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# **Evidence review for an evidence-informed toolkit for local authorities:**

## **Commissioning better oral health for vulnerable older people**

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## Executive summary

This evidence review formed the basis for “Commissioning better oral health for vulnerable older people. An evidence-informed toolkit for local authorities.” The aim was to review the evidence in order to make recommendations for effective interventions and approaches which might be used by local authorities and others.

To do this, the review synthesised evidence for 10 key areas for potential interventions. Searches were undertaken using electronic databases for systematic reviews and other reviews published from 1991 onwards. Additional searches were undertaken for additional studies published in the respective subject areas but not captured in the published reviews. Studies were critically appraised and key data relevant to the review aims were extracted, discussed and tabulated. Recommended interventions were:

- prescribing of dentifrices containing 2,800 or 5,000 parts per million fluoride by health professionals
- programmes involving dental professionals applying fluoride varnish to the teeth to prevent dental caries (dental decay)
- oral hygiene regimes to improve oral health and possibly reduce the risk of aspiration pneumonia
- programmes of training in oral care for care staff/carers
- protocols developed for oral care in care settings
- routine denture identification marking to ensure that lost dentures can be returned to the right person
- water fluoridation

There was less clear evidence of effectiveness for:

- interventions promoting dietary change in community settings
- outreach programmes and interventions to independently living older people
- comprehensive geriatric assessment and multidisciplinary integrated preventive approach in primary care for independently living older people including integration of oral health into primary care and opportunistic assessment of need.

The National Institute for Health and Care Excellence (NICE, 2016) has given specific recommendations for further research for vulnerable older adults in care homes (NICE Guideline NG48). In addition, more research is needed to identify effective health improvement programmes to reduce the risk of oral health problems for vulnerable older people living in the community and especially how to improve daily mouth care routines and facilitate access to appropriate dental care.

## Introduction

From 1 April 2013 local authorities became responsible for assessing the oral health needs of their local population, developing oral health strategies and commissioning population based oral health improvement programmes to meet these needs. Public Health England's specialist dental public health workforce provides support for local authorities to enable them to fulfil these functions. In order to support this work PHE is developing oral health improvement commissioning toolkits. The first, "Local authorities improving oral health: commissioning better oral health for children and young people" published in 2014, focused on the needs of children and young people (PHE, 2014a). In 2016 work began on a similar toolkit to help address the needs of vulnerable older people. "Commissioning better oral health for vulnerable older people. An evidence-informed toolkit for local authorities" is based on the evidence reviewed here.

While the needs and capabilities of older people vary widely across a spectrum as defined in the Seattle care pathway (Pretty et al, 2014) this review is focused on vulnerable older people, aged 65 years and over in need of special care, support, or protection because of age, disability, or risk of abuse or neglect. These needs may arise from a physical or mental impairment or illness that means a person's ability to function in everyday life is compromised. The focus is on those groups for whom adult social care departments in local authorities commission services which include:

- residential and nursing home residents
- older people living with dementia
- older people living with learning disabilities
- frail older people.

## Aim

The aim of this review is to provide the evidence base for an evidence-informed toolkit:

- to support local authorities to commission oral health improvement programmes for vulnerable older people
- to enable local authorities to review and evaluate existing oral health improvement programmes for vulnerable older people and consider future commissioning intentions
- to provide an evidence-informed approach to commissioning for vulnerable older people
- support implementation of NICE guidance.

# Methods

## The evidence review method

This review of the evidence followed the methodological approach adopted for the previous PHE guidance “Commissioning Better Oral Health for Children and Young People” (PHE, 2014a) and originated by the US Centers for Disease Control (CDC), Community Services Task Force (Department of Health and Human Services, 2010) and the Department of Health in Victoria, Australia (Haby & Bowen, 2010).

The review process comprised:

- identification of research evidence
- selection of studies for inclusion
- data extraction for included studies
- assessment of strength of evidence of included studies
- synthesis of results
- discussion and review of findings

The draft review was then subject to independent assessment by two public health academics who were otherwise not involved in the review.

The evidence was restricted to relevant published oral health and related systematic and narrative reviews, supplemented by primary studies where an important research question could not otherwise be answered. There was an appreciation that although a randomised controlled trial (RCT) will give the most robust evidence for some types of interventions, for many interventions in this review an RCT design was not feasible or was inappropriate and interventions could only be evaluated by other study designs (WHO, 1998). This is especially true for complex interventions where there may be several confounding factors, inability to randomise to groups, difficulties in standardising the intervention or generalising the results from a study carried out in one context to applying it in another. The following criteria defined the evidence search.

## Participants

Participants included older adults (aged 65 and older) with physical impairments or illness, mental impairments including learning disability or mental illness including dementia. Participants were residents of residential and nursing homes or people living independently with or without support.

## Interventions

Interventions included were:

- any intervention or combination of interventions given for the prevention of dental problems
- models of care provision and principles for the prevention and management of dental problems

## Outcomes

Outcomes included were:

- functional impacts, for example, activities of daily living
- subjective/self-assessment of oral health/oral health related quality of life
- policy and organisational outcomes
- economic outcomes

## Exclusion criteria

The exclusion criteria were:

- adults in hospitals providing secondary or tertiary care for example acute hospitals or specialised units
- adults in prison or homeless
- children and young people
- specific clinical dental interventions - contrast with models and principles of care provision.

## Limitations

The search was limited to English language studies and studies published in the last 25 years.

## Identifying studies

This review sought to identify studies of any intervention or combination of interventions given for the prevention or management of dental problems in vulnerable older people as defined above. Outcomes of interest were not limited to clinical outcomes but also included impact on activities of daily living, self-assessed oral health, quality of life, organisational outcomes and outcomes of economic evaluations. The evidence for individual dental practice-based interventions was not included. Preventive programmes

and protocols for care were the main focus. Preventive aspects of professional care are covered in the publication ‘Delivering Better Oral Health: an evidence-based toolkit’ but it also seemed important to include preventive techniques which might be applied within programmes for vulnerable older people.

Searches were made of the following sources: MEDLINE, PubMed, Cochrane, peer networks and reference lists of reviewed articles (see Appendices 1 and 2). Work on the review began in January 2016 and initial searches were updated in May 2017 and January 2018. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow chart in Appendix 2 shows the final results of all searches. NICE guideline “Oral health for adults in care homes” NG48. was in draft form at the time of initiating the review and the published version was subsequently included (NICE, 2016). This review is complementary to the NICE guidance (NG48) and aims to avoid duplication while drawing on and incorporating NICE findings as appropriate.

Using a multifactorial approach to assess the evidence for oral health improvement, interventions were classified and assessed using a range of key public health criteria to inform the final recommendations based on the totality of evidence. The effectiveness of each intervention was assessed based on the criteria used by Haby and Bowen (2010) and Rogers (2011) shown in Table 1.

**Table 1. Strength of evaluation and research evidence**

Strong evidence of effectiveness	One systematic review or meta-analysis of comparative studies; or several good quality randomised controlled trials or comparative studies
Sufficient evidence of effectiveness	One randomised controlled trial; one comparative study of high quality; or several comparative studies of lower quality
Some evidence of effectiveness	Impact evaluation (internal or external) with pre and post-testing; or indirect, parallel or modelling evidence with sound theoretical rationale and program logic for the intervention
Weak evidence of effectiveness	Impact evaluation conducted, but limited by pre or post-testing only; or only indirect, parallel or modelling evidence of effectiveness
Inconclusive evidence of effectiveness	No position could be reached because existing research/evaluations give conflicting results; or available studies were of poor quality
No evidence of effectiveness	No position could be reached because no evidence of impact/outcome was available at present. (This is not the same as evidence of ineffectiveness)
Evidence of ineffectiveness	Good evaluations (high quality comparative studies) show no effect or a negative effect



## Research questions

From an initial appraisal of the literature, it was possible to refine the overall aims to the following research question.

