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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.

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[Intervention Review]

Oral care measures for preventing nursing home-acquired pneumonia

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Editorial group: Cochrane Oral Health Group.
Publication status and date: New, published in Issue 9, 2018.

Citation: Liu C, Cao Y, Lin J, Ng L, Needleman I, Walsh T, Li C. 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.

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ABSTRACT

Background

Pneumonia occurring in residents of long-term care facilities and nursing homes can be termed 'nursing home-acquired pneumonia' (NHAP). NHAP is the leading cause of mortality among residents. NHAP may be caused by aspiration of oropharyngeal flora into the lung, and by failure of the individual's defence mechanisms to eliminate the aspirated bacteria. Oral care measures to remove or disrupt oral plaque might be effective in reducing the risk of NHAP.

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

Cochrane Oral Health's Information Specialist searched the following databases: Cochrane Oral Health's Trials Register (to 15 November 2017), the Cochrane Central Register of Controlled Trials (CENTRAL) (the Cochrane Library, 2017, Issue 10), MEDLINE Ovid (1946 to 15 November 2017), and Embase Ovid (1980 to 15 November 2017) and Cumulative Index to Nursing and Allied Health Literature (CINAHL; 1937 to 15 November 2017). The US National Institutes of Health Trials Registry (ClinicalTrials.gov) and the World Health Organization International Clinical Trials Registry Platform were searched for ongoing trials. No restrictions were placed on the language or date of publication when searching the electronic databases. We also searched the Chinese Biomedical Literature Database, the China National Knowledge Infrastructure, and the Sciencepaper Online to 20 November 2017.

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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 ratio (RR) for dichotomous outcomes, mean difference (MD) for continuous outcomes, and hazard ratio (HR) for time-to-event outcomes, using random-effects models.

Main results

We included four RCTs (3905 participants), all of which were at high risk of bias. The studies all evaluated one comparison: professional oral care versus usual oral care. We did not pool the results from one study (N = 834 participants), which was stopped at interim analysis due to lack of a clear difference between groups.

We were unable to determine whether professional oral care resulted in a lower incidence rate of NHAP compared with usual oral care over an 18-month period (hazard ratio 0.65, 95% CI 0.29 to 1.46; one study, 2513 participants analysed; low-quality evidence).

We were also unable to determine whether professional oral care resulted in a lower number of first episodes of pneumonia compared with usual care over a 24-month period (RR 0.61, 95% CI 0.37 to 1.01; one study, 366 participants analysed; low-quality evidence).

There was low-quality evidence from two studies that professional oral care may reduce the risk of pneumonia-associated mortality compared with usual oral care at 24-month follow-up (RR 0.41, 95% CI 0.24 to 0.72, 507 participants analysed).

We were uncertain whether or not professional oral care may reduce all-cause mortality compared to usual care, when measured at 24-month follow-up (RR 0.55, 95% CI 0.27 to 1.15; one study, 141 participants analysed; very low-quality evidence).

Only one study (834 participants randomised) measured 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-quality evidence suggests that professional oral care could reduce mortality due to pneumonia in nursing home residents when compared to usual care, this finding must be considered with caution. Evidence for other outcomes is inconclusive. We found no high-quality evidence to determine which oral care measures are most effective for reducing nursing home-acquired pneumonia. Further trials are needed to draw reliable conclusions.

PLAIN LANGUAGE SUMMARY

Mouth care for preventing pneumonia in nursing homes

Review question

Does oral (mouth) care cut down pneumonia (a lung infection) in nursing homes? We aimed to summarise the findings from studies known as 'randomised controlled trials' in order to identify whether mouth care helped prevent pneumonia in elderly people living in nursing homes or other care facilities, and which approach to mouth care was best.

Background

Pneumonia is common among elderly people living in nursing homes. Nursing home-acquired pneumonia (NHAP) is a bacterial infection of the lung that occurs in residents of long-term care facilities and nursing homes. Poor oral hygiene is considered to contribute to the likelihood of contracting an infection. Professional mouth care is a combination of brushing teeth and mucosa, cleaning dentures, using mouthrinse, and check-up visits to a dentist, while usual mouth care is generally less intensive, and is self-administered, or provided by nursing home staff without special training in oral hygiene.

Study characteristics

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This review was carried out through Cochrane Oral Health. We searched scientific databases for relevant studies, up to 15 November 2017. We included four studies, with a total of 3905 participants randomly assigned to treatment or usual care. Participants were long-term-care elderly residents in nursing homes who did not have pneumonia at the beginning of the studies. Some of the participants had dementia or systemic diseases. All studies focused on the comparison between 'professional' mouth care and 'usual' mouth care. None of the studies evaluated oral care versus no oral care.

Key results

We identified four studies, all of which compared professional mouth care to usual mouth care in nursing home residents.

From the limited evidence, we could not tell whether professional oral mouth care was better or worse than usual mouth care for preventing pneumonia. The evidence for death from any cause was inconclusive, but the studies did suggest that professional mouth care may reduce the number of deaths caused by pneumonia, compared to usual mouth care, when measured after 24 months.

Only one study measured negative effects of the interventions, and reported that there were no serious events. The most common non-serious events reported were damage to the mouth and tooth staining.

Quality of the evidence

The quality of the evidence is low or very low, because of the small number of studies and problems with their design. Therefore, we cannot rely on the findings, and further research is required.

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SUMMARY OF FINDINGS FOR THE MAIN COMPARISON [Explanation]

Professional oral care versus usual oral care

Population: elderly people
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)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Usual oral care	Professional oral care				
Incidence rate of NHAP Clinical and radiological assessment Follow-up: 18 months	**5.1 per 10,000** patient-days	**3.3 per 10,000** (2.7 to 4.1) patient-days	**HR 0.65** (0.29 to 1.46)	2513 (1 study)	⊕⊕◯◯ **low** [a,b]	A second study (834 participants) that was stopped at interim analysis, with an average 1.13-year follow-up, reported that the HR of incidence rate of NHAP was 1.12 (0.84 to 1.50)
Incidence proportion (cumulative incidence) of NHAP Clinical and radiological assessment Follow-up: 24 months	**187 per 1000**	**114 per 1000** (69 to 189)	**RR 0.61** (0.37 to 1.01)	366 (1 study)	⊕⊕◯◯ **low** [a,b]	A second study (2513 participants) reported that the RR of cumulative incidence of NHAP at 18-month follow-up was 0.87, 95% CI 0.69 to 1.09
Mortality (pneumonia-associated) Clinical and radiological assessment Follow-up: 24 months	**154 per 1000**	**63 per 1000** (37 to 111)	**RR 0.41** (0.24 to 0.72)	507 (2 studies)	⊕⊕◯◯ **low** [c]	A third study (2513 participants) reported that the RR of pneumonia-associated mortality at 18-month follow-

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						up was 1.09, 95% CI 0.58 to 2.05
Mortality (all-cause) Clinical assessment Follow-up: 24 months	**234 per 1000**	**129 per 1000** (63 to 270)	**RR 0.55** (0.27 to 1.15)	141 (1 study)	⊕◯◯◯ **very low** [b,c]	A second study (834 participants) that was stopped at interim analysis, with an average follow-up of 1.13 years, reported that the HR of all-cause mortality was 1.16, 95% CI 0.88 to 1.53
Adverse effects of interventions	Measured in one study only, which reported that there were 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** (e.g. the median control group risk across studies) is provided in footnotes. 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; **RR:** risk ratio; **HR:** hazard ratio
NHAP: nursing home-acquired pneumonia

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

[a] Downgraded one level due to serious risk of bias (performance bias)
[b] Downgraded one level due to serious imprecision
[c] Downgraded two levels due to serious risk of bias (performance bias and attrition bias)

BACKGROUND

Description of the condition

Residents of nursing homes and long-term care facilities are comprised predominantly of a geriatric population. Institutionalised older adults are prone to poor oral health because they have reduced access to professional dental care, and are unable to maintain the practice of good personal oral hygiene (Berg 2000; Gaszynska 2014). Many studies have found that older adults require professional oral hygiene care as well as personal oral hygiene instruction (e.g. Frenkel 2000; Gaszynska 2014; Gluhak 2010; Petelin 2012). The incidence of community-acquired pneumonia (CAP) requiring hospitalisation is 1.96 to 10 times higher amongst elderly nursing home residents than community-dwelling elderly people (Marrie 2002; Ronald 2008; Ticinesi 2016), with a 2.29 times higher rate of 30-day mortality (Liapikou 2014). This may be attributable to the particular characteristics of residents of nursing homes and long-term care facilities, as they tend to be older, have greater functional impairment, and to have increased comorbidities, polypharmacy, and dependence upon caregivers (Dudas 2000; Martínez-Moragón 2004). Pneumonia occurring in residents of long-term care facilities and nursing homes can be termed nursing home-acquired pneumonia (NHAP); it closely resembles CAP, and may be caused by multidrug-resistant bacteria (Craven 2006; Mylotte 2002). This is suggested by data from the United States and Asia (Micek 2007; Nakagawa 2014), but is not confirmed by European data (Brito 2009; Ewig 2010). Nursing home-acquired pneumonia is the leading cause of mortality among residents (Cho 2011; Nicolle 1996). Its reported mean incidence ranges from 1 to 3.2 per 1000 patient days, with 600,000 emergency department admissions (El-Solh 2010; Medina-Walpole 1999; Muder 1998). It has been suggested that NHAP may be caused by aspiration of oropharyngeal flora into the lung, and by failure of host defence mechanisms to eliminate aspirated bacteria (Scannapieco 2014; Verghese 1983).

Comorbidities considered to be risk factors for NHAP include the following (Klapdor 2012; Ticinesi 2016):

- physical impairment;
- dementia;
- chronic obstructive pulmonary disease;
- mechanical ventilation;
- ageing.

A growing body of evidence shows that 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 the elderly, 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). A systematic review by Azarpazhooh 2006 concluded that there was 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 elderly living in nursing homes, and especially those in intensive care units. However, an RCT by Juthani-Mehta 2015 indicated that advanced oral care measures did not significantly reduce the incidence of radiographically-confirmed pneumonia or lower respiratory tract infection compared with usual care, in residents of nursing homes. Given that NHAP may be linked to oral hygiene, interventions for maintaining good oral hygiene might be of significant interest for this population.

Description of the intervention

It is widely believed that improved oral hygiene and frequent professional oral health care can be effective in reducing the incidence or progression of respiratory infection in residents of nursing homes and long-term care facilities (Azarpazhooh 2006; Scannapieco 2003; Sjögren 2008; Watando 2004). Multiple oral care measures have been reinforced by the National Institute for Health and Care Excellence (NICE) guideline that introduced detailed oral care measures, and recommended that care home managers should ensure care home policies set out plans and actions to promote and protect residents' oral health (NICE guideline 2016). The nature of oral care measures that have been proposed is diverse, but they can be classified broadly as follows.

- Mechanical aids to remove plaque and debris from the oral cavity, for example:
    - toothbrushing;
    - swabbing with water.
- Topical (chemical) disinfection to reduce colonisation, for example:
    - mouthrinse;
    - sprays;
    - liquids;
    - gels.

Antiseptics are broadly defined to include saline, chlorhexidine, povidone-iodine, cetylpyridium, and others, but to exclude antibiotics (Shi 2013).

- Combination of mechanical plaque removal and topical disinfection, for example:
    - swabbing with antiseptic;
    - toothbrushing with antibacterial toothpaste;
    - daily toothbrushing plus antiseptic rinse.
- Professional dental care, for example:
    - aided toothbrushing;
    - suction to remove excess fluid.

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

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How the intervention might work

Increasing evidence suggests a link between colonisation of bacteria and respiratory infection and pneumonia. Gram-negative bacilli, such as *Pseudomonas aeruginosa*, *Klebsiella pneumoniae,* and *Enterobacter* species, have been suspected as causative pathogens of pneumonia (Craven 1992; Liapikou 2014). Dependent and frail elderly patients have a higher detection rate of gram-negative bacilli in their oropharyngeal cavities (Leibovitz 2003; Mylotte 1994; Palmer 2001). Sumi 2007 showed that in a group of 138 dependent elderly, a potential respiratory pathogen colonised the dental plaques of 89 participants (64.5%). Aspiration of oropharyngeal fluid may cause translocation and colonisation of potential pulmonary pathogens in the lower respiratory tract and lungs (Gibbons 1989; Munro 2004; Whittaker 1996); the latter may cause aspiration pneumonia (Van der Maarel-Wierink 2013). Therefore, oral care measures that reduce the colonisation of bacteria could result in decreased risk of pneumonia.

