont or Eludril or Perioxidin or Chlorohex or Savacol or Periogard or Chlorhexamed or Nolvasan or Sebidin or Tubulicid or hibitane)
S11 (plaque N3 (control* or remov*))
S10 (denture* N5 (clean* or clens*))
S9 (care N3 teeth)
S8 ((oral or mouth or dental) N3 (care or hygiene or health))
S7 (MH "Povidone-Iodine")
S6 (MH "Chlorhexidine")
S5 (mh "Anti-infective agents, local")
S4 (mh "oral health")
S3 (mh mouthwashes)
S2 (mh dentifrices)
S1 (mh "preventive dentistry+")

The above subject search was linked with the highly sensitive search strategy designed by Cochrane for identifying randomised controlled trials and controlled clinical trials in CINAHL (as described in Lefebvre 2022, box 3f).

S1 MH randomized controlled trials
S2 MH double-blind studies
S3 MH single-blind studies
S4 MH random assignment
S5 MH pretest-posttest design
S6 MH cluster sample
S7 TI (randomised OR randomized)
S8 AB (random*)
S9 TI (trial)
S10 MH (sample size) AND AB (assigned OR allocated OR control)
S11 MH (placebos)
S12 PT (randomized controlled trial)
S13 AB (control W5 group)
S14 MH (crossover design) OR MH (comparative studies)
S15 AB (cluster W3 RCT)
S16 MH animals+
S17 MH (animal studies)
S18 TI (animal model*)
S19 S16 OR S17 OR S18
S20 MH (human)
S21 S19 NOT S20
S22 S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15
S23 S22 NOT S21

### Appendix 6. ClinicalTrials.gov search strategy

pneumonia and nursing home

### Appendix 7. WHO International Clinical Trials Registry Platform search strategy

pneumonia and nursing home

## WHAT'S NEW

| Date | Event | Description |
|---|---|---|
| 16 November 2022 | New citation required but conclusions have not changed | The addition of 2 new studies did not change conclusions |
| 16 November 2022 | New search has been performed | Search updated and 2 new studies identified for inclusion (Higashiguchi 2017; Zimmerman 2020). |

## HISTORY

Protocol first published: Issue 10, 2016
Review first published: Issue 9, 2018

## CONTRIBUTIONS OF AUTHORS

Conceiving and designing the review: CL
Conducting and writing the review: YC, CL
Screening search results: YC, CL, CLi
Extracting data and assessing risk of bias: YC, CL, CLi
Analysing and interpreting data (including GRADE assessment): YC, CL, TW, CLi
Approving the final review prior to submission: YC, CL, JL, LN, IN, TW, CLi

## DECLARATIONS OF INTEREST

YC: none
CL: none
JL: none
LN: none
IN: has received funding for lectures and research from industry related to oral hygiene products that could be used in the prevention of ventilator-associated pneumonia, such as GSK (now Haleon) and Procter & Gamble. IN is an editor with Cochrane Oral Health but was not involved in the editorial processing of the review.
TW: none. TW is an editor with Cochrane Oral Health but was not involved in the editorial processing of the review.
CLi: none

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### External sources

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## DIFFERENCES BETWEEN PROTOCOL AND REVIEW

In Assessment of risk of bias in included studies, we deleted "Blinding of outcome assessment is less important for our objective outcomes mortality (all-cause death) and mortality (pneumonia-associated death). We will consider this when assessing the quality of evidence on mortality in 'Summary of findings' tables". We considered that outcome assessment blinding might affect judgement of causes of death.

In Measures of treatment effect, we deleted "If all measures fail, we will consider the use of RR for time-to-event data presented as one-year survival, two-year survival, and so on". Instead, we decided to use methods proposed in Parmar 1998.

## NOTES

This is the first update of a review published in 2018 (Liu 2018). The protocol for the review was published in 2016 (Li 2016).

## INDEX TERMS

### Medical Subject Headings (MeSH)

Cross Infection [epidemiology] [*prevention & control]; Dental Care [*methods]; Denture Cleansers; Incidence; Long-Term Care; Mouthwashes [therapeutic use]; *Nursing Homes; *Oral Health; Oral Hygiene [*methods]; Pneumonia [epidemiology] [*prevention & control]; Randomized Controlled Trials as Topic; Toothbrushing [methods]

### MeSH check words

Aged; Humans