What is the evidence for the following interventions and hence what recommendations can be made?

1. Effective agents in toothpastes for older adults.
2. Programmes involving dental professionals applying varnish or solutions to the teeth to prevent dental caries.
3. Oral hygiene regimes to reduce the risk of aspiration pneumonia, as well as improve oral health.
4. Programmes of training in oral care for care staff/carers.
5. Protocols and policies for oral care in care settings.
6. Behavioural interventions promoting dietary change in community settings.
7. Outreach programmes and interventions for independently living older people.
8. Multidisciplinary integrated preventive approaches in primary care for independently living older people.
9. Routine denture identification marking.
10. Water fluoridation.

## Discussion

Appendix 3 gives the key evidence reviewed and Appendix 4 summarises the evidence with recommendations. The rationale for these follows.

### 1. Prescription of dentifrices containing 2,800 or 5,000 parts per million fluoride

Strong evidence of effectiveness was found for the use of higher concentration fluoride toothpastes in this population group. Although rated as strong evidence it comprises few studies, and some indirect measures of effectiveness; there is a need for further research. Use of these toothpastes is already part of the “Delivering Better Oral Health” toolkit for clinical dental teams (PHE, 2014b). Clearly it should be considered as part of care for vulnerable older people who are at higher risk of dental caries. A limiting factor in implementation is that both formulations are only available as prescription-only-medicines and so require individual prescription or patient group directives (PGDs) where a group is identified as being at risk such as care home residents. The use of high concentration fluoride toothpaste, as part of community programmes, has not been evaluated.

## 2. Programmes involving dental professionals applying varnish or solutions to the teeth to prevent dental caries.

A 2015 systematic review examined the management of root caries, including 30 studies which used 28 chemical agents, alone or in combination (Wierichs et al, 2015). It concluded that several agents were effective: silver diamine fluoride gel professionally applied (3 - 12 monthly) and professionally applied chlorhexidine gel (4 -12 monthly) and daily use of self-applied 5,000 parts per million fluoride toothpaste. However, the findings were based on two to three studies per agent and were of limited follow-up (median 15 months). There were no direct comparisons and different outcomes were used so it was not possible to differentiate between the three agents. Ghezzi (2014) included a wider range of interventions in her narrative review (fluoride, chlorhexidine, xylitol, casein phosphopeptide-amorphous calcium phosphate, ozone, and herbal liquorice) and could find good evidence for effectiveness only for fluoride application. Current clinical guidelines (“Delivering Better Oral Health” and “Oral health: local authorities and partners”. NICE Public Health Guidance PH55) recommend fluoride product use for adults at risk of caries (PHE, 2014b; NICE, 2014). Fluoride varnish is a convenient means to achieve this and it can be applied by dental nurses with additional training, which helps limit the staffing costs. It is not clear whether use of fluoride varnish as a community-based prevention programme would be cost-effective in vulnerable older adults.

## 3. Oral hygiene regime to reduce the risk of aspiration pneumonia, as well as improve oral health.

It is well accepted that regular removal of the plaque biofilm is essential for the control of dental caries and periodontal diseases (Axelsson et al, 2004; Needleman et al, 2005). There is a hypothesis that good oral hygiene gives an additional benefit in reducing the risk of aspiration pneumonia. Several studies have shown an association between a reduced risk of aspiration pneumonia or lower respiratory tract infection and improved oral hygiene. The outcomes assessed included indicators of swallowing and coughing function and microbiological markers but also, in two intervention studies, the risk of dying from pneumonia was reduced among those receiving help with oral hygiene. However Juthani-Mehta et al (2015) in a large well conducted RCT tested an intervention among care home residents at high risk of pneumonia but failed to show any benefit. The intervention comprised manual brushing with assistance if needed, chlorhexidine rinse (0.12%) twice daily and upright positioning during feeding. A further cluster randomised controlled clinical trial, this time multi-centred, is now underway which will test the effect of daily application of chlorhexidine solution (0.05%) on the incidence of aspiration pneumonia in care home residents (Hollaar et al, 2017).

Respiratory pathogens are commonly found in denture plaque (O'Donnell et al, 2016) and there is some evidence for increased risk of pneumonia among subjects who leave their dentures in the mouth while sleeping (Iinuma et al, 2015).

Maintaining oral hygiene is crucial to maintaining people's dignity and their oral health. In addition there is evidence that oral hygiene interventions reduce the risk of pneumonia in community-living and hospital-based patients. But caution is needed about the interpretation of this result. Most of the evidence is for people who are critically ill in an intensive care unit (Manger et al, 2017). Most of the interventions include weekly professional care (that is, professional cleaning by a dentist or hygienist) or the use of chlorhexidine rinse or gel or povidone iodine or combinations of these interventions. Reducing dental plaque levels by assisted tooth brushing alone has not been shown, in a well-designed trial, to impact the incidence of pneumonia. Van der Maarel-Wierink's team (2013) summarise their conclusions as "oral health care consisting of tooth brushing after each meal, cleaning dentures once a day, and professional oral health care once a week, seems the best intervention to reduce the incidence of aspiration pneumonia". Chlorhexidine rinse or gel may give additional benefit. Clearly further research is needed to establish an oral hygiene protocol that is effective in reducing the risk of pneumonia.

There is insufficient evidence to make a confident claim that improving oral hygiene will, in itself, reduce the risk of respiratory infections. However, there remain clear benefits from hygiene measures (for teeth and dentures), not only to the dental and periodontal tissues but also for a person's dignity and well-being (Yoon et al. 2013). Hence it is recommended to continue with traditional advice on cleaning teeth and dentures, that is, to clean teeth and dentures twice a day, especially just before bed, and leave dentures out of the mouth while sleeping.

#### 4. Programmes of training in oral care for care staff/carers

Providing support for a vulnerable older person to help with their daily oral care needs can be very demanding. Barriers identified included: lack of training, care related distress from cognitively impaired clients, lack of prioritisation by care home providers resulting in lack of materials for oral hygiene for example provision of gloves, lack of incentives, lack of time, distressed residents and lack of confidence in the task (Frenkel, 1999; Simons, 2000). NICE guideline NG48 "Oral health for adults in care homes" (2016) reviewed 46 studies on this topic and concluded that staff should receive training and care homes should receive regular support and advice on supporting support their residents. It is self-evident that carers in other settings would also benefit from similar support.

Although there are many evaluations of training programmes, interpretation is often difficult. Not all studies of training programmes showed an improvement in clinical

indicators of oral cleanliness and in many the effect size was small and outcomes evaluated were short term. In some studies the description of the intervention was minimal. There was probably also an enhanced effectiveness in most of the studies due to the staff knowing that their work was being evaluated (Hawthorne effect).

Most effective are carer education programmes including active motivation and ongoing support from health professionals. Strategies aimed at knowledge alone are insufficient but should include self-efficacy and facilitation of the desired behaviour and be tailored to address the specific barriers in that context (Weening-Verbree et al, 2013; Sloane et al, 2013).