The risk of NHAP might be reduced by measures that mechanically disrupt the biofilm (such as manual or electric toothbrushing), by the use of oral antiseptics that may remain active on oral tissues for several hours after application, or both, thus reducing the build-up of plaque. 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). Oral conditions of elderly people have been shown to be improved by rinsing with 0.12% CHX solution daily or weekly for six weeks (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). With removal or disruption of the oral plaque, pneumonia could be significantly reduced (Shi 2013; Van der Maarel-Wierink 2013). Such oral care measures can be used alone, or in combination. For example, 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

Cochrane Oral Health undertook an extensive prioritisation exercise in 2014 to identify a core portfolio of clinically important review titles to be maintained in *The Cochrane Library* (Worthington 2015). The dental public health expert panel identified this review as a priority title (ohg.cochrane.org/priority-reviews).

Although good oral hygiene has been shown to play an important role in maintaining the oral health and well-being of institutionalised people, oral care measures have generally been afforded low priority in nursing homes. In some guidelines, such as British Thoracic Society guidance on the prevention of CAP, oral hygiene is not mentioned (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, but bespoke oral health education has been shown to have a positive effect on caregivers' knowledge and attitudes (Charteris 2001; Frenkel 2001; Frenkel 2002; Sjögren 2010). A systematic review by Kaneoka 2015 found that mechanical oral cleaning significantly reduced the risk of fatal pneumonia in residents in nursing homes. However, no other kinds of oral care measures were evaluated, and no Cochrane systematic review has focused on this issue.

We believe it is important to synthesise the evidence from randomised controlled trials of oral care interventions that have evaluated their effectiveness in reducing NHAP. Identifying effective oral care interventions is also an essential step towards improving oral health and quality of life for nursing home residents.

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

We included parallel randomised controlled trials (RCTs) assessing the effects of oral care measures in residents of nursing homes and other long-term care facilities. We included cluster-RCTs, for which the unit of randomisation was the care facility. 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 was usual 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 random.

We included all studies of oral care in which the purpose of the study was 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 for which the only available information was presented in an abstract, with no record of a full-text publication; since this would have provided insufficient information for a full assessment of risk of bias.

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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, using dentures, having physical or intellectual disabilities, being mechanically ventilated, using alternative feeding route). We excluded participants with pneumonia or respiratory infection at baseline.

Types of interventions

We included studies comparing oral care measure(s) for prevention of NHAP versus no treatment, placebo, usual care, or any other oral care measure(s) used to prevent NHAP (head-to-head trials).

- Intervention group: participants received clearly defined oral care measure(s), 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 received placebo or another specific oral care measure(s), no treatment, or usual care, including self-care.

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

Types of outcome measures

Primary outcomes

- Incidence, incidence proportion or prevalence of NHAP of any severity (diagnosis of NHAP should have been 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 the 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 fever higher than 37.8°C, and prolonged number of febrile days
- Change in data on economics and quality of life
- Oral health indices, such as gingival index, plaque index, bleeding index, periodontal index, etc.

Search methods for identification of studies

Electronic searches

Cochrane Oral Health's Information Specialist conducted systematic searches in the following databases for randomised controlled trials and controlled clinical trials. There were no language, publication year or publication status restrictions:

- Cochrane Oral Health's Trials Register (searched 15 November 2017; see Appendix 1);
- Cochrane Central Register of Controlled Trials (CENTRAL; in the Cochrane Register of Studies, searched 15 November 2017; see Appendix 2);
- MEDLINE Ovid (1946 to 15 November 2017; see Appendix 3);
- Embase Ovid (1980 to 15 November 2017; see Appendix 4);
- CINAHL EBSCO (Cumulative Index to Nursing and Allied Health Literature; 1937 to 15 November 2017; see Appendix 5).

Subject strategies were modelled on the search strategy designed for MEDLINE Ovid. Where appropriate, they were combined with subject strategy adaptations of the highly sensitive search strategy, designed by Cochrane for identifying randomised controlled trials and controlled clinical trials, as described in the *Cochrane Handbook for Systematic Reviews of Interventions* Chapter 6 (Lefebvre 2011).

We also searched:

- Chinese Biomedical Literature Database (1978 to 20 November 2017; see Appendix 6);
- China National Infrastructure (1994 to 20 November 2017; see Appendix 7).

Searching other resources

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

- US National Institutes of Health Ongoing Trials Register ClinicalTrials.gov (clinicaltrials.gov/; searched 15 November 2017; see Appendix 8);
- World Health Organization International Clinical Trials Registry Platform (apps.who.int/trialsearch; searched 15 November 2017; see Appendix 9).

We also searched Sciencepaper Online (searched 20 November 2017; see Appendix 10).

We searched the reference lists of included studies and identified 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.

Review authors scanned records from 19 Chinese dental and nursing journals (2000 to 2010), as listed below.

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- *Chinese Journal of Stomatology,*
- *Journal of Practical Stomatology,*
- *Shanghai Journal of Stomatology,*
- *Journal of Clinical Stomatology,*
- *West China Journal of Stomatology,*
- *Journal of Modern Stomatology,*
- *Journal of Stomatology,*
- *Journal of Oral Science Research,*
- *Journal of Dental Prevention and Treatment,*
- *International Journal of Stomatology,*
- *Beijing Journal of Stomatology,*
- *Chinese Journal of Geriatric Dentistry,*
- *Chinese Journal of Nursing,*
- *Chinese Nursing Management,*
- *Nursing Journal of Chinese People's Liberation,*
- *Journal of Nursing Science,*
- *Chinese Journal of Practical Nursing,*
- *Chinese Nursing Research,*
- *Modern Clinical Nursing.*

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. These were filtered out early in the selection process if they were not randomised. We independently assessed eligibility according to the inclusion criteria, and obtained full-text copies of studies that appeared to meet the inclusion criteria, or when information in the title or the abstract was insufficient to allow us 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 clearly did not meet the inclusion criteria, and recorded the reasons for exclusion in the 'Characteristics of excluded studies' table.

Data extraction and management

Two review authors independently extracted data, and resolved disagreements by discussion.

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 proportions of non-oral feeding, dysphagia, xerostomia, tongue coating, mechanical ventilation, and methicillin-resistant *Staphylococcus aureus* (MRSA).
- Diagnostic criteria of CAP or NHAP: outcomes, 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; and timing of measurement.
- Management and intensity of specific interventions.

If any important data were missing, we contacted the authors of the study to request them. We collected data from multiple reports of single trials, and analysed them as from a single trial.

Assessment of risk of bias in included studies

Two review authors independently assessed risk of bias, and resolved disagreements by discussion. We used the Cochrane tool for assessing risk of bias (Higgins 2011a).

We used seven items to assess the risk of bias in included studies. For each item, we provided information from the trial report on measures taken to address possible bias, and arrived at a judgement of 'low risk', 'unclear risk' and 'high risk' of bias. We presented the seven domains and their descriptions below.

- Random sequence generation: selection bias (biased allocation to interventions) due to inadequate generation of a randomised sequence. We considered low risk of bias only if the generation of random numbers was clearly described. We considered an unclear description of random sequence generation with the phase 'stratified randomisation', 'block randomisation scheme', or 'randomisation completed by statistician or nurse' as having unclear risk of bias.
- Allocation concealment: selection bias (biased allocation to interventions) due to inadequate concealment of the 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, even if details of blinding were not reported.
- 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 elsewhere in the table, such as baseline imbalance, contamination, or co-intervention.

We classified the overall risk of bias in included studies as below. We summarised the risk of bias information graphically.

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Risk of bias	Interpretation	In outcome	In included studies
Low risk of bias	Plausible bias unlikely to seriously alter the results	Low risk of bias for all key domains	Most information was from studies at low risk of bias.
Unclear risk of bias	Plausible bias that raised some doubt about the results	Unclear risk of bias for one or more key domains	Most information was from studies at low or unclear risk of bias
High risk of bias	Plausible bias that seriously weakened confidence in the results	High risk of bias for one or more key domains	The proportion of information from studies at high risk of bias was sufficient to affect interpretation of results

Measures of treatment effect

We treated the incidence proportion and prevalence of NHAP as dichotomous data (presence or absence) and the incidence of NHAP and mortality as time-to-event data when these were reported.

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

For time-to-event data, we expressed the treatment effect as a hazard ratio (HR) or a rate ratio. If the HR was not reported, we calculated the log HR and the standard error from available summary statistics or Kaplan-Meier curves, according to the methods proposed by Parmar 1998, or we requested the data from study authors.

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 95% confidence interval (CI). When different scales were used to measure the same outcome, we used the standardised mean difference (SMD), with 95% CI, as the effect measure.

We anticipated that the number of participants reporting adverse reactions would be low, so we calculated a Peto odds ratio as the effect estimate.

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 by statistical measures that took clustering into account, we used the reported effect estimate and the standard error. When the investigators 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 trial to request missing details and summary statistics. Where no response was received, 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% confidence interval) to quantify the degree of statistical heterogeneity as follow (Deeks 2011).

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

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

Assessment of reporting biases

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

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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 was wider than the value that would be obtained if a fixed effect approach was used, leading to a more conservative interpretation.

Subgroup analysis and investigation of heterogeneity

Had there been sufficient studies and heterogeneity, we would have considered subgroup analyses: types of oral care measures, trial design (cluster or parallel), length of follow-up, characteristics of participants (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 a single very large trial, we would have undertaken a sensitivity analysis comparing the effect estimates from both random-effects and fixed-effect models. If these were different, we would have reported on both analyses as part of the results section, and we would have considered possible interpretation.

Assessing the quality of the evidence

We had planned to assess the quality 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 quality of the evidence for our only comparison (Atkins 2004; Guyatt 2008; Schünemann 2011). Evidence from RCTs is regarded as high quality, and our confidence in the body of evidence might be decreased due to study limitations (risk of bias), indirectness of the evidence, heterogeneity, imprecision of effect estimates, and risk of publication bias (see above Assessment of reporting biases). We classified the quality of a body of evidence into one of four categories: high, moderate, low, or very low (Guyatt 2008).

Summarising findings

We presented all important comparisons and key outcomes (pneumonia, death, and adverse effects) in the 'Summary of findings' tables, together with illustrative comparative risks, relative effect, numbers of participants and studies involved, quality of the evidence, and related comments. We used GRADEpro GDT to develop the 'Summary of findings' tables (GRADEpro GDT).

RESULTS

Description of studies

Results of the search

Through our electronic searches and handsearches, we identified 1849 references. There were 1173 records after we removed duplicates. After scanning the titles and abstracts, we considered 18 reports to be potentially eligible, and obtained the full texts for further review. We included four studies (reported in eight articles) in this systematic review, and two studies await classification. We excluded the remaining eight records. The flow diagram is shown in Figure 1.

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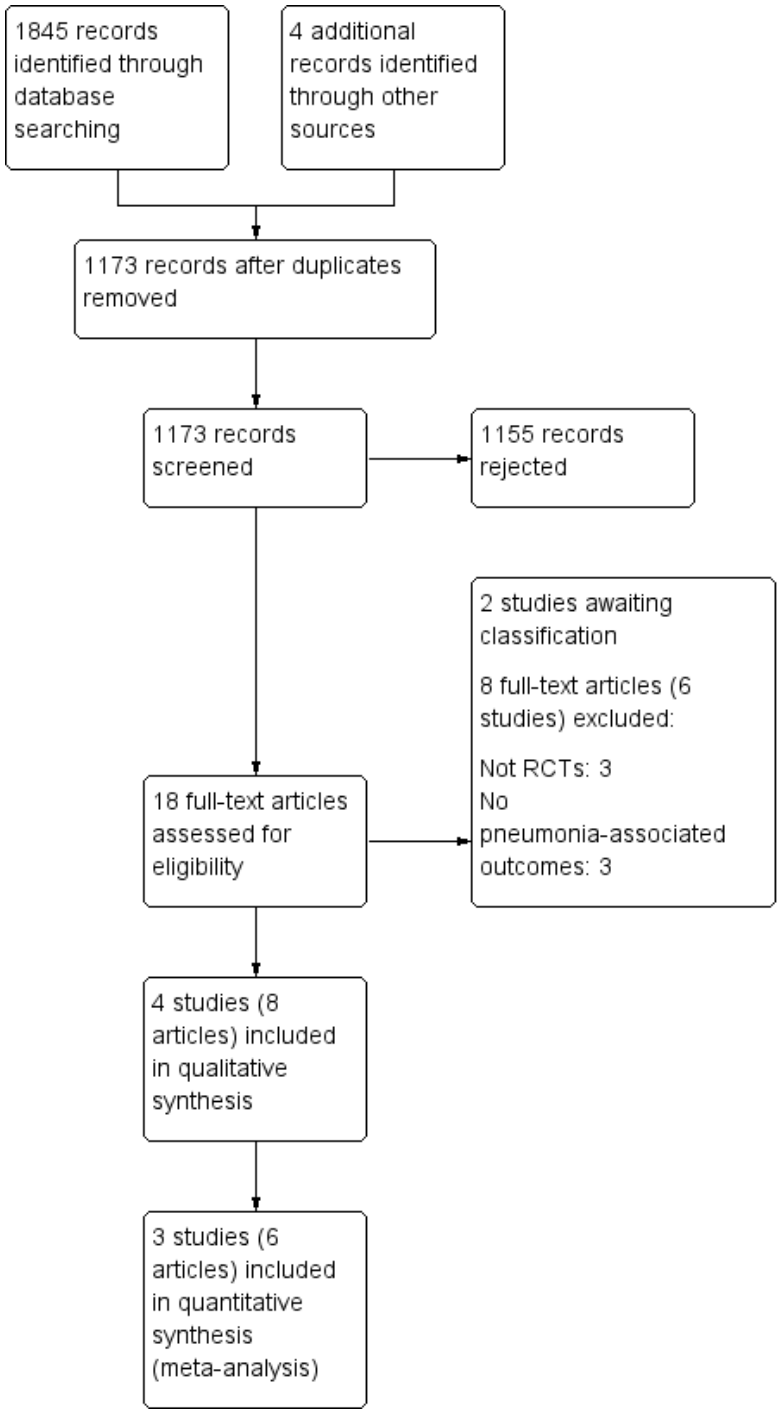
Figure 1. Study flow diagram



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Included studies

This review includes four randomised controlled trials (RCT), which were published between 2002 and 2015 (Adachi 2002; Bourigault 2011; Juthani-Mehta 2015; Yoneyama 2002). The details of the included studies are listed in the 'Characteristics of included studies' tables.

Trial designs and settings

All included studies used a two-arm parallel group design. Two studies randomised individual participants, and two studies randomised care homes, in a cluster-randomised design (Bourigault 2011; Juthani-Mehta 2015). The setting for all included studies was a care home.

The duration of follow-up of participants was 24 months in Adachi 2002 and Yoneyama 2002, and 18 months in Bourigault 2011. The duration of follow-up of participants was intended to be 30 months in the remaining trial, but the follow-up duration varied among participants, with a mean follow-up of 1.13 years, when the trial was terminated at the interim analysis for lack of clear effect (Juthani-Mehta 2015).

Two studies were conducted in Japan (Adachi 2002; Yoneyama 2002), one in France (Bourigault 2011), and one in the United States (Juthani-Mehta 2015).

Only one study reported sample size calculation (Juthani-Mehta 2015).

All four studies reported that they received non-industrial funding.

Participants

This review involved 3905 randomised participants. A total of 259 participants were lost during follow-up, leaving data from 3646 participants for analysis. Age and sex distribution of randomised participants was not described in Bourigault 2011 or Yoneyama 2002. In the remaining two studies, the mean age was 86.0, and the proportion of males was 24.1%. The inclusion criteria for participants in the included studies generally specified long-term care elderly residents of nursing homes, with no clinical pneumonia at baseline. In Adachi 2002, several patients had febrile days at the beginning of the trial, which did not exclude pneumonia, but suggested susceptibility to pneumonia.

Interventions

We classified the identified interventions into two broad groups.

- Professional oral care: oral health care with instruction or assistance of dental practitioners (dentists, dental hygienists, dental nurses), or caregivers with professional oral health-related knowledge, with interventions that consisted of more than basic oral care (brushing teeth and denture everyday), with or without oral disinfectants or mouth rinses
    - Brushing teeth
    - Brushing or swabbing buccal mucosa and tongue
    - Cleaning denture(s)
    - Mouthrinse
    - Dental visit
- Usual oral care: basic oral health care (brushing teeth and denture) without instruction or assistance of dental practitioners (dentists, dental hygienists, dental nurses), or caregivers with professional oral health-related knowledge, with or without the use of oral disinfectants or mouthrinse
    - Brushing teeth (varying frequency)
    - May also include swabbing buccal mucosa and tongue
    - May also include cleaning denture(s)

We evaluated the comparison between professional oral care and usual oral care, which was further divided into two subgroups according to the duration of follow-up:

- 18-month follow-up (Bourigault 2011);
- 24-month follow-up (Adachi 2002; Yoneyama 2002).

In Juthani-Mehta 2015, the participants were followed up for a maximum of 2.5 years, but the follow-up duration was variable, with a mean follow-up of 1.13 years at termination of the trial. As such, we avoided including the number of events in any pooled calculation.

No studies were identified comparing oral care versus no oral care.

Measures of primary outcomes

Incidence rate of nursing home-acquired pneumonia (NHAP)

Incidence rate was defined as the number of new cases of pneumonia over the summed person-years/days of observation during the trial follow-up. The incidence rate of NHAP was reported in two studies (Bourigault 2011; Juthani-Mehta 2015).

Incidence proportion (cumulative incidence) of NHAP

We defined the incidence proportion as the proportion of the initially disease-free population that developed pneumonia during the trial follow-up. Incidence of NHAP was reported in three studies (Bourigault 2011; Juthani-Mehta 2015; Yoneyama 2002).

Mortality (pneumonia-associated)

Three studies reported pneumonia-associated mortality during follow-up (Adachi 2002; Bourigault 2011; Yoneyama 2002). This outcome was reported as death due to aspiration pneumonia in

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Adachi 2002, pneumopathy in Bourigault 2011, and pneumonia in Yoneyama 2002.

Mortality (all-cause)

Two studies reported the outcomes of all-cause death during follow-up (Adachi 2002; Juthani-Mehta 2015). Adachi 2002 reported both the number and the reasons of death; the reasons of death were not reported in Juthani-Mehta 2015. 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 this outcome.

Adverse reactions to the interventions

Adverse events were reported in only one study (Juthani-Mehta 2015). The adverse events reported in Juthani-Mehta 2015 were mostly oral cavity disturbances and dental staining, but the authors did not define oral cavity disturbances.

Incidence proportion 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). In Adachi 2002, monthly proportions of participants with fever, and the average prevalence of participants with fever were described, but we could not extract the data for how many participants had suffered from febrile days during 24-month follow-up. In Yoneyama 2002, participants who had febrile days for more than seven cumulative days during two years were assumed to be participants with fever. Both studies considered a temperature 37.8°C or more as a feverish condition.

Change in data on economics and quality of life

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

Oral health indices

Yoneyama 2002 reported the change of debris index (DI). No other oral health indices were mentioned.

Studies awaiting classification

Two studies await classification (NCT00841074; Ohsawa 2003). See Characteristics of studies awaiting classification.

Excluded studies

We excluded six studies, reported in eight publications, for the reasons summarised below. See the 'Characteristics of excluded studies' table for details.

- Not an RCT: Bassim 2008 was a retrospective cohort study, Hollaar 2017 used a non-randomised controlled design, and Morino 2010 was a quasi-RCT.
- Did not assess pneumonia incidence or mortality: Izumi 2016; Quagliarello 2009; Watando 2004.

Risk of bias in included studies

See Figure 2; Figure 3.

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

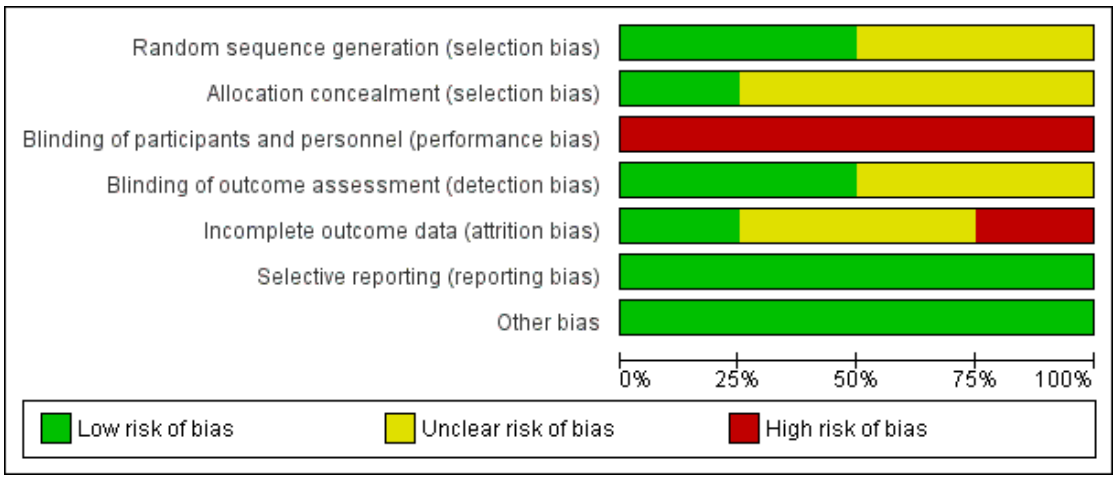

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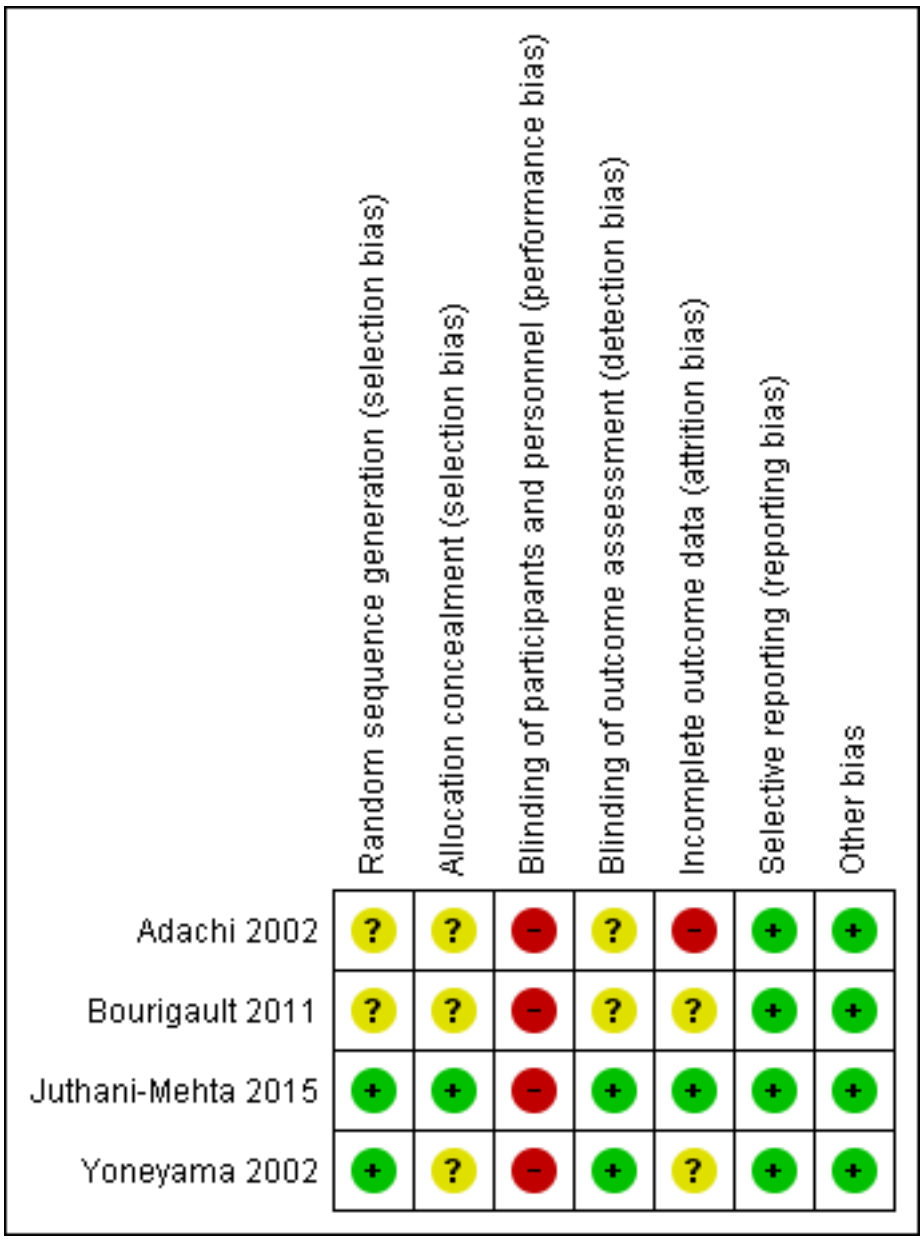
Figure 3. Risk of bias summary: review authors' judgements about each risk of bias item for each included study



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Allocation

Sequence generation

Juthani-Mehta 2015 adopted a permuted block randomisation and Yoneyama 2002 used a random number table to achieve random sequence generation, which we considered as low risk of bias. The remaining two studies stated that allocation was random but provided no further details, and were therefore assessed at unclear risk of bias for this domain.

Allocation concealment

In three studies, allocation concealment was not described in sufficient detail to determine risk of bias, and we rated these studies at unclear risk of bias. We assessed Juthani-Mehta 2015 at low risk of bias, because randomisation status of the home was revealed after enrolment in the trial.

Blinding

In all four studies, blinding of the participants and their caregivers to the allocated treatment was not possible because the active and control treatments differed significantly. We assessed them at high risk of performance bias.

Blinding of outcome assessment was possible in all of the included studies, and was described in two studies, which we assessed as being at low risk of detection bias (Juthani-Mehta 2015; Yoneyama 2002). In the other two studies, there was insufficient information provided, and we judged the risk of detection bias to be unclear.

Incomplete outcome data

Juthani-Mehta 2015 applied intention-to-treat analysis, so we judged it to be at low risk of attrition bias. We judged two other studies as unclear risk of bias: Yoneyama 2002 excluded 12.2% of participants due to fatal causes other than pneumonia from the analysis; in Bourigault 2011, there was insufficient information available to determine the risk of attrition bias. Adachi 2002 included only some of the participants who had pneumonia-related outcomes, and we judged it at high risk of attrition bias.

Selective reporting

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

Other potential sources of bias

We assessed all four included studies at low risk of other bias.

Overall risk of bias

All four included studies were at high risk of bias overall.

Effects of interventions

See: **Summary of findings for the main comparison** Professional oral care versus usual oral care; **Summary of findings 2** Oral care versus no oral care

The four included studies evaluated professional versus usual oral care (see Summary of findings for the main comparison).

Professional oral care versus usual oral care

Incidence rate of nursing home-acquired pneumonia (NHAP)

Two studies reported the incidence of NHAP (Bourigault 2011; Juthani-Mehta 2015). As Juthani-Mehta 2015 was stopped early, we considered it inappropriate to pool the data from this trial.

In the Bourigault 2011 trial, they presented a crude incidence rate of the first pneumonia episode of 3.3 (95% confidence interval (CI) 2.7 to 4.1) per 10,000 days in the experimental group and 5.1 (95% CI 4.5 to 5.9) in the control group. There was no evidence of a clear difference between professional oral care and usual oral care on the incidence of NHAP at 18 months (hazard ratio (HR) 0.65, 95% CI 0.29 to 1.46; one study, 2513 participants analysed; low-quality evidence; Analysis 1.1). In Juthani-Mehta 2015, the authors reported a HR of 1.12 (95% CI 0.84 to 1.50; 834 participants analysed) at the time that the study was stopped. Results in both studies were compatible with an increase or a decrease or no difference in the outcome as a result of professional oral care.

Incidence proportion (cumulative incidence) of NHAP

Three studies reported the incidence proportion of NHAP (Bourigault 2011; Juthani-Mehta 2015; Yoneyama 2002) (Analysis 1.2). In Bourigault 2011, the authors reported the probability of a first episode of pneumonia occurring at 18 months from the time-to-event analysis, which was lower in the professional care group (15.2%, 95% CI 12.5 to 18.3) compared to the usual care group (22.6%, 95% CI 19.7 to 25.8). Results were reported as percentages only, the number of events and numbers of participants on which this analysis was based were not reported. The authors reported the number of participants experiencing at least one episode of pneumonia (93 people in the experimental group and 203 people in the control group). Using this information, we were able to calculate the RR for the cumulative incidence using the number of participants at risk at the start of the follow-up period (RR 0.87, 95% CI 0.69 to 1.09; 2513 participants). However, it is unlikely that all participants will have been observed for the entire period of follow-up due to loss to follow-up and competing risk of death (some participants may have died prior

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to the end of follow-up making it impossible to know whether they would have developed pneumonia if they had not died early because of another risk).

Similarly, the cumulative incidence of a first pneumonia was reported in Juthani-Mehta 2015 (119 first episodes in 434 participants randomised in the intervention arm and 94 first episodes in 400 participants in the control arm). However, as the trial was stopped for futility, there was wide variation in the duration of follow-up for the participants and so the use of the number of randomised participants as a denominator may not be appropriate. Furthermore, the time period to which the incidence proportion relates is unclear. One study followed participants for 24 months and reported fewer participants with pneumonia in the professional oral care group (21 from 184) than the usual oral care group (34 from 182) (low-quality evidence; RR 0.61, 95% CI 0.37 to 1.01; 366 participants) (Yoneyama 2002). The use of the number of randomised participants as a denominator may not be appropriate.

Overall, no evidence of an effect was observed for the incidence proportion of NHAP, with data suggesting either an increase or decrease in the outcome is possible as a result of professional oral care.

Mortality (pneumonia-associated)

Three studies reported on pneumonia-associated death (Adachi 2002; Bourigault 2011; Yoneyama 2002). There was no clear evidence of a difference between the groups who received professional oral care or usual oral care at 18-month follow-up (RR 1.09, 95% CI 0.58 to 2.05; one study, 2513 participants; Analysis 1.3). At 24-month follow-up, there was evidence that professional oral care may reduce pneumonia-associated mortality more than usual oral care (RR 0.41, 95% CI 0.24 to 0.72; two studies, 507 participants; Analysis 1.3; low-quality evidence).

Mortality (all-cause)

Two studies reported on all-cause mortality (Adachi 2002; Juthani-Mehta 2015). Very low-quality evidence indicated there was no clear difference in all-cause mortality between the groups who received professional oral care or usual oral care (RR 0.55, 95% CI 0.27 to 1.15; one study, 141 participants; Analysis 1.4). We considered it inappropriate to pool the data from Juthani-Mehta 2015, but the authors reported an HR of 1.16, 95% CI 0.88 to 1.53 at the time that the study was stopped.

Change in systemic antibiotic use

None of the studies measured this outcome.

Adverse reactions to the interventions

Juthani-Mehta 2015 stated that "there were no protocol-related serious adverse events, and there were 64 protocol-related non-serious adverse events, all of which were anticipated. The most common protocol-related non-serious adverse events were oral cavity disturbances and dental staining". The oral cavity disturbances included anything that could have been related to the oral care intervention, e.g. gum bleeding or mouth sores.

Incidence or prevalence of fever

No study reported fever by time-to-event data. Two studies reported the prevalence of fever (Adachi 2002; Yoneyama 2002). Adachi 2002 stated that "the occurrence of fevers of 37.8°C or more in the POHC group was found to be significantly lower than that in the non-POHC group ($P < 0.05$)". They 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. One study suggested that the risk of participants having fever was 51% lower in the professional oral care group (RR 0.49, 95% CI 0.33 to 0.75; 366 participants; Analysis 1.5).

Change in data on economics and quality of life

None of the studies measured the economics of oral care.

Only one study measured change in quality of life measures (Yoneyama 2002). The authors evaluated cognitive impairment with the Mini-Mental State Examination (MMSE), and activities of daily living (ADLs) with the modified Barthel Index. MMSE scores tend to reduce with age, but at the end of the 24-month follow-up, they noted that professional oral care mitigated this reduction in comparison to usual oral care (intervention group: 1.5 $\pm$ 4.9, 170 participants; control group: 3.0 $\pm$ 5.9, 152 participants; $P = 0.032$).

Oral health indices

Yoneyama 2002 reported a change in debris index. They found a debris index of 2.6 $\pm$ 0.8 in the professional care group (109 participants), and of 2.5 $\pm$ 0.8 in the usual care group (90 participants). Yoneyama 2002 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).

Oral care versus no oral care

No studies evaluated this comparison (see Summary of findings 2).

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ADDITIONAL SUMMARY OF FINDINGS *[Explanation]*

Oral care versus no oral care					
Population: elderly people **Setting:** nursing homes **Intervention:** oral care **Comparison:** no oral care					
Outcomes	**Illustrative comparative risks (95% CI)**	**Relative effect (95% CI)**	**Number of Participants (studies)**	**Quality of the evidence (GRADE)**	**Comments**
Incidence rate of NHAP	No studies				
Incidence proportion of NHAP	No studies				
Mortality (pneumonia-associated)	No studies				
Mortality (all-cause)	No studies				
Adverse effects of interventions	No studies				
NHAP: nursing home-acquired pneumonia					

DISCUSSION

Summary of main results

The aim of this review was to assess the effects of oral care measures for preventing nursing-home acquired pneumonia (NHAP) in residents of nursing homes. We identified four eligible RCTs for the review. The studies focused on the comparison between professional oral care and usual oral care.

- It was not possible 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-quality evidence).
- It was not possible to establish whether or not professional oral care can lower the number of first episodes of pneumonia compared with usual care over a 24-month period (low-quality evidence).
- Professional oral care may reduce pneumonia-associated death by 60% in comparison with usual oral care at 24-month follow-up (low-quality evidence).
- We could not draw any conclusions about the effect of professional oral care compared to usual care on all-cause mortality (very-low quality evidence).
- Adverse effects were measured in only one study, which was stopped early. This study 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 quality of the evidence, we should treat the results cautiously.

Overall completeness and applicability of evidence

Studies included in the review recruited participants residing in nursing homes. Some participants were dentate; some were edentulous. Some participants were able to care for themselves; others were not, possibly suffering from a variety of diseases. We considered that the results might be applicable to residents with different health conditions in nursing homes; however, no relevant data about the prevalence of systemic diseases were provided in the included studies. Two of studies included in the review were conducted in Japan (Adachi 2002; Yoneyama 2002), one in the USA (Juthani-Mehta 2015), and one in France (Bourigault 2011).

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 was not possible to blind participants and caregivers to the oral care measures, which might have led to a Hawthorne effect, and influenced the results (Sedgwick 2015).

All of our primary outcomes and most of our secondary outcomes were assessed in the review. Caregivers in nursing homes should understand that we only assessed the effect of oral care measures on new incidences of NHAP. Thus, the review does not provide evidence of whether oral care measures would affect the incidence or frequency of recurrent pneumonia. We noted that systemic diseases might be confounding factors that could influence the death of participants. Only Adachi 2002 reported all causes of death, and no studies made an attempt to analyse potential effects of these confounding factors. The studies also investigated the relationship between oral care measures and the administration of antibiotics. We were unable to acquire information about whether oral care measures could reduce expenses in nursing homes.

In conclusion, evidence provided by this review might be applicable for a variety of residents in nursing homes, but it is essential to adequately consider the limitation and bias of studies included in the review, and to interpret the data with care.

Quality of the evidence

We assess all the included studies at high risk of bias due to the lack of blinding of participants; one study was also at high risk of bias owing to incomplete outcome data (Figure 2). Due to the high risk of bias in the studies, the quality of evidence was downgraded one level for incidence rate and cumulative incidence of NHAP, and two levels for mortality (pneumonia-associated and all-cause).

In most analyses, there was only one study that measured the outcome or the subgroup. One subgroup consisted of two studies with no heterogeneity (Analysis 1.3; 24-month follow-up; two studies; $I^2 = 0\%$). Hence none of the evidence was downgraded for inconsistency.

The number of events was mostly insufficient, reflected in the wide confidence intervals. So the evidence was downgraded for imprecision for incidence rate, cumulative incidence, and all cause mortality.

None of the evidence was downgraded for indirectness.

Due to the limited number of included studies, we did not generate a funnel plot to examine the publication bias across studies, thus none of the evidence was downgraded for this.

Therefore, we downgraded the quality of evidence to low on incidence rate, cumulative incidence of NHAP, and pneumonia-associated mortality, and to very low on all-cause mortality (Summary of findings for the main comparison). We emphasise that it is necessary to treat the evidence with caution, due to the small number of included studies.

Potential biases in the review process

In order 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 in order to obtain information that was not included in the published reports. We also searched the reference lists of other published

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reviews concerning oral care for nursing home residents. However, we still failed to acquire the data from a potentially relevant study, entitled 'Chlorhexidine & Pneumonia in Nursing Home Residents', registered in clinicaltrials.gov (NCT00841074). We did not include Ohsawa 2003 because we were unable to clarify whether the data were part of the study described in Yoneyama 2002.

For this review, we also chose very broad inclusion criteria, which resulted in a clinically heterogeneous group of studies including elderly people who were either dentulous or edentulous, with or without cognitive impairment, and possibly with a variety of systemic diseases. The trial method was described poorly in some studies, which made it difficult to assess the similarity between studies. There might have been potential variation in the diagnoses and assessment of outcomes. Another potential bias in this review was that there is no gold standard used to diagnose NHAP.

In data analysis, we assessed whether the follow-up duration of oral care measures influenced the results in a subgroup analysis. We noticed that oral care measures were provided by different caregivers, or participants themselves. Discrepancy in the performance of operators might influence results, but due to the limited studies and incomplete information, we did not attempt further analysis. The results from Juthani-Mehta 2015 were in contradiction to the results of the other included studies. We excluded it from meta-analysis due to the variable duration of follow-up among participants. Hence, we did not downgrade the relevant evidence due to inconsistency. Moreover, there are conflicting opinions as to whether trials stopped early should be included in a meta-analysis.

Agreements and disagreements with other studies or reviews

Other reviews of the effects of oral care measures on NHAP have been published (El-Rabbany 2015; Kaneoka 2015; Sjögren 2016). These three systematic reviews included participants in hospitals as well as nursing homes. El-Rabbany 2015 concluded 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. Sjgren 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. This Cochrane review found that professional oral care may reduce mortality due to pneumonia when compared to usual care at 24 months; however, our confidence in this effect estimate was limited. In terms of the incidence rate or proportion of NHAP, the limited body of evidence indicated that professional oral care may have little or no difference in these outcomes at 24 months. However, our confidence in these effects is limited.

AUTHORS' CONCLUSIONS

Implications for practice

Low-quality evidence suggested that professional oral care may reduce mortality due to pneumonia compared to usual care, when measured at 24 months. Low-quality evidence was inconclusive about the effects of professional care compared to usual oral care on incidence of nursing-home acquired pneumonia, number of first episodes of nursing-home acquired pneumonia, and mortality from any cause. The only study to measure adverse effects reported that there were no serious adverse effects. We found no high-quality evidence to determine which oral care measures are most effective for reducing nursing home-acquired pneumonia. Further trials are needed to draw reliable conclusions.

Implications for research

Considering the limited number of trials in this field, there is a need for more trials focusing on the effect of oral care measures on nursing home-acquired pneumonia (NHAP) prevention. We hope future studies can address the following issues.

- Participants: studies with a large number of participants in nursing homes are expected. Sample size calculation and baseline comparability should be taken into consideration.

- Intervention: more oral care measures are needed in future RCTs, for instance, electronic toothbrush, dental floss, interdental brush, and different mouthrinses. More practical and flexible oral care protocols aimed at residents with different conditions could be used; for example, how can we ensure elderly people with dementia can accept the same oral care measures as mentally healthy residents? Measures for preventing aspiration should be considered as well.

- Comparisons: so far, all trials in this field focused on the comparison between professional oral care and usual oral care; future trials should consider comparisons of different oral care measures.

- Outcomes: we recommend that incidence with fixed follow-up duration, as time-to-event data, be measured. 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, such as chronic obstructive pulmonary diseases, cardiovascular diseases, diabetes, and age. In addition, we hope future studies will pay more attention to systemic antibiotic use, economics, quality of life, and oral health indices.

- Risk of bias: future studies should find ways to reduce the risk of bias. Although blinding of participants and personnel may not be easy, blinding of outcome assessment should be achieved.

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- Method of analyses: if there is uncertainty as to whether all participants can reasonably be followed for the entire follow-up period, then a time-to-event approach would be the most appropriate method of analysis. Analysing cumulative incidence as though all participants are observed for the entire follow-up period can lead to erroneous inferences.

ACKNOWLEDGEMENTS

The review authors would like to thank Anne Littlewood, Information Specialist, Cochrane Oral Health, for developing the search strategy and providing assistance in literature searching. We would also like to thank Laura MacDonald, Managing Editor of Cochrane Oral Health, for help and suggestions on this review. We thank Professor Anne-Marie Glenny, Trevor Johnson, and Susan Furness from Cochrane Oral Health, copy editor Victoria Pennick, and our external referees Dr Deborah Wright and Dr Wei Shen Lim for their comments on drafts of the review. We also thank Dr Huixu Xie, Dr Ping Wang, Professor E Chen, Dr Mervyn Singer, Dr Qi Zhang, and Professor Zongdao Shi for special contributions on the design and advice for the protocol of this review.

REFERENCES

References to studies included in this review

Adachi 2002 ***{published data only}***

Adachi M, Ishihara K, Abe S, Okuda K. Professional oral health care by dental hygienists reduced respiratory infections in elderly persons requiring nursing care. *International Journal of Dental Hygiene* 2007;**5**(2):69–74. DOI: 10.1111/j.1601-5037.2007.00233.x

* Adachi M, Ishihara K, Abe S, Okuda K, Ishikawa T. Effect of professional oral health care on the elderly living in nursing homes. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics* 2002;**94**:191–5. DOI: 10.1067/moe.2002.123493

Bourigault 2011 ***{published data only}***

Bourigault C, Lietard C, Golmard JL, Maman L, Nabet C, Carrat F, et al. Impact of bucco-dental healthcare on the prevention of pneumonia in geriatrics: a cluster-randomised trial. *Journal of Hospital Infection* 2011;**77**(1):78–80. DOI: 10.1016/j.jhin.2010.08.013

Juthani-Mehta 2015 ***{published data only}***

* Juthani-Mehta M, Van Ness PH, McGloin J, Argraves S, Chen S, Charpentier P, et al. A cluster-randomized controlled trial of a multicomponent intervention protocol for pneumonia prevention among nursing home elders. *Clinical Infectious Diseases* 2015;**60**(6):849–57. DOI: 10.1093/cid/ciu935

NCT00975780. A Randomized Controlled Trial to Reduce Pneumonia in Nursing Home Residents. clinicaltrials.gov/ct2/show/NCT00975780 (first received 10 September 2009).

Van Ness PH, Peduzzi PN, Quagliarello VJ. Efficacy and effectiveness as aspects of cluster randomized trials with nursing home residents: methodological insights from a pneumonia prevention trial. *Contemporary Clinical Trials* 2012;**33**(6):1124–31. DOI: 10.1016/j.cct.2012.08.004

Yoneyama 2002 ***{published data only}***

Yoneyama T. Oral care reduces pneumonia in older patients. *Geriatrics and Gerontology International* 2004;**4**:S165–6. DOI: 10.1111/j.1447-0594.2004.00188.x

* Yoneyama T, Yoshida M, Ohrui T, Mukaiyama H, Okamoto H, Hoshiba K, et al. Oral care reduces pneumonia in older patients in nursing homes. *Journal of the American Geriatrics Society* 2002;**50**(3):430–3. DOI: 10.1046/j.1532-5415.2002.50106.x

Yoshida M, Yoneyama T, Akagawa Y. Oral care reduces pneumonia of elderly patients in nursing homes, irrespective of dentate or edentate status. *Nihon Ronen Igakkai Zasshi* 2001;**38**(4):481–3. PUBMED: 11523155]

References to studies excluded from this review

Bassim 2008 ***{published data only}***

Bassim CW, Gibson G, Ward T, Paphides BM, DeNucci DJ. Modification of the risk of mortality from pneumonia with oral hygiene care. *Journal of the American Geriatrics Society* 2008;**56**(9):1601–7. PUBMED: 18691286]

Hollaar 2017 ***{published data only}***

Hollaar V, Van der Maarel-Wierink C, Van der Putten GJ, De Swart B, De Baat C. Effect of daily application of a 0.05% chlorhexidine solution on the incidence of (aspiration) pneumonia in care home residents: design of a multicentre cluster randomised controlled clinical trial. *BMJ* 2015;**5**(12):e007889. DOI: 10.1136/bmjopen-2015-007889

* Hollaar VRY, Van der Putten GJ, Van der Maarel-Wierink CD, Bronkhorst EM, De Swart BJM, Creugers NHJ. The effect of a daily application of a 0.05% chlorhexidine oral rinse solution on the incidence of aspiration pneumonia in nursing home residents: a multicenter study. *BMC Geriatrics* 2017;**17**(1):128. DOI: 10.1186/s12877-017-0519-z

Izumi 2016 ***{published data only}***

Izumi M, Takeuchi K, Ganaha S, Akifusa S, Yamashita Y. Effects of oral care with tongue cleaning on coughing ability in geriatric care facilities: a randomized controlled trial. *Journal of Oral Rehabilitation* 2016;**43**(12):953–9. DOI: 10.1111/joor.12451

Morino 2010 ***{published data only}***

JPRN-UMIN000003212. Effect of professional oral health care for toothed elderly people who need nursing

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care. apps.who.int/trialsearch/Trial2.aspx?TrialID=JPRN-UMIN000003212 (first received 22 February 2010).
* Morino T, Haruta N, Ookawa K, Hagiwara Y, Seki M. Effect of professional oral health care on elderly: randomized trial. *International Journal of Dental Hygiene* 2010;**12**:291–7. DOI: 10.1111/idh.12068

Quagliarello 2009 ***{published data only}***
Quagliarello V, Juthani-Mehta M, Ginter S, Towle V, Allore H, Tinetti M. Pilot testing of intervention protocols to prevent pneumonia in nursing home residents. *Journal of the American Geriatrics Society* 2009;**57**(7):1226–31. DOI: 10.1111/j.1532-5415.2009.02311.x.

Watando 2004 ***{published data only}***
Watando A, Ebihara S, Ebihara T, Okazaki T, Takahashi H, Asada M, et al. Daily oral care and cough reflex sensitivity in elderly nursing home patients. *Chest* 2002;**126**(4): 1066–70. DOI: 10.1378/chest.126.4.1066

References to studies awaiting assessment

NCT00841074 ***{published data only}***
NCT00841074. Effect of topical oral chlorhexidine in reducing pneumonia in nursing home residents. clinicaltrials.gov/show/NCT00841074 (first received 9 February 2009).

Ohsawa 2003 ***{published data only}***
Ohsawa T, Yoneyama T, Hashimoto K, Kubota E, Ito M, Yoshida K. Effects of professional oral health care on the ADL of elderly patients in a nursing home. *Bulletin of Kanagawa Dental College* 2003;**31**:51–4.

Additional references

Abe 2008
Abe S, Ishihara K, Adachi M, Okuda K. Tongue-coating as risk indicator for aspiration pneumonia in edentate elderly. *Archives of Gerontology and Geriatrics* 2008;**47**(2):267–75.

American Thoracic Society 2005
American Thoracic Society, Infectious Diseases Society of America. Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia. *American Journal of Respiratory and Critical Care Medicine* 2005;**171**(4):388–416.

Atkins 2004
Atkins D, Best D, Briss PA, Eccles M, Falck-Ytter Y, Flottorp S, et al. Grading quality of evidence and strength of recommendations. *BMJ* 2004;**328**(7454):1490–4.

Azarpazhooh 2006
Azarpazhooh A, Leake JL. Systematic review of the association between respiratory diseases and oral health. *Journal of Periodontology* 2006;**77**(9):1465–82.

Begg 1994
Begg CB, Mazumdar M. Operating characteristics of a rank correlation test for publication bias. *Biometrics* 1994;**50**(4): 1088–101.

Berg 2000
Berg R, Berkey DB, Tang JM, Baine C, Altman DS. Oral health status of older adults in Arizona: results from the Arizona Elder Study. *Special Care in Dentistry* 2000;**20**(6): 226–33.

Brito 2009
Brito V, Niederman MS. Healthcare-associated pneumonia is a heterogeneous disease, and all patients do not need the same broad-spectrum antibiotic therapy as complex nosocomial pneumonia. *Current Opinion in Infectious Diseases* 2009;**22**(3):316–25.

Charteris 2001
Charteris P, Kinsella T. The oral care link nurse: a facilitator and educator for maintaining oral health for patients at the Royal Hospital for Neuro-disability. *Special Care Dentistry* 2001;**21**(2):68–71.

Chiba 2009
Chiba Y, Shimoyama K, Suzuki Y. Recognition and behaviour of caregiver managers related to oral care in the community. *Gerodontology* 2009;**26**(2):112–21.

Cho 2011
Cho YJ, Jung BK, Ahn JS. A comparative study of nursing home-acquired pneumonia with community-acquired pneumonia. *Tuberculosis and Respiratory Diseases* 2011;**70**: 224–34.

Craven 1992
Craven DE, Steger KA, Barat LM, Duncan RA. Nosocomial pneumonia: epidemiology and infection control. *Intensive Care Medicine* 1992;**18**(Suppl 1):S3–9.

Craven 2006
Craven DE. What is healthcare-associated pneumonia, and how should it be treated?. *Current Opinion in Infectious Diseases* 2006;**19**(2):153–60.

Deeks 2011
Deeks JJ, Higgins JPT, Altman DG. Chapter 9: Analysing data and undertaking meta-analyses. 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.

DeRiso 1996
DeRiso AJ, Ladowski JS, Dillon TA, Justice JW, Peterson AC. Chlorhexidine gluconate 0.12% oral rinse reduces the incidence of total nosocomial respiratory infection and nonprophylactic systemic antibiotic use in patients undergoing heart surgery. *Chest* 1996;**109**(6):1556–61.

Dudas 2000
Dudas V, Hopefl A, Jacobs R, Guglielmo BJ. Antimicrobial selection for hospitalized patients with presumed community-acquired pneumonia: a survey of nonteaching US community hospitals. *Annals of Pharmacotherapy* 2000; **34**(4):446–52.

Egger 1997
Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ* 1997;**315**(7109):629–34.

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Ekstrand 2013
Ekstrand KR, Poulsen JE, Hede B, Twetman S, Qvist V, Ellwood RP. A randomized clinical trial of the anti-caries efficacy of 5,000 compared to 1,450 ppm fluoridated toothpaste on root caries lesions in elderly disabled nursing home residents. *Caries Research* 2013;**47**(5):391–8.

El-Rabbany 2015
El-Rabbany M, Zaghlol N, Bhandari M, Azarpazhooh A. Prophylactic oral health procedures to prevent hospital-acquired and ventilator-associated pneumonia: a systematic review. *International Journal of Nursing Studies* 2015;**52**(1): 452–64.

El-Solh 2010
El-Solh AA, Niederman MS, Drinka P. Nursing home-acquired pneumonia: a review of risk factors and therapeutic approaches. *Current Medical Research and Opinion* 2010;**26** (12):2707–14.

Ewig 2010
Ewig S, Welte T, Chastre J, Torres A. Rethinking the concepts of community-acquired and health-care-associated pneumonia. *Lancet Infectious Diseases* 2010;**10**(4):279–87.

Frenkel 2000
Frenkel H, Harvey I, Newcombe RG. Oral health care among nursing home residents in Avon. *Gerodontology* 2000;**17**(1):33–8.

Frenkel 2001
Frenkel H, Harvey I, Newcombe RC. Improving oral health in institutionalized elderly people by educating caregivers: a randomized controlled trial. *Community Dentistry and Oral Epidemiology* 2001;**29**(4):289–97.

Frenkel 2002
Frenkel H, Harvey I, Needs K. Oral health care education and its effect on caregivers' knowledge and attitudes: a randomized controlled trial. *Community Dentistry and Oral Epidemiology* 2002;**30**(2):91–100.

Gaszynska 2014
Gaszynska E, Szatko F, Godala M, Gaszynski T. Oral health status, dental treatment needs, and barriers to dental care of elderly care home residents in Lodz, Poland. *Clinical Interventions in Aging* 2014;**9**:1637–44.

Gibbons 1989
Gibbons RJ. Bacterial adhesion to oral tissues: a model for infectious disease. *Journal of Dental Research* 1989;**68**(5): 750–60.

Gluhak 2010
Gluhak C, Arnetzl GV, Kirmeier R, Jakse N, Arnetzl G. Oral status among seniors in nine nursing homes in Styria, Austria. *Gerodontology* 2010;**27**(1):47–52.

GRADEpro GDT [Computer program]
McMaster University (developed by Evidence Prime). GRADEpro GDT. Version accessed 1 May 2018. Hamilton (ON): McMaster University (developed by Evidence Prime), 2015.

Guyatt 2008
Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ* 2008;**336**(7650):924–6.

Higgins 2011a
Higgins JPT, Altman DG, Sterne JAC. Chapter 8: Assessing risk of bias in included studies. 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.

Higgins 2011b
Higgins JPT, Deeks JJ, Altman DG. Chapter 16: Special topics in statistics. 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.

Jablonski 2005
Jablonski RA, Munro CL, Grap MJ, Elswick RK. The role of biobehavioral, environmental, and social forces on oral health disparities in frail and functionally dependent nursing home elders. *Biological Research For Nursing* 2005;**7** (1):75–82.

Janssens 2005
Janssens JP. Pneumonia in the elderly (geriatric) population. *Current Opinion in Pulmonary Medicine* 2005;**11**(3): 226–30.

Kaneoka 2015
Kaneoka A, Pisegna JM, Miloro KV, Lo M, Saito H, Riquelme LF, et al. Prevention of healthcare-associated pneumonia with oral care in individuals without mechanical ventilation: a systematic review and meta-analysis of randomized controlled trials. *Infection Control and Hospital Epidemiology* 2015;**36**(8):899–906.

Klapdor 2012
Klapdor B, Ewig S, Schaberg T, Rohde G, Pletz MW, Schütte H, et al. CAPNETZ Study Group. Presentation, etiology and outcome of pneumonia in younger nursing home residents. *Journal of Infection* 2012;**65**(1):32–8.

Lefebvre 2011
Lefebvre C, Manheimer E, Glanville J. Chapter 6: Searching for studies. 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.

Leibovitz 2003
Leibovitz A, Plotnikov G, Habot B, Rosenberg M, Segal R. Pathogenic colonization of oral flora in frail elderly patients fed by nasogastric tube or percutaneous enterogastric tube. *Journals of Gerontology Series A: Biological Sciences and Medical Sciences* 2003;**58**(1):52–5.

Liapikou 2014
Liapikou A, Polverino E, Cilloniz C, Peyrani P, Ramirez J, Menendez R, et al. Community-Acquired Pneumonia Organization (CAPO) Investigators. A worldwide perspective of nursing home-acquired pneumonia compared

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with community-acquired pneumonia. *Respiratory Care* 2014;**59**(7):1078–85.

Lim 2009
Lim WS, Baudouin SV, George RC, Hill AT, Jamieson C, Le Jeune I, et al. BTS guidelines for the management of community acquired pneumonia in adults: update 2009. *Thorax* 2009;**64**(Suppl 3):iii1–55.

Marrie 2002
Marrie TJ. Pneumonia in the long-term-care facility. *Infection Control and Hospital Epidemiology* 2002;**23**(3): 159–64.

Martínez-Moragón 2004
Martínez-Moragón E, García Ferrer L, Serra Sanchis B, Fernández Fabrellas E, Gómez Belda A, Julve Pardo R. Community-acquired pneumonia among the elderly: differences between patients living at home and in nursing homes. *Archivos de Bronconeumologia* 2004;**40**(12):547–52.

Medina-Walpole 1999
Medina-Walpole AM, Katz PR. Nursing home-acquired pneumonia. *Journal of the American Geriatrics Society* 1999; **47**(8):1005–15.

Micek 2007
Micek ST, Kollef KE, Reichley RM, Roubinian N, Kollef MH. Health care-associated pneumonia and community-acquired pneumonia: a single-center experience. *Antimicrobial Agents and Chemotherapy* 2007;**51**(10): 3568–73.

Muder 1998
Muder RR. Pneumonia in residents of long-term care facilities: epidemiology, etiology, management, and prevention. *American Journal of Medicine* 1998;**105**(4): 319–30.

Munro 2004
Munro CL, Grap MJ. Oral health and care in the intensive care unit: state of the science. *American Journal of Critical Care* 2004;**13**(1):25–33.

Mylotte 1994
Mylotte JM, Ksiazek S, Bentley DW. Rational approach to the antibiotic treatment of pneumonia in the elderly. *Drugs & Aging* 1994;**4**(1):21–33.

Mylotte 2002
Mylotte JM. Nursing home-acquired pneumonia. *Clinical Infectious Diseases* 2002;**35**(10):1205–11.

Nakagawa 2014
Nakagawa N, Saito Y, Sasaki M, Tsuda Y, Mochizuki H, Takahashi H. Comparison of clinical profile in elderly patients with nursing and healthcare-associated pneumonia, and those with community-acquired pneumonia. *Geriatrics & Gerontology International* 2014;**14**(2):362–71.

NICE guideline 2016
National Institute for Health and Care Excellence (NICE). Oral Health for Adults in Care Homes. NICE guideline (NG48). www.nice.org.uk/guidance/indevelopment/gid-phg62 (accessed 23 September 2016). [nice.org.uk/guidance/ng48]

Nicolle 1996
Nicolle LE, Strausbaugh LJ, Garibaldi RA. Infections and antibiotic resistance in nursing homes. *Clinical Microbiology Reviews* 1996;**9**(1):1–17.

O'Donnell 2016
O'Donnell LE, Smith K, Williams C, Nile CJ, Lappin DF, Bradshaw D, et al. Dentures are a reservoir for respiratory pathogens. *Journal of Prosthodontics* 2016;**25**(2):99–104.

Palmer 2001
Palmer LB, Albulak K, Fields S, Filkin AM, Simon S, Smaldone GC. Oral clearance and pathogenic oropharyngeal colonization in the elderly. *American Journal of Respiratory and Critical Care Medicine* 2001;**164**(3):464–8.

Parmar 1998
Parmar MK, Torri V, Stewart L. Extracting summary statistics to perform meta-analysis of the published literature for survival endpoints. *Statistics in Medicine* 1998;**17**(24): 2815–34.

Persseon 1991
Persseon ER, Trulove L, Leresche L, Robinovitch MR. Therapeutic effects of daily or weekly chlorhexidine rinsing on oral health of a geriatric population. *Oral Surgery, Oral Medicine, and Oral Pathology* 1991;**72**(2):184–91 .

Petelin 2012
Petelin M, Cotič J, Perkič K, Pavlič A. Oral health of the elderly living in residential homes in Slovenia. *Gerodontology* 2012;**29**(2):e447–57.

Pyle 2005
Pyle MA, Jasinevicius TR, Sawyer DR, Madsen J. Nursing home executive directors' perception of oral care in long-term care facilities. *Special Care Dentistry* 2005;**25**(2): 111–7.

Ronald 2008
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.

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 JPT, 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.

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Sedgwick 2015
Sedgwick P, Greenwood N. Understanding the Hawthorne effect. *BMJ* 2015;**351**:h4672. DOI: 10.1136/bmj.h4672

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. 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.

Verghese 1983
Verghese A, Berk SL. Bacterial pneumonia in the elderly. *Medicine (Baltimore)* 1983;**62**(5):271–85.

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

Worthington 2015
Worthington H, Clarkson J, Weldon J. Priority oral health research identification for clinical decision-making. *Evidence-based Dentistry* 2015;**16**(3):69–71.

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.

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.

* *Indicates the major publication for the study*

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CHARACTERISTICS OF STUDIES

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

Adachi 2002

Methods	**Study design:** RCT, 2 parallel groups **Location:** Tokyo, Japan **Number of centres:** 2 **Study period:** not stated **Funding source:** Grant from Tokyo Dental College to the Oral Health Science Center
Participants	**Setting:** nursing homes **Inclusion criteria:** elderly in nursing homes, afflicted with a variety of medical problems, and under medication of some kind **Exclusion criteria:** not stated **Number randomised:** 141 (female/male: 104/37, mean age: 84; intervention group: 77; control group: 64); however, only 88 participants assigned at the beginning of the study had outcomes correlated to pneumonia **Number evaluated:** 88 (intervention group: 40; control group: 48)
Interventions	**Comparison: caregiver-provided professional oral care versus caregiver-provided usual oral care** Intervention group: brushing teeth, buccal mucosa and tongue (electric brush with an automatic water supply, an interdental brush, a sponge brush) + cleaning denture, by dental hygienists Control group: swabbing teeth, buccal mucosa, tongue (sponge brush) + cleaning denture Operators: dental hygienists, number not stated As for daily oral care, those 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 a day by the nursing home staff
Outcomes	1. Mortality (pneumonia-associated; 24 months of follow-up) 2. Mortality (all-cause; 24 months of follow-up) 3. Prevalence of fever (24 months of 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." Comment: unclear risk; method of sequence generation not described

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Adachi 2002 (*Continued*)

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." Comment: unclear risk; method of allocation concealment not described
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: high risk; blinding not possible
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Comment: unclear risk; unclear information about blinding of outcome assessors
Incomplete outcome data (attrition bias) All outcomes	High risk	Comment: high risk; no withdrawals, but authors did not report the pneumonia-related data from all included participants (88 in 141 participants had pneumonia-related outcome)
Selective reporting (reporting bias)	Low risk	Comment: low risk; expected outcomes reported, including fatal causes, except pneumonia
Other bias	Low risk	Comment: low risk; no other sources of bias identified

Bourigault 2011

Methods	**Study design:** cluster-RCT, 2 parallel groups **Location:** France **Number of centres:** 18 **Study period:** from June 2005 to December 2006 **Funding source:** Colgate-Palmolive and the 'Programme Hospitalier de Recherche Clinique' 2003
Participants	**Setting:** nursing homes **Inclusion criteria:** volunteer facilities with more than 30 beds and patients aged > 65 years **Exclusion criteria:** not stated **Number randomised:** not stated **Number evaluated:** 2513 participants (Intervention group: 868; control group: 1645)
Interventions	**Comparison: professional oral care versus usual oral care** Intervention group: brushing teeth, buccal mucosa and tongue (three times a day and after each meal) + mouthrinse (chlorhexidine) + dental visit (annual visit to dentists)

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Bourigault 2011 (*Continued*)

	Control group: usual mouth care (not stated in detail) Operators: not stated	
Outcomes	1. Incidence of first NHAP (18 months of follow-up) 2. Mortality (pneumonia-associated; 18 months of 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." Comment: unclear risk; method of sequence generation not described
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." Comment: unclear risk; method of allocation concealment not described
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: high risk; blinding not possible
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Comment: unclear risk; unclear information about blinding of outcome assessors
Incomplete outcome data (attrition bias) 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)." Comment: unclear risk; patients of a facility in control group were not included in analysis, but the number was not stated
Selective reporting (reporting bias)	Low risk	Comment: low risk; expected outcomes reported
Other bias	Low risk	Comment: low risk; no other sources of bias identified

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Juthani-Mehta 2015

Methods	**Study design:** cluster-RCT, 2 parallel groups **Location:** New Haven, Connecticut, USA **Number of centres:** 36 **Study period:** not stated **Funding source:** The National Institutes of Health, the National Institute on Aging (NIA) (K23AG028691, R01AG030575, K07AG030093, and P30AG021342)
Participants	**Setting:** nursing homes **Inclusion criteria:** nursing home facilities housing at least 90 residents. Long-term care residents age > 65 years, resident at the nursing home for at least 1 month, with at least 1 of 2 modifiable risk factors for pneumonia (i.e. impaired oral hygiene, swallowing difficulty) **Exclusion criteria**: (1) housing for short-term rehabilitation; (2) presence of a gastric (including percutaneous endoscopic gastrostomy or nasogastric tube) or jejunostomy tube; (3) presence of a tracheostomy; (4) life expectancy < 3 months; (5) current use of chlorhexidine; (6) pneumonia within the previous 6 weeks; (7) previous enrolment in the study; (8) unwillingness to give informed consent (from residents or designated surrogates); (9) non-English speaking; or (10) inappropriateness for the study in the opinion of nursing home administration **Number randomised:** 834 participants (female/male: 636/198, mean age: 86.3; intervention group: 434; control group: 400) **Number evaluated:** 834 participants (259 participants lost to follow-up, but intention-to-treat analysis was used)
Interventions	**Comparison: caregivers provided or instructed professional oral care + upright feeding positioning versus usual oral care + usual feeding position** Intervention group: brushing teeth (twice a day) + cleaning denture + mouthrinse (0.12% chlorhexidine oral rinse, twice a day) + upright feeding positioning, by nurses. (The intervention protocol was tailored to participants who could either perform self-care or required assistance.) Control group: usual oral care + usual feeding position (not stated in detail) Operators: nursing home staff, number not stated
Outcomes	1. Incidence of first NHAP (up to 30 months of follow-up) 2. Mortality (all-cause; up to 30 months of follow-up) 3. Adverse reactions to the interventions (up to 30 months of follow-up)
Notes	Sample size calculation: stated in detail. 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

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Juthani-Mehta 2015 (*Continued*)

Random sequence generation (selection bias)	Low risk	Quote: "Homes were randomized within each stratumusing, a permuted block design with equal allocation to intervention or control arms." Comment: low risk
Allocation concealment (selection bias)	Low risk	Quote: "After enrolment, the randomization status of the home was revealed." Comment: low risk
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: high risk; blinding not possible
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "Blinded study personnel performed screening assessments and approached eligible residents (or designated surrogates) for consent." Comment: low risk
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "Analyses of primary and secondary endpoints were by intent-to-treat." Comment: low risk
Selective reporting (reporting bias)	Low risk	Comment: low risk; expected outcomes reported
Other bias	Low risk	Comment: low risk; no other sources of bias identified.

Yoneyama 2002

Methods	**Study design:** RCT, 2 parallel groups **Location:** Japan **Number of centres:** 11 **Study period:** not stated **Funding source:** Comprehensive Research on Aging and Health from 1999 to 2000 of the Japan Welfare Ministry
Participants	**Setting:** nursing homes in Japan **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 **Exclusion criteria:** no participant had any chronic pulmonary disease, such as chronic obstructive pulmonary disease, bronchial asthma, or pulmonary fibrosis. No participant

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	had feeding tubes **Number randomised:** 417 participants **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** 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 a week) by dentists or dental hygienists, + cleaning denture (every day) Control group (N = 182): brushing teeth (once a day or irregularly) by themselves without caregivers + cleaning denture (every day) Operators: nurses, caregivers, dentists, and dental hygienists. Number not stated
Outcomes	1. Incidence of first NHAP (24 months of follow-up) 2. Mortality (pneumonia-associated; 24 months of follow-up) 3. Prevalence of fever (24 months of follow-up) 4. Change in data on quality of life (24 months of follow-up) 5. Oral health indices (24 months of follow-up)
Notes	Sample size calculation: not reported

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." Comment: low risk
Allocation concealment (selection bias)	Unclear risk	Comment: unclear risk; method of allocation concealment not described
Blinding of participants and personnel (performance bias) All outcomes	High risk	Comment: high risk; blinding not possible
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "Two radiologists who were not involved in the studies made the diagnosis of pneumonia." Comment: low risk

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Yoneyama 2002 (*Continued*)

Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Quote: "51 patients were excluded from the analysis because they died from causes other than pneumonia during follow-up." Comment: unclear risk; the ratio of participants excluded from the analysis was 12.2%
Selective reporting (reporting bias)	Low risk	Comment: low risk; expected outcomes reported
Other bias	Low risk	Comment: low risk; no other sources of bias identified

POHC = professional oral hygiene care; NHAP = nursing home-acquired pneumonia; RCT = randomised controlled trial

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

Study	Reason for exclusion
Bassim 2008	Retrospective cohort study
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
Watando 2004	Not conducted to assess pneumonia incidence or mortality

Characteristics of studies awaiting assessment *[ordered by study ID]*

NCT00841074

Methods	**Study design:** RCT, 2 parallel groups **Location:** USA **Number of centres:** not stated **Study period:** not stated **Funding source:** not stated

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NCT00841074 (*Continued*)

Participants	**Setting:** nursing homes **Inclusion criteria:** participants must be at least 65 years old; be dependent in 2 or more activities of daily living (ADL), one of which must be personal hygiene, wear complete or partial dentures, or a combination; expected to be a resident in a nursing home for two years **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 **Number randomised:** 75 participants **Number evaluated:** unclear
Interventions	**Comparison: Peridex mouthwash versus placebo mouthwash** Intervention group: 0.12% chlorhexidine mouthwash spray, ~1.3 mL, twice a day Control group: placebo mouthwash spray application of ~1.3 mL twice a day
Outcomes	1. Incidence of NHAP (12 months of follow-up) 2. Oral health indices (12 months of follow-up)
Notes	It was stated that the trial was completed, but no published articles retrieved and no useful data available. We tried to contact the authors for the data we needed. The author replied that "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. The study will be considered for inclusion once the trial authors provide the outcome data

Ohsawa 2003

Methods	**Study design:** RCT, 2 parallel groups **Location:** Japan **Number of centres:** 11 **Study period:** not stated **Funding source:** not stated
Participants	**Setting:** nursing homes in Japan **Inclusion criteria:** physical symptoms and cognitive impairment must have been stable for the preceding 3 months. During this 3-month period, potential participants must not have 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 **Exclusion criteria:** no chronic pulmonary disease such as chronic obstructive pulmonary disease, bronchial asthma, or pulmonary fibrosis. No feeding tubes **Number randomised:** 49 participants (female/male: 41/8, mean age: 85.5 ± 8.0) **Number evaluated:** 49 participants (female/male: 41/8, mean age: 85.5 ± 8.0)
Interventions	**Comparison: caregivers provided professional oral care versus usual oral care** Intervention group (n = 25): brushing teeth (after each meal) + swabbing mucosa (with 1% povidone iodine, used in some cases), by nurses or caregivers + dental visit (twice or three times a week), by dentists or dental hygienists + cleaning denture (every day) Control group (n = 24): brushing teeth (after each meal), by caregivers + cleaning denture (every day) Operators: nurses, caregivers, dentists and dental hygienists. Number not stated

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Ohsawa 2003 (*Continued*)

Outcomes	1. Incidence of first NHAP (24 months of follow-up) 2. Prevalence of fever (24 months of follow-up) 3. Change in data on quality of life (24 months of follow-up)
Notes	Sample size calculation: not reported We were not sure whether the data partially overlapped with that of Yoneyama 2002. We tried to contact trial authors, but did not receive a reply

NHAP = nursing home-acquired pneumonia

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DATA AND ANALYSES

Comparison 1. Professional oral care versus usual oral care

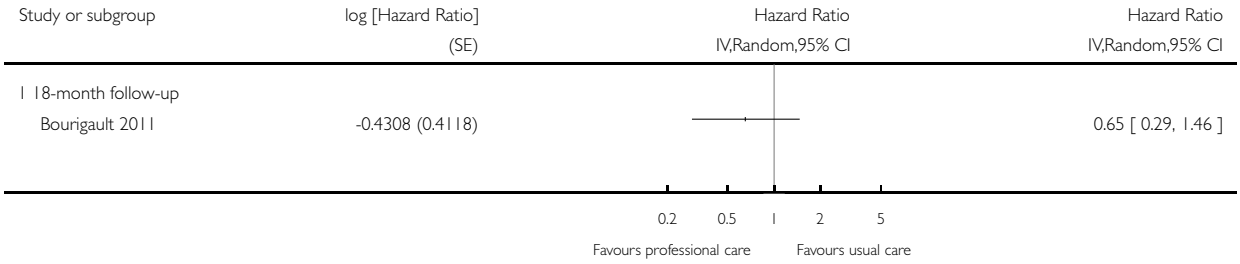
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Incidence rate of NHAP	1		Hazard Ratio (Random, 95% CI)	Totals not selected
1.1 18-month follow-up	1		Hazard Ratio (Random, 95% CI)	0.0 [0.0, 0.0]
2 Incidence proportion (cumulative incidence) of NHAP	2		Risk Ratio (M-H, Random, 95% CI)	Totals not selected
2.1 18-month follow-up	1		Risk Ratio (M-H, Random, 95% CI)	0.0 [0.0, 0.0]
2.2 24-month follow-up	1		Risk Ratio (M-H, Random, 95% CI)	0.0 [0.0, 0.0]
3 Mortality (pneumonia-associated)	3	3020	Risk Ratio (M-H, Random, 95% CI)	0.56 [0.25, 1.27]
3.1 18-month follow-up	1	2513	Risk Ratio (M-H, Random, 95% CI)	1.09 [0.58, 2.05]
3.2 24-month follow-up	2	507	Risk Ratio (M-H, Random, 95% CI)	0.41 [0.24, 0.72]
4 Mortality (all-cause)	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
4.1 24-month follow-up	1		Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
5 Prevalance of fever	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
5.1 24-month follow-up	1		Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]

Analysis 1.1. Comparison 1 Professional oral care versus usual oral care, Outcome 1 Incidence rate of NHAP.

Review: Oral care measures for preventing nursing home-acquired pneumonia

Comparison: 1 Professional oral care versus usual oral care

Outcome: 1 Incidence rate of NHAP



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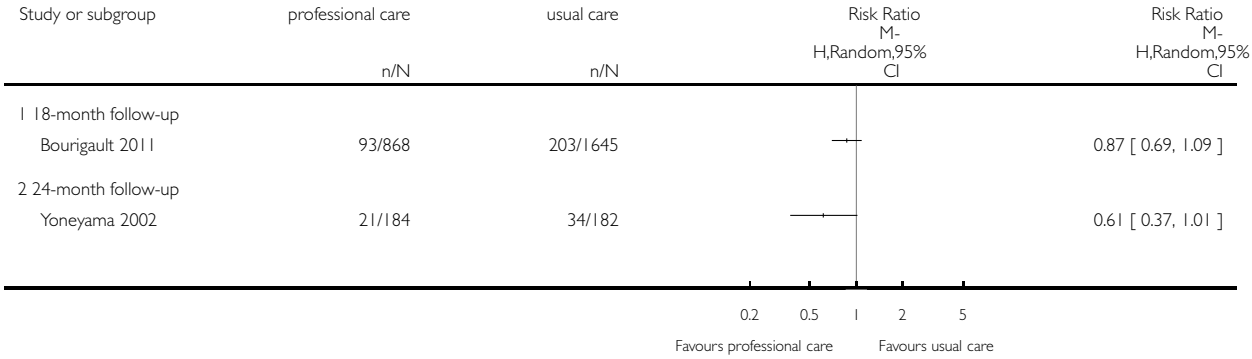
Analysis 1.2. Comparison 1 Professional oral care versus usual oral care, Outcome 2 Incidence proportion (cumulative incidence) of NHAP.

Review: Oral care measures for preventing nursing home-acquired pneumonia

Comparison: 1 Professional oral care versus usual oral care

Outcome: 2 Incidence proportion (cumulative incidence) of NHAP



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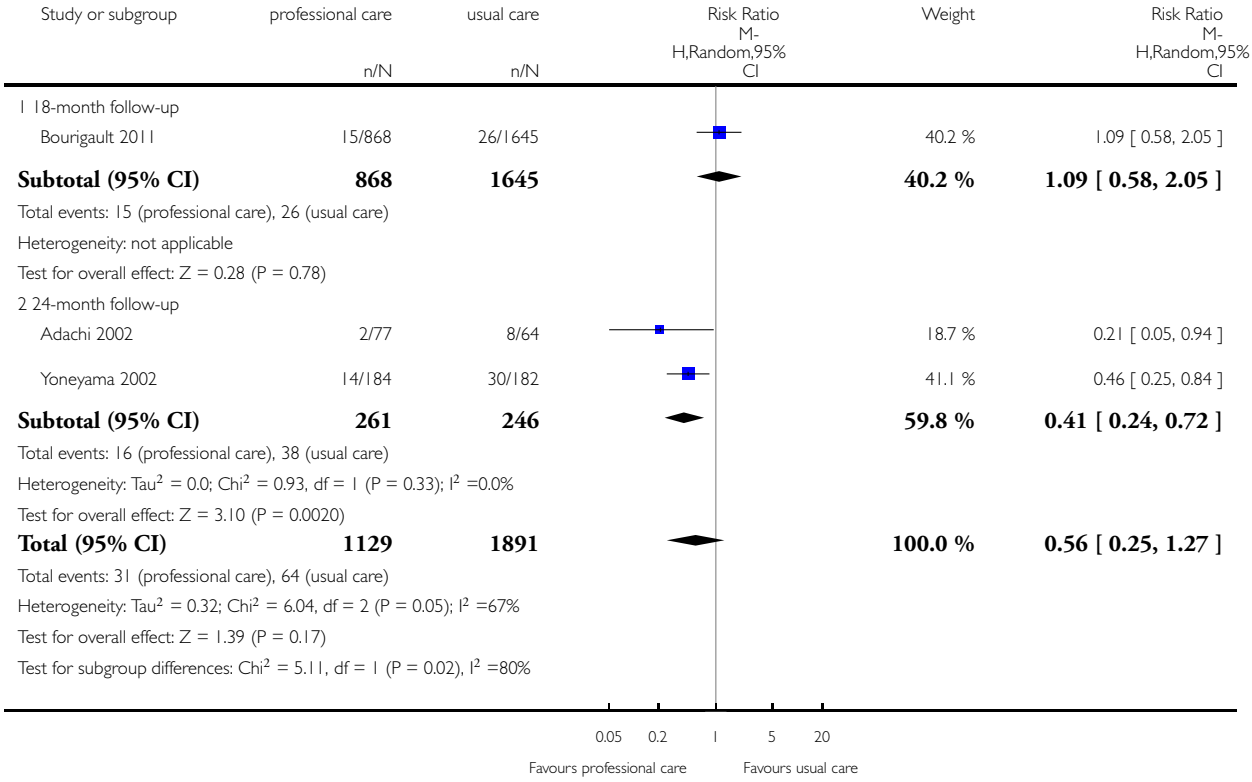
Analysis 1.3. Comparison 1 Professional oral care versus usual oral care, Outcome 3 Mortality (pneumonia-associated).

Review: Oral care measures for preventing nursing home-acquired pneumonia

Comparison: 1 Professional oral care versus usual oral care

Outcome: 3 Mortality (pneumonia-associated)



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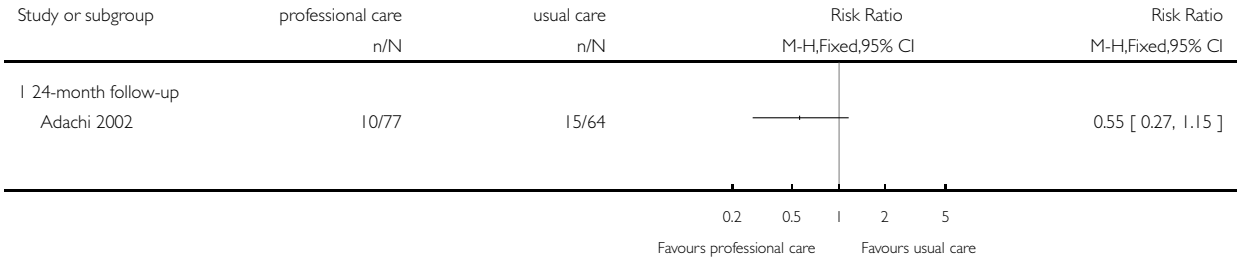
Analysis 1.4. Comparison 1 Professional oral care versus usual oral care, Outcome 4 Mortality (all-cause).

Review: Oral care measures for preventing nursing home-acquired pneumonia

Comparison: 1 Professional oral care versus usual oral care

Outcome: 4 Mortality (all-cause)

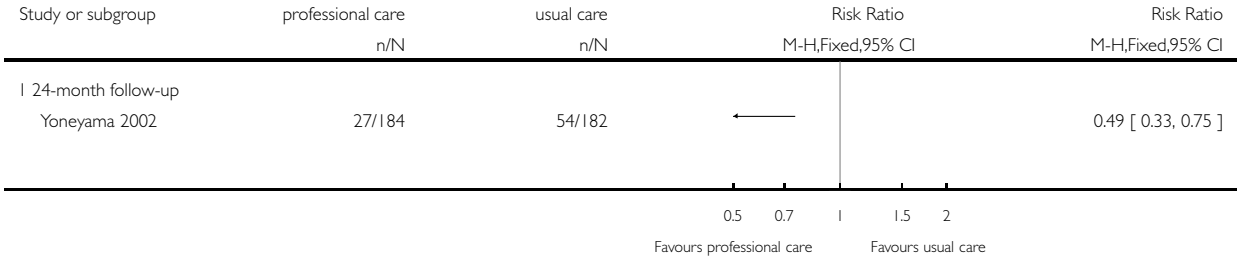


Analysis 1.5. Comparison 1 Professional oral care versus usual oral care, Outcome 5 Prevalance of fever.

Review: Oral care measures for preventing nursing home-acquired pneumonia

Comparison: 1 Professional oral care versus usual oral care

Outcome: 5 Prevalance of fever



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APPENDICES

Appendix 1. Cochrane Oral Health Trials Register search strategy

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}

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#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

This subject search was linked to the Cochrane Highly Sensitive Search Strategy (CHSSS) for identifying randomised trials in MEDLINE: sensitivity-maximising version (2008 revision) as referenced in Chapter 6.4.11.1 and detailed in box 6.4.c of *The Cochrane Handbook for Systematic Reviews of Interventions,* Version 5.1.0 [updated March 2011] (Lefebvre 2011).

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

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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

This subject search was linked to an adapted version of the Cochrane Centralised Search Project filter for identifying RCTs in Embase Ovid (see http://www.cochranelibrary.com/help/central-creation-details.html for information):

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. trial.ti.
19. or/1-18
20. (exp animal/ or animal.hw. or nonhuman/) not (exp human/ or human cell/ or (human or humans).ti.)
21. 19 not 20

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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 to Cochrane Oral Health's filter for identifying RCTs in CINAHL EBSCO:
S1 MH Random Assignment or MH Single-blind Studies or MH Double-blind Studies or MH Triple-blind Studies or MH Crossover design or MH Factorial Design
S2 TI ("multicentre study" or "multicenter study" or "multi-centre study" or "multi-center study") or AB ("multicentre study" or "multicenter study" or "multi-centre study" or "multi-center study") or SU ("multicentre study" or "multicenter study" or "multi-centre study" or "multi-center study")
S3 TI random* or AB random*
S4 AB "latin square" or TI "latin square"
S5 TI (crossover or cross-over) or AB (crossover or cross-over) or SU (crossover or cross-over)
S6 MH Placebos
S7 AB (singl* or doubl* or trebl* or tripl*) or TI (singl* or doubl* or trebl* or tripl*)
S8 TI blind* or AB mask* or AB blind* or TI mask*
S9 S7 and S8
S10 TI Placebo* or AB Placebo* or SU Placebo*
S11 MH Clinical Trials
S12 TI (Clinical AND Trial) or AB (Clinical AND Trial) or SU (Clinical AND Trial)
S13 S1 or S2 or S3 or S4 or S5 or S6 or S9 or S10 or S11 or S12

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Appendix 6. Chinese Biomedical Literature Database search strategy

1. 主题词:预防牙科学/全部树/全部副主题词-限定:-
2. 主题词:洁齿剂/全部树/全部副主题词 -限定:-
3. 主题词:漱口药/全部树/全部副主题词 -限定:-
4. 主题词:口腔保健/全部树/全部副主题词 -限定:-
5. 主题词:氯己定/全部树/全部副主题词 -限定:-
6. #5 or #4 or #3 or #2 or #1 -限定:-
7. 主题词:肺炎/全部树/全部副主题词 -限定:-
8. #7 and #6 -限定:-

Appendix 7. China National Knowledge Infrastructure search strategy

摘要=肺炎 AND 篇名=口腔 AND (摘要=养老院 OR 摘要=社区)

Appendix 8. ClinicalTrials.gov search strategy

pneumonia and nursing home

Appendix 9. WHO International Clinical Trials Registry Platform search strategy

pneumonia and nursing home

Appendix 10. Sciencepaper Online search strategy

(题目 =牙周 OR 题目 =口腔清洁 OR 题目 =口腔卫生) AND 摘要=肺炎, limit to 首发论文

CONTRIBUTIONS OF AUTHORS

Conceiving and designing the review: Chunjie Li

Conducting and writing the review: Chang Liu, Yubin Cao

Screening search results: Chang Liu, Yubin Cao, Chunjie Li

Extracting data and assessing risk of bias: Chang Liu, Yubin Cao, Chunjie Li

Analysing and interpreting data: Chang Liu, Yubin Cao, Tanya Walsh, Chunjie Li

Approving the final review prior to submission: Chang Liu, Yubin Cao, Jie Lin, Linda Ng, Ian Needleman, Tanya Walsh, Chunjie Li

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DECLARATIONS OF INTEREST

Chang Liu: none known

Yubin Cao: none known

Jie Lin: none known

Linda Ng: none known

Ian Needleman has received funding for lectures and research from industry related to oral hygiene products and prevention of ventilator-associated pneumonia. Professor Needleman is an editor with Cochrane Oral Health.

Tanya Walsh: none known. Dr Walsh is an editor with Cochrane Oral Health.

Chunjie Li: none known

SOURCES OF SUPPORT

Internal sources

- West China School of Stomatology and State Key Laboratory of Oral Diseases, Sichuan University, China.
- School of Dentistry, The University of Manchester, Manchester Academic Health Sciences Centre (MAHSC) and the NIHR Manchester Biomedical Research Centre, UK.

External sources

- National Institute for Health Research (NIHR), UK.

This project was supported by the NIHR, via Cochrane Infrastructure funding to Cochrane Oral Health. The views and opinions expressed therein are those of the authors and do not necessarily reflect those of the Systematic Reviews Programme, NIHR, NHS or the Department of Health.

- Cochrane Oral Health Global Alliance, Other.

The production of Cochrane Oral Health reviews has been supported financially by our Global Alliance since 2011 (oralhealth.cochrane.org/partnerships-alliances). Contributors over the past year have been the American Association of Public Health Dentistry, USA; AS-Akademie, Germany; the British Association for the Study of Community Dentistry, UK; the British Society of Paediatric Dentistry, UK; the Canadian Dental Hygienists Association, Canada; the Centre for Dental Education and Research at All India Institute of Medical Sciences, India; the National Center for Dental Hygiene Research & Practice, USA; New York University College of Dentistry, USA; NHS Education for Scotland, UK; and the Swiss Society for Endodontology, Switzerland.

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".

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".

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