Other features probably contributing to effectiveness are:

- hands-on practical component to the training (Zenthöfer et al, 2013; Weening-Verbree et al, 2013)
- protocol for oral care adapted to the individual (De Visschere et al, 2011)
- repeated training (Van der Putten et al, 2013; Wang et al, 2015)
- active involvement including demonstration, group discussion and questions and answers (de Baat et al., 1993)
- monitoring of implementation for example by care home manager (Van der Putten et al, 2013; De Visschere et al, 2012, 2013)
- daily oral care combined with regular professional cleaning (de Baat et al, 1993)
- use of electric toothbrush (Day et al, 1998; Fjeld et al, 2014)
- offering incentives to care-givers to attend training (Nicol et al, 2005)
- having a source of continuing advice – phone or visitor resource pack (Nicol et al, 2005)
- having a champion or organiser at ward level (Van der Putten et al, 2013; De Visschere et al, 2012, 2013)
- feedback on clinical improvements (de Baat et al, 1993; Weening-Verbree et al, 2013)
- including oral health assessment training (NICE, 2016)
- support at organisational level (MacEntee et al, 2007; Peltola et al, 2007)

All frontline health and social care staff should have training in how to protect and improve the oral health of those for whom they care. Features probably contributing to lack of effectiveness include:

- higher dependency levels (de Baat et al, 1993)
- inadequate staffing intensity (Wang et al, 2015)
- high staff turnover (Wang et al, 2015).

## 5. Protocols for oral care in care settings

Those working in the field have produced guidance and protocols for oral care in care settings. Fiske et al (2000) provided a guideline for oral care for residents of long-stay facilities. Lewis et al (2015) described how the Australian government endorsed a national evidence based oral health model when it introduced the first nursing home oral and dental health plan in 2010, called Better Oral Health in Residential Care. It promoted a multidisciplinary approach with doctors, nurses, care workers and dental professionals sharing responsibility for the four key processes of oral health screening, oral health care planning, daily oral hygiene and access to dental treatment. Frail and dependent residents were most conveniently treated on-site using portable dental equipment. NICE guidance PH55 on oral health (NICE, 2014) included a requirement for “frontline health and social care staff to receive training in promoting oral health” at induction and with regular updating. NICE guidance NG48 on oral health for adults in care homes (NICE, 2016) recommended that every care home should have policy which sets out their plans and actions to promote and protect residents' oral health. Key to this is a process of oral health assessment for every resident. It is recommended that staff:

- assess the mouth care needs of all residents as soon as they start living in a care home, regardless of the length or purpose of their stay
- make an appointment for the resident to see a dental practitioner, if necessary
- record the results of the assessment and the appointment in the residents' personal care plan
- review and update residents' mouth care needs in their personal care plans as their mouth care needs change.

There may be challenges to people in care home accessing appropriate high quality dental care services, particularly for more vulnerable residents (Watson et al, 2015) and it may be beneficial to develop local care pathways with NHS England through local professional networks to ensure that service provision is equitable.

In addition, staff should provide help as necessary with daily mouth care. Staff should be trained for these tasks, including being able to recognise and respond to changes in a resident's mouth care needs and knowing who to approach for help and advice. Also included are recommendations for local dental practitioners to ensure the availability and accessibility of appropriate dental services. Local oral health promotion teams are recommended to provide support for the care settings in promoting oral health.

## 6. Interventions promoting dietary change in community settings

There have been many attempts to improve the diet of populations and communities. There is a good evidence base for the ideal diet from an oral health perspective. Key to this for dentate individuals is to restrict the amount and frequency of foods and drinks containing free sugars. This may involve substituting artificial sweeteners for sugar, changing from medicines that contain sugar to sugar-free formulations and substituting non-sugar containing or lower sugar items into the diet. Any dietary advice or intervention must be consistent with current guidelines for promoting general health in a shared risk factor approach (The Scientific Advisory Committee on Nutrition, 2015). This can then be applied to any advice and any communal provision of meals eg. Lunch clubs, meals provided by carers or within hospitals and care homes. Certain key features may be identified in any behaviour change intervention and these are in common with behaviour change in other contexts (Michie et al. 2009; Sahyoun et al. 2004).

It is clear that many initiatives and programme that may impact older people's dietary intake go unevaluated (Jones et al. 2009). Even when interventions are evaluated many programmes lack a theoretical basis and studies are beset by methodological difficulties: short duration; self-reported outcomes; variability in known and unknown influencing factors and the tendency for the observation to alter the delivery of the programme (Bully et al, 2015; Bull et al, 2014; Marcus-Varwijk et al, 2016; Maderuelo-Fernandez et al, 2015).

Nevertheless, some improvements can be advocated to improve dietary intake through the coordination of service provision for older people; making the most of social eating for example lunch clubs or involving other family members; training peer educators as community nutrition assistants and ensuring home care workers are allocated longer time slots to assist with nutrition where needed. Clearly a multidisciplinary approach and the involvement of nutritionists is appropriate.

## 7. Outreach programmes and interventions for independently living older people

Most of the published literature on oral health improvement programmes for older adults is based in care homes. NICE guideline PH55 (2014) reviewed the evidence around oral health promotion programmes that local authorities might use. They also reported qualitative work on barriers and facilitating factors. In particular, NICE examined how oral health was perceived as a low priority for many service users with complex and competing life pressures. "The studies described how, against a backdrop of other, often more immediate and competing life problems, oral health was a low and non-urgent priority for many. This made it difficult for intervention staff to engage service users in issues of oral health. They suggested the aims and timing of oral health

interventions should fully acknowledge the life circumstances of the service users in order to be realistic and appropriate". Against this background, staff asked to deliver programmes could be reluctant, sensing that advice would not be well received, they were interfering with people's lives, or that they might alienate the service users.

Another important factor for the effectiveness of programmes was self-efficacy among the staff, that is the extent to which service providers feel they will be able to do what is expected within the oral health intervention or programme. This included staff feeling more confident and empowered to introduce and tailor oral health advice to their service users.

Other facilitating factors included:

- self-proficiency; described as the possession of the skills necessary for implementation
- adequate resources of all types
- adequate time

NICE guideline PH55 (2014) reported four UK based studies showing the importance of perceived benefit as facilitating implementation and conversely how a lack of perceived benefit among service users can act as a barrier to implementation.

NICE guideline PH55 (2014) reviewed the evidence on work based oral health education. They found only an RCT and a cross sectional study, both from Japan. These gave weak evidence for such programmes being associated with improved oral health amongst employed adults.

A systematic review (Kim et al, 2016) investigated the use of community-based health workers in a variety of non-dental general health promotion programmes. The community-based health worker is a lay person recruited from the community and trained for a particular role. They are intended to be trusted members of the local community. The review included a wide range of interventions across community settings, workplaces and home visits. Conclusions were that the use of community-based health workers could be effective and cost-effective in reaching underserved communities but generalisability may be limited in that most studies were US based.



## 8. Multidisciplinary integrated preventive approach in primary care for independently living older people

It seems obvious that primary care is the appropriate setting at which to identify needs and coordinate care for older people. Equally it seems obvious that organisation of services for this group should be integrated into the rest of healthcare (CQC, 2016). However, research in this area is sparse in the dental literature and so the evidence around such interventions for general health have been included within this review in an effort to identify any patterns and principles to apply.

A Cochrane systematic review examined interventions for improving outcomes in people, mostly elderly, with more than one chronic health condition in primary care and community settings (Smith et al, 2016). The review included 18 RCTs of interventions aimed at whole patient care and not specifically oral health. Interventions were generally complex and multifaceted, being categorised using the EPOC (Effective Practice and Organisation of Care) classification as follows.

<b>Categorisation of health service interventions</b>
1. Professional interventions: for example, education designed to change the behaviour of clinicians. Such interventions may work by altering professionals' awareness of multi-morbidity or providing training or education designed to equip clinicians with skills in managing these individuals, thus improving their healthcare delivery.
2. Financial interventions: for example, financial incentives to providers to reach treatment targets. These interventions might work by incentivising health service delivery and providing resources to extend consultation length for people with multi-morbidity.
3. Organisational interventions: these can be further divided into organisational changes delivered through practitioners or directly to patients, for example, any changes to care delivery such as case management or the addition of different healthcare workers such as a pharmacist to the healthcare team. These interventions may work by changing care delivery to match the needs of people with multi-morbidity across a range of areas such as coordination of care, medicines management, or use of other health professionals such as physiotherapists and occupational therapists to address needs relating to physical and social functioning.
4. Patient-oriented interventions: this would include any intervention directed primarily at individuals, for example, education or support for self-management. These interventions might work by improving self-management, thus enabling people to manage their conditions more effectively and to seek appropriate health care.
5. Regulatory interventions: for example, changes to local or national regulations designed to alter care delivery in order to improve outcomes. Such interventions might work by introducing regulatory changes that facilitate and enable the funding of care that is directed towards those with complex health needs. An example could be the introduction of free primary care for people with multi-morbidity on the basis that preventive care might prevent subsequent more costly hospital admissions. While we did not find these types of interventions, we believe they could exist and would fall within the scope of this review for future updates. (Smith et al, 2016)



The authors commented that although the studies generally used a conceptual model, especially the Chronic Care Model, the studies did not match outcomes to particular elements of the intervention making it difficult to differentiate which elements were effective and why.

Although the effects were mixed there was good evidence that effectiveness was more likely where interventions can be targeted at risk factors in common conditions such as depression. There was also evidence, though less strong, for the effectiveness of multidisciplinary team interventions focused on specific functional difficulties in people with more than one chronic health condition.

Hoogendijk (2016) reported the results of three RCTs carried out after 4 to 5 years of the Netherlands national programme of multidisciplinary approaches to improve the health of frail elderly living independently. Core themes were tailored care based on comprehensive geriatric assessments performed by practice nurses and collaboration across healthcare professionals. Results showed a small improvement in dependency and possible cost effectiveness in one of the three studies but otherwise no impact on health-related quality of life, functional limitations, self-rated health, psychological well-being, social functioning and hospitalisation.

Iliffe et al (2014) reported a UK general practice-based feasibility study of a case management package (CAREDEM) for patients with memory loss. The case management involved a social worker or practice nurse, co-ordinating services for people with dementia using a care pathway to provide individualised support. From the qualitative and quantitative evaluation of the project insufficient gains were shown to justify further implementation of this model and the study demonstrated the difficulties and complexities of these types of interventions and their evaluation.

In these complex evaluations of complex interventions there is a difficulty in implementation and a difficulty of research in this area where the research processes themselves can have a detrimental effect on the implementation and evaluation of innovative ways of working.

Stall et al (2014) in a systematic review of outcomes from home-based primary care programs for homebound older adults, described how several home-based primary care programmes have emerged internationally with the goal of providing homebound older adults with comprehensive ongoing primary care in the home. In general, robust home-based primary care programs involve fully integrated interprofessional care teams, regular (at least weekly) care meetings, comprehensive geriatric assessments at intake, and an after-hours urgent telephone service. Only four of the 9 studies included financial analyses, with two reporting substantial cost savings and two reporting higher costs per patient.

One more recent study not included in Smith's systematic review is that by Looman et al (2016) which tested a multidisciplinary integrated preventive approach for the care of older adults living in the community in the Netherlands. The approach used was the Walcheren Integrated Care Model (WICM) of integrated care for frail elderly people who are living independently and have an informal caregiver. This model includes:

- evidence-based preventive frailty screening and needs assessments
- needs assessment of the informal caregiver
- single entry point
- multidisciplinary care plan
- case management
- multidisciplinary consultations and meetings
- protocols
- steering group
- task specialisation/delegation
- integrated information system supporting the chain of care

The study was reported at 12 months and showed some improvement in health-related quality of life. However WICM was more costly than conventional care and not shown to be cost-effective, although a societal perspective was not included in the analysis for example the costs of informal care.

Boult et al (2010) started with expert consensus about the available evidence and identified four proactive, continuous processes all tailored to a person's goals and preferences that can substantially improve the primary care of community-dwelling older people who have multiple chronic conditions:

- comprehensive assessment
- evidence-based care planning and monitoring
- promotion of patients' and (family caregivers') active engagement in care
- coordination of professionals in care of the patient

Incorporating these features into models of care appears to improve some aspects of the effectiveness and the efficiency of complex primary care. In a recent review of general practice based integrated complex interventions Siebenhofer and her team (2017) found that only 15% of projects showed an improvement in the predetermined patient-based outcomes and highlighted the challenges of implementing and evaluating such programmes.

By contrast the intervention described by Sin et al (2015) is a simple checklist for practitioners and would be categorised as professional interventions. The "Hong Kong Reference Framework for Preventive Care for Older Adults" involves practitioners in a comprehensive, integrated and preventive approach to care of older people in the

primary care setting. The practitioners are provided with a core document providing up-to-date evidence based recommendations for preventive care of older adults in primary care setting. Alongside this are educational modules and a two page summary as a quick reference highlighting what screening, investigations and interventions are appropriate for older adults across three categories:

1. independent older adult with no known chronic diseases
2. independent older adult with chronic diseases
3. older adults with disabilities

Health promotion and disease prevention activities are the focus for category one, while category three will have a comprehensive assessment leading to formulation of an individualised care plan. At appropriate intervals or in the event of a change in their condition, individuals would be reassessed. Linked education materials have also been produced. Oral health is included for each of the three categories. Practitioners are recommended to remind people about oral hygiene and enquire about any functional problems that require attention. Sin's paper is purely descriptive and no evaluation has yet been published.

Lowe et al (2007) is an example of an RCT of an oral health outreach intervention based within primary care for independently living older people. Three general medical practices in Cheshire, North West England were the site. People identified as 75 years and older were invited to attend the practice for an interview about their oral health with a practice nurse. Some 87% of those invited attended and 50% of these attended for a clinical oral health assessment, also within the medical practice. Of these 36% had not seen a dentist within the previous 10 years. In the following six months there was a significant increase in verified dental attendance (at an NHS dental provider) among the intervention group, most among those with current problems or pain and those without a regular dentist. The study was limited by being based within affluent population and excluding those patients with any cognitive impairment. Despite the limitations the study does demonstrate the feasibility of using general medical practice for identifying vulnerable older people and as a base for outreach.

## 9. Routine denture identification marking

Denture marking is compulsory in Sweden and Iceland and recommended in many countries by professional organisations. Advantages include the ability to identify the owner of lost dentures, especially those lost in a hospital or care setting. This can mean that costly replacements are avoided. Replacements may also be ineffective as it may not be possible to make a successful denture as the older person experiences a declining ability to adapt to changes in the denture shape and design. Many people who wear dentures are unaware of denture marking but in the few surveys conducted they seem to accept the idea and even welcome it once it is explained (Cunningham and

Hoad-Reddick, 1993; Richmond and Pretty, 2007). While cost is a barrier it is minimal compared with remaking dentures and an approach is advocated to include identification in all dentures during manufacture. This routine denture marking during manufacture is also a recommendation of NICE guideline NG48 (2016).

## 10. Water fluoridation impact for vulnerable older people

There is considerable evidence on the effect of water fluoridation on child dental health (PHE, 2016). Ongoing monitoring continues to show sizeable differences in levels of dental caries between fluoridated and non-fluoridated areas in both primary and permanent (adult) teeth (PHE 2016; Young et al, 2015). There is less evidence for adults, partly because of challenges in the design and implementation of studies to determine this. These challenges include: recruiting subjects, estimation of life-time exposure to fluoridated water in a mobile population, fluctuation in fluoride levels in water over time, variations in other sources of fluoride over a lifetime, changes in diagnostic and treatment thresholds (leading to teeth being restored at different stages of the disease process in some people compared to others) and teeth being lost for reasons other than dental caries.

Despite these problems, several recent studies, systematic and other reviews have been undertaken. Some have shown a prevented fraction of around 25% in adults (Griffin et al, 2007; Parnell et al, 2009). Others have seen lesser, though still substantial, effects (Do et al, 2017; O'Sullivan and O'Connell, 2015; Peres et al, 2016; Spencer et al, 2017). There is some evidence that lifetime exposure is likely to be more effective than childhood-only or recent exposure alone (Spencer et al, 2017) but recent exposure may be more important in reducing the risk of dental caries developing. There is good evidence showing a reduction in caries experience both in the crowns and root surfaces of teeth among adults exposed to water fluoridation (PHE, 2016). There are studies which suggest a reduction in inequality between deprived and affluent groups but these are in children. Surveys of adults in the UK, however, show a greater risk for dental caries in those from more deprived communities and so it is reasonable to assume that these people have the most to gain from water fluoridation. The main advantage of this method of delivery of fluoride is that no behaviour change is needed on the part of the public for them to benefit from the measure. Less independent older people and those with multiple other health issues will, therefore, be predictably reached in a way that no other preventive intervention can match. Vulnerable people will benefit without the need to change what they or their carers are doing, or to have any intervention from a dental professional. The low costs, spread over a large population and the cumulative benefit accrued over a lifetime of treatment costs averted, mean that water fluoridation gives the clearest and largest cost benefit of any of the preventive interventions considered.

The comparison of intervention costs and benefits varies with treatment costs, disease levels and across different settings and, while not directly comparable to the UK, there

are two systematic reviews of studies from USA, Canada, Australia and New Zealand which showed the economic benefits exceeded the costs of water fluoridation (Ran and Chattopadhyay, 2016; Moore et al, 2017). The cost benefit ratios were in the range 1:1.12 to 1:135 and 1:9 respectively. The cost effectiveness increased with the size of the population served and was generally agreed to be uneconomic below 1,000 population. Health surveillance continues to give reassurance about the safety of water fluoridation (PHE, 2018).

## Economic implications

There is little evidence on the economic implications of most of these interventions. For their “Oral health for adults in care homes” NG48 guideline, NICE (2016) examined the impact of a care home introducing staff training, use of a protocol for planning and delivering oral care, compliance checking and enhanced routine oral care practices on two economic models. They concluded that “delivery of an education intervention need not incur a large cost to care homes. In the model it is frequent activities (daily or weekly) that generate the greatest cost through placing demand on care home staff time, in particular performing oral care to residents and monitoring compliance. Consideration should be given to which activities plausibly lead to the greatest benefit in terms of improved oral health; activities that can do so with infrequent demand on staff time would have a greater efficiency than activities that are frequent, demanding a large volume of staff time.” They commented that, for those care homes already achieving this level of oral care, the cost of delivering oral care would not apply, being already absorbed within the care home’s expenditure. For other care homes the cost would be appreciable and also incurs opportunity cost, displacing other activities, such as treating pressure sores.

Overall NICE did not reach a conclusion about which interventions might represent value for money. They did make clear that this reluctance was based on the lack of research which identifies and quantifies clearly the benefits which might derive from interventions to improve oral health. Likely benefits include: a comfortable, pain-free mouth, the ability to enjoy food and eat a nutritious diet, the ability to socialise comfortably, avoiding the costs of multiple dental treatments if oral health declines, the potential effects of oral health on maintaining general health.

The other intervention which did include economic analysis was that of water fluoridation. Two economic reviews show lifetime benefits of water fluoridation exceeding costs, by a large margin in some studies (Ran and Chattopadhyay, 2016; Moore et al, 2017). Caution is needed in interpreting these conclusions as they are not based on UK data and may not be directly applicable here.

As acknowledged above, there are very few academic studies comparing the cost effectiveness or even effectiveness across different programmes. However, there are

ways of minimising costs in implementing a particular programme, for example, by using dental care professionals or using nondental staff rather than dentists for permitted tasks.

## Recommendations for further research

Although there is good evidence for the effectiveness of higher dose fluoride toothpastes in caries control in older adults there is a need for further research to confirm efficacy. To this end a Health Technology Assessment (HTA) commissioned funding process is underway. Professionally applied fluoride agents continue to be developed and refined and it may be that new evidence will show one of these to be more effective than self-applied toothpastes. But there remains the problem of the additional costs for application by a dental professional and achieving cost-effectiveness is likely to be challenging.

In the NICE guideline NG48 “Oral health for adults in care homes” there are several research questions suggested for future studies:

1. What interventions are effective and cost effective at improving and maintaining access to dental services and what is the impact on residents' oral health?
2. How effective and cost effective are oral health interventions in care homes including suitable person-centred outcome measures and what are the differential effects on sub-populations in care homes: people with dementia, people in poor physical health, those with a short life expectancy and younger adults?
3. How can interventions to improve and maintain oral health and wellbeing, or to prevent dental disease, be measured using a patient-centred approach that can also be used to judge cost effectiveness? This approach seeks to recognise the needs and values and perspectives of residents and care staff.
4. Does the delivery of a daily mouth care regimen in care homes maintain or improve adult residents' oral health-related quality of life and any other aspect of their physical health and wellbeing?
5. Do preventive oral health interventions in residential and nursing care homes reduce demands on other health and social care services?
6. What are the facilitators and barriers to delivering daily oral care and conducting oral health assessments in residential and nursing care homes so that this can aid development of an evidence-based, practical mouth care and assessment manual for care home workers?

Older adults living independently are even more of a challenge to identify and reach with any programme or intervention and these in turn are more complex and difficult to evaluate. There is a need for actions and messages to promote oral health to be incorporated into programmes promoting health more generally so that there is

consistency across all fronts. So any assessment of vulnerable older people must include oral health alongside general health. Interventions promoting healthy eating should be consistent with oral health. There is a responsibility to evaluate the effectiveness and impact of current health improvement programmes using appropriate designs, implementation analysis and assessing both process and outcomes.

Research is also needed on programmes which aim to improve the oral health of vulnerable older adults. The oral health needs of this group are clear and impact the quality of life of very many. Research in this topic has mostly focused on older adults who are most convenient to study, that is, in institutions of various sorts. Oral health improvement interventions are rarely aimed at older people in the community and the research evidence to support them is sparse. If any improvement is to be made in the oral health of vulnerable older people there is a need for specific research to answer the following questions.

1. What health improvement programmes can reduce the risk of poor oral health in vulnerable older people living in the community?
2. What health improvement programmes can improve daily mouth care routines in vulnerable older people living in the community?
3. What is the impact of health improvement programmes on oral health related quality of life in vulnerable older people living in the community?
4. How can access to appropriate dental care be facilitated for vulnerable older people living in the community?

These interventions may be integrated within larger health promoting programmes but need to be subject to research specifically focused on these oral health related questions. Particular design features would include: clearly defined and assessed outcomes; clearly described context of the interventions; precisely specified methodology and procedures; matching particular elements of the programme to particular outcomes; having a theoretical basis for the interventions and including economic evaluation where possible.

For this group, as for care home residents, oral health-related quality of life and person-centred outcome measures will also be appropriate. However, community based older adults include a wider spectrum of dependency and a potentially longer remaining span of life, hence the need to include specifically caries risk reduction and oral cleanliness to control disease as far as possible.



## References

- Ajwani, S., Jayanti, S., Burkolter, N., Anderson, C., Bhole, S., Itaoui, R., & George, A. (2017). Integrated oral health care for stroke patients – a scoping review. *Journal of Clinical Nursing*, 26(7-8), pp. 891–901.
- Amerine, C., Boyd, L.D., Bowen, D.M., Neill, K., Johnson, T., & Peterson, T. (2013). Oral health champions in long-term care facilities – a pilot study. *Special Care in Dentistry*, 34 (4), pp. 164-170.
- Axelsson, P., Nystrom, B., & Lindhe, J. (2004). The long-term effect of a plaque control program on tooth mortality, caries and periodontal disease in adults. *Journal of Clinical Periodontology*, 31, pp. 749-757.
- Boult, C., & Wieland, G.D. (2010). Comprehensive primary care for older patients with multiple chronic conditions: "Nobody rushes you through". *Journal of American Medical Association*, 304(17), pp. 1936-1943.
- Bull, E.R., Dombrowski, S.U., McCleary, N., & Johnston, M. (2014). Are interventions for low-income groups effective in changing healthy eating, physical activity and smoking behaviours? A systematic review and meta-analysis. *BMJ Open*. 4(11):e006046, 2014.
- Bully, P., Sanchez, A., Zabaleta-del-Olmo, E., Pombo, H., & Grandes, G. (2015). Evidence from interventions based on theoretical models for lifestyle modification (physical activity, diet, alcohol and tobacco use) in primary care settings: A systematic review. [Review] *Preventive Medicine*, 76 Suppl, pp. S76-93.
- Chalmers, J., & Pearson, A. (2005). Oral hygiene care for residents with dementia: a literature review. *Journal of Advanced Nursing*. 52 (4), pp. 410– 419.
- CQC (Care Quality Commission) (2016). *Building bridges, breaking barriers*. Newcastle upon Tyne: Care Quality Commission.
- Cunningham, M., & Hoad-Reddick, G. (1993). Attitudes to identification of dentures: The patients' perspective. *Quintessence International*, 24 (4), pp. 267-270.
- Day, J., Martin, M.D., & Chin, M. (1998). Efficacy of a sonic toothbrush for plaque removal by caregivers in a special needs population. *Special Care in Dentistry*, 18 (5), pp. 202-206.
- De Baat, C., Kalk, W., & Schuil, R.G.E. (1993). The effectiveness of oral hygiene programmes for elderly people - a review. *Gerodontology*, 10 (2), pp. 109-113.
- De Visschere, L., de Baat, C., Schols, J.M., Deschepper, E., & Vanobbergen, J. (2011). Evaluation of the implementation of an 'oral hygiene protocol' in nursing homes: a 5-year longitudinal study. *Community Dentistry & Oral Epidemiology*, 39(5), pp. 416-425.



De Visschere, L., de Baat, C., De Meyer, L., van der Putten, G.-J., Peeters, B., Söderfelt, B., & Vanobbergen, J. (2013). The integration of oral health care into day-to-day care in nursing homes: a qualitative study. *Gerodontology*, 32(2), pp. 115–122.

De Visschere, L.D., Schols, J., van der Putten, G.J., de Baat, C., & Vanobbergen, J. (2012). Effect evaluation of a supervised versus non-supervised implementation of an oral health care guideline in nursing homes: a cluster randomised controlled clinical trial. *Gerodontology*, 29, pp. e96–e106.

Department of Health and Human Services. (2010). *Evidence-based clinical and public health: generating and applying the evidence*. USA: Department of Health and Human Services.

Do, L., Ha, D., Peres, M.A., Skinner, J., Byun, R., & Spencer, A.J. (2017). Effectiveness of water fluoridation in the prevention of dental caries across adult age groups. *Community Dentistry and Oral Epidemiology*, 45(3), pp. 225–232.

Ekstrand, K.R. (2016). High Fluoride Dentifrices for Elderly and Vulnerable Adults: Does It Work and if So, Then Why? *Caries Research*, 50(1), pp. 15–21.

Fiske, J., Griffiths, J., Jamieson, R., & Manger, D. (2000). Guidelines for Oral Health Care for Long-stay Patients and Residents. *Gerodontology*, 17 (1), pp. 55-64.

Fjeld, K.G., Mowe, M., Eide, H., & Willumsen, T. (2014). Effect of electric toothbrush on residents' oral hygiene: a randomized clinical trial in nursing homes. *European Journal of Oral Science*, 122, pp. 142–148.

Frenkel, H.F. (1999). Behind the screens: care staff observations on delivery of oral health care in nursing homes. *Gerodontology*, 16, pp. 75–80.

Ghezzi, E.M. (2014). Developing pathways for oral care in elders: evidence-based interventions for dental caries prevention in dentate elders. *Gerodontology*, 31 (Suppl.1), pp. 31–36.

Griffin, S.O., Regnier, E., Griffin, P.M., & Huntley, V. (2007). Effectiveness of Fluoride in Preventing Caries in Adults. *Journal of Dental Research*, 86(5), pp. 410–415.

Haby, M. & Bowen, S. (2010). *Making decisions about interventions. A guide for evidence-informed policy and practice*. Prevention and population health branch. Victoria: Victoria Government Department of Health.

Hakuta, C., Mori, C., Ueno, M., Shinada, K., & Kawaguchi, Y. (2009). Evaluation of an oral function promotion programme for the independent elderly in Japan. *Gerodontology*, 26(4), pp. 250-258.

Hjertstedt, J., Barnes, S.L., & Sjosted, J.M. (2013). Investigating the impact of a community-based geriatric dentistry rotation on oral health literacy and oral hygiene of older adults. *Gerodontology*, 31, pp. 296–307.

Hollaar, V.R.Y., Putten, G.J., Maarel-Wierink, C.D., Bronkhorst, E.M., Swart, B.J.M., & Creugers, N.H.J. (2017). 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*, 17 (128), pp. 1-11.

Hoogendijk, E.O. (2016). How effective is integrated care for community dwelling frail older people? The case of the Netherlands. *Age and Ageing*, p.afw081.

Iinuma, T., Arai, Y., Abe, Y., Takayama, M., Fukumoto, M., Fukui, Y., Iwase, T., Takebayashi, T., Hirose, N., Gionhaku, & N., Komiyama, K. (2015). Denture Wearing during Sleep Doubles the Risk of Pneumonia in the Very Elderly. *Journal of Dental Research*, 94(3 Suppl), pp. 28S–36S.

Iliffe, S., Waugh, A., Poole, M., Bamford, C., Brittain, K., Chew-Graham, C., Fox, C., Katona, C., Livingston, G., Manthorpe, J., Steen, N., Stephens, B., Hogan, V., & Robinson, L. CAREDEM research team. (2014). The effectiveness of collaborative care for people with memory problems in primary care: results of the CAREDEM case management modelling and feasibility study. *Health technology assessment*, 18(52), pp.1-148.

Innes, N., & Evans, D. (2009). Caries prevention for older people in residential care homes *Evidence-based Dentistry*, 10 (3), pp. 83-87.

Jones, J., Duffy, M., Coull, Y., & Wilkinson, H. (2009). *Older People Living in the Community - Nutritional Needs, Barriers and Interventions: a Literature Review*. Scottish Government Social Research, The Scottish Government, Edinburgh.

Juthani-Mehta, M., Van Ness, P.H., McGloin, J., Argraves, S., Chen, S., Charpentier, P., Miller, L., Williams, K., Wall, D., Baker, D., Tinetti, M., Peduzzi, P., & Quagliarello, V.J. (2015). A Cluster-Randomized Controlled Trial of a Multicomponent Intervention Protocol for Pneumonia Prevention Among Nursing Home Elders. *Clinical Infectious Disease*, 60 (6), pp. 849-857.

Kalyan, A., Clark, R.K.F., & Radford, D.R. (2014). Denture identification marking should be standard practice. *British Dental Journal*, 216, pp. 615-617.

Kim, K., Choi, J.S., Choi, E., Nieman, C.L., Joo, J.H., Lin, F.R., Gitlin, L.N., & Han, H. (2016). Effects of community-based health worker interventions to improve chronic disease management and care among vulnerable populations: A systematic review. *American Journal of Public Health*, 106 (4), pp. E3-E28.

Komulainen, K., Ylöstalo, P., Syrjälä, A.M., Ruoppi, P., Knuuttila, M., Sulkava, R., & Hartikainen, S. (2015). Oral health intervention among community-dwelling older people: a randomised 2-year intervention study. *Gerodontology*, 32(1), pp. 62-72.

Kuo, Y.W., Yen, M., Fetzer, S., Chiang, L.C., Shyu, Y. II, Lee, T.H., & Ma, H.I. (2016). A home-based training programme improves family caregivers' oral care practices with stroke survivors: A randomized controlled trial. *International Journal of Dental Hygiene*, 14(2), pp. 82–91.

Lewis, A., Wallace, J., Deutsch, A., & King, P. (2015). Improving the oral health of frail and functionally dependent elderly. *Australian Dental Journal*, 60 (1 Suppl), pp. 95–105.

Looman, W.M., Huijsman, R., Bouwmans-Frijters, C.A.M., Stolk, E.A., & Fabbriotti, I.N. (2016). Cost-effectiveness of the 'Walcheren Integrated Care Model' intervention for community-dwelling frail elderly. *Family Practice*, 33 (2), pp. 154-160.

Lowe, C., Blinkhorn, A.S., Worthington, H.V., & Craven, R. (2007). Testing the effect of including oral health in general health checks for elderly patients in medical practice – a randomized controlled trial. *Community Dentistry Oral Epidemiology*, 35, pp. 12–17.

Lyndon, H. (2016). Personal communication.

MacEntee, M.I., Wyatt, C.C., Beattie, B.L., Paterson, B., Levy-Milne, R., McCandless, L., & Kazanjian, A. (2007). Provision of mouth-care in long-term care facilities: an educational trial. *Community Dentistry & Oral Epidemiology*, 35(1), pp. 25-34.

Maderuelo-Fernandez, J.A., Recio-Rodriguez, J.I., Patino-Alonso, M.C., Perez-Arechaederra, D., Rodriguez-Sanchez, E., Gomez-Marcos, M.A., & Garcia-Ortiz, L. (2015). Effectiveness of interventions applicable to primary health care settings to promote Mediterranean diet or healthy eating adherence in adults: A systematic review. *Preventive Medicine*, 76 Suppl:S pp. 39-55.

Maeda, K., Akagi, J. (2014). Oral care may reduce pneumonia in the tube-fed elderly: a preliminary study. *Dysphagia*, 29(56), pp. 16-261.

Manger, D.M., Walshaw, M., Fitzgerald, R., Doughty, J., Wanyonyi, K.L., White, S., & Gallagher, J.E. (2017). Evidence summary: the relationship between oral health and pulmonary disease. *British Dental Journal*, 222, pp. 527-533.

Marcus-Varwijk, A.E., Koopmans, M., Visscher, T.L.S., Seidell, J.C., Slaets, J.P.J., & Smits, C.H.M. (2016). Optimizing Tailored Health Promotion for Older Adults: Understanding Their Perspectives on Healthy Living. *Gerontology & Geriatric Medicine*, 2, pp. 1–9.

Mariño, R., Calache, H., & Morgan, M. (2013). A community-based culturally competent oral health promotion for migrant older adults living in Melbourne, Australia. *Journal of the American Geriatrics Society*, 61(2), pp. 270-275.

Mariño, R.J., Fajardo, J., Calache, H., & Morgan, M. (2014). Cost-minimization analysis of a tailored oral health intervention designed for immigrant older adults. *Geriatrics Gerontology International*, 14, pp. 336–340.

Marshall, S., Northridge, M.E., De La Cruz, L.D., Vaughan, R.D., O'Neil-Dunne, J., & Lamster, I.B. (2009). ElderSmile: A Comprehensive Approach to Improving Oral Health for Seniors. *American Journal of Public Health*, 99 (4), pp. 595-599.

Michie, S., Abraham, C., Whittington, C., McAteer, J., & Gupta, S. (2009). Effective Techniques in Healthy Eating and Physical Activity Interventions: A Meta-Regression. *Health Psychology*, 28 (6), pp. 690–701.

Moore, D., Poynton, M., Broadbent, J.M., & Thomson, W.M. (2017). The costs and benefits of water fluoridation in NZ. *BMC Oral Health*, 17(1), pp. 1–8.

Needleman, I., Suvan, J., Moles, D.R. & Pimlott, J. (2005). A systematic review of professional mechanical plaque removal for prevention of periodontal diseases. *Journal of Clinical Periodontology*, 32, pp. 229-282.

NICE (National Institute for Health and Care Excellence) (2014). *Oral health: local authorities and partners*. NICE Public Health Guideline PH55. London: NICE.

NICE (National Institute for Health and Care Excellence) (2016). *Oral health for adults in care homes*. NICE Guideline NG48. London: NICE.

Nicol, R., Sweeney, M.P., McHugh, S., & Bagg, J. (2005). Effectiveness of health care worker training on the oral health of elderly residents of nursing homes. *Community Dentistry & Oral Epidemiology*, 33(2), pp.115-124.

O'Donnell, L.E., Smith, K., Williams, C., Nile, C.J., Lappin, D.F., Bradshaw, D., Lambert, M., Robertson, D.P., Bagg, J., Hannah, V., & Ramage, G. (2016). Dentures are a Reservoir for Respiratory Pathogens. *Journal of Prosthodontics*, 25, pp. 99–104.

Oliver, D., Foot, C., & Humphries, R. (2014). The King's Fund. *Making our health and care systems fit for an ageing population*.

O'Sullivan, V., & O'Connell, B.C. (2015). Water fluoridation, dentition status and bone health of older people in Ireland. *Community Dentistry and Oral Epidemiology*, 43(1), pp. 58–67.

Parnell, C., Whelton, H., & O'Mullane, D. (2009). Water Fluoridation. *European Archives of Paediatric Dentistry Oral Health Services Research Centre*, 10(3), pp.141–148.

Peltola, P., Vehkalahti, M.M., & Simoila, R. (2007). Effects of 11-month interventions on oral cleanliness among the long-term hospitalised elderly. *Gerodontology*, 24(1), pp. 14-21.

Peres, M.A., Peres, K.G., Barbato, P.R., & Höfelmann, D.A. (2016). Access to Fluoridated Water and Adult Dental Caries. *Journal of Dental Research*, 95(8), pp. 868–874.

PHE (Public Health England) (2014a). *Local authorities improving oral health: commissioning better oral health for children and young people*. London: PHE.

PHE (Public Health England) (2014b). *Delivering better oral health: an evidence-based toolkit for prevention*. 3rd ed. London: PHE.

PHE (Public Health England) (2016). *Improving oral health: a community water fluoridation toolkit for local authorities*. London: PHE.

PHE (Public Health England) (2018). *Water Fluoridation Health monitoring report for England 2018*. London: PHE.

Powell, L.V., Persson, R.E., Kiyak, H.A., & Hujoel, P.H.P. (1999). Caries Prevention in a Community- Dwelling Older Population. *Caries Research*, 33, pp. 333–339.

Pretty, I.A., Ellwood, R.P., Lo, E.C.M., MacEntee, M.I., Muller, F., Rooney, E., Thomson, W.M., Van der Putten, G.-J., Ghezzi, E.M., Walls, A. & Wolff, M.S. (2014). The Seattle Care Pathway for securing oral health in older patients. *Gerodontology*, 31 (Suppl 1), pp. 77–87.

Raghoonandan, P., Cobban, S.J., & Compton, S.M. (2011). A scoping review of the use of fluoride varnish in elderly people living in long term care facilities. *Canadian Journal Dental Hygiene*, 45 (4), pp. 217–222.

Ran, T., & Chattopadhyay, S.K. (2016). Community Preventive Services Task F. Economic Evaluation of Community Water Fluoridation: A Community Guide Systematic Review. *American Journal of Preventive Medicine*, 50(6), pp. 790–796.

Richmond, R., & Pretty, I.A. (2007). *Denture Marking—Patient Preference of Various Methods*. *Journal of Forensic Sciences*, 52 (6) pp.1338-1342.

Rogers, J.G. (2011). *Evidence-based oral health promotion resource*. Prevention and Population Health Branch, Government of Victoria, Department of Health, Melbourne.

SACN (Scientific Advisory Committee on Nutrition). (2015). *Carbohydrates and Health*. London: TSO.

Sahyoun, N.R., Pratt, C.A., Anderson, A. (2004). Evaluation of Nutrition Education Interventions for Older Adults: A Proposed Framework. *Journal of American Dietetics Association*, 104, pp. 58-69.

Siebenhofer, A., Paulitsch, M.A., Pregartner, G., Berghold, A., Jeitler, K., Muth, C., & Engler, J. (2017). Cluster-randomised controlled trials evaluating complex interventions in general practices are mostly ineffective: A systematic review. *Journal of Clinical Epidemiology*,

Simons, D., Baker, P., Jones, B., Kidd, E.A.M., Beighton, D. (2000). An evaluation of an oral health training programme for carers of the elderly in residential homes. *British Dental Journal*, 188, pp. 206–210.

Sin, C.K.L., Fu, S.N., Tsang, C.S.H., Tsui, W.W.S., Chan, F.H.W. (2015). Prevention in primary care is better than cure: The Hong Kong Reference Framework for Preventive Care for Older Adults—translating evidence into practice. *Hong Kong Medical Journal*, 21, pp. 353–359.

Sjogren, P., Kullberg, E., Hoogstraate, J., Johansson, O., Herbst, B., Forsell, M. (2010). Evaluation of dental hygiene education for nursing home staff. *Journal of Advanced Nursing*, 66 (2), pp. 345-349.

Sloane, P.D., Zimmerman, S., Chen, X., Barrick, A.L., Poole, P., Reed, D., Mitchell, M., Cohen, L.W. (2013). Effect of a person-centered mouth care intervention on care processes and outcomes in three nursing homes. *Journal of the American Geriatrics Society*, 61 (7), pp. 1158-1163.

Smith, S.M., Wallace, E., O'Dowd, T., Fortin, M. (2016). Interventions for improving outcomes in patients with multimorbidity in primary care and community settings. *Cochrane Database of Systematic Reviews*, Issue 3. Art. No.: CD006560. DOI: 10.1002/14651858.CD006560.pub3.

Spencer, A.J., Liu, P., Armfield, J.M., & Do, L.G. (2017). Preventive benefit of access to fluoridated water for young adults. *Journal of Public Health Dentistry*, 77(3), pp. 263–271.

Srinivasan, M., Schimmel, M., Riesen, M., Ilgner, A., Wicht, M.J., Warncke, M., Ellwood, R.P., Nitschke, I., Muller, F., Noack, M.J. (2014). High-fluoride toothpaste: a multicenter randomized controlled trial in adults. *Community Dentistry & Oral Epidemiology*, 42 (4), pp. 333-340.

Stall, N., Nowaczynski, M., Sinha, S.K. (2014). Systematic review of outcomes from home-based primary care programs for homebound older adults. *Journal of the American Geriatrics Society*, 62(12), pp. 2243-2251.

Van der Maarel-Wierink, C.D., Vanobbergen, J.N.O., Bronkhorst, E.M., Schols, J.M.G.A., de Baat, C. (2013). Oral health care and aspiration pneumonia in frail older people: a systematic literature review. *Gerodontology*, 30, pp. 3–9.

Van der Putten, G.J., Mulder, J., De Baat, C., De Visschere, L.M., Vanobbergen, J.N., Schols, J.M. (2013). Effectiveness of supervised implementation of an oral health care guideline in care homes; a single-blinded cluster randomized controlled trial. *Clinical Oral Investigations*, 17, pp. 1143-53.

Wang, T.F., Huang, C.M., Chou, C., Yu, S. (2015). Effect of oral health education programs for caregivers on oral hygiene of the elderly: A systemic review and meta-analysis. *International Journal of Nursing Studies*, 52(6), pp.1090-1096.

Watson, F., Tomson, M., Morris, A.J., Taylor-Weetman, K., Wilson, K.I. (2015). West Midlands Care Home Dental Survey 2011: Part 1. Results of questionnaire to care home managers. *British Dental Journal*, 219, pp. 343-346.

Weening-Verbree, L., Huisman-de Waal, G., van Dusseldorp, L., van Achterberg, T., Schoonhoven, L. (2013). Oral health care in older people in long term care facilities: A systematic review of implementation strategies. *International Journal of Nursing Studies*, 50, pp. 569–582.

Weintraub, J.A. (2003). Fluoride varnish for caries prevention: comparisons with other preventive agents and recommendations for a community-based protocol. *Special Care Dentistry*, 23(5), pp. 180-186.

WHO (World Health Organization) (1998). *Health promotion evaluation: recommendations to policy-makers . Report of the WHO European working group on health promotion evaluation*. Copenhagen: World Health Organization.

Wierichs, R.J., Meyer-Lueckel, H. (2015). Systematic Review on Noninvasive Treatment of Root Caries Lesions. *Journal of Dental Research*, 94 (2), pp. 261–271.

Willumsen, T., Solemdal, K., Wenaasen, M., Øgaard, B. (2007). Stannous fluoride in dentifrice: an effective anti-plaque agent in the elderly? *Gerodontology*, 24, pp. 239–243.

Yoon, H-S., Kim, H-Y., Patton, L.L., Chun, J-H., Bae, K-H., Lee, M-O. (2013). Happiness, subjective and objective oral health status, and oral health behaviors among Korean elders. *Community Dentistry Oral Epidemiology*, 41, pp. 459–465.

Young, N., Newton, J., Morris, J., Morris, J., Langford, J., Iloya, J., Edwards, D., Makhani, S., Verne, J. (2015). Community water fluoridation and health outcomes in England: a cross-sectional study. *Community Dentistry and Oral Epidemiology*, 43(6), pp.550-559.

Zenthöfer, A., Cabrera, T., Rammelsberg, P., Hassel, A.J. (2016). Improving oral health of institutionalized older people with diagnosed dementia. *Aging & Mental Health*, 20 (3), pp. 303-308.

Zenthöfer, A., Dieke, R., Dieke, A., Wege, K-C., Rammelsberg, P., & Hassel, A.J. (2013). Improving oral hygiene in the long-term care of the elderly-a RCT. *Community Dentistry and Oral Epidemiology*, 41(3), pp. 261–268.

## Appendix 1: Search strategy

Terms used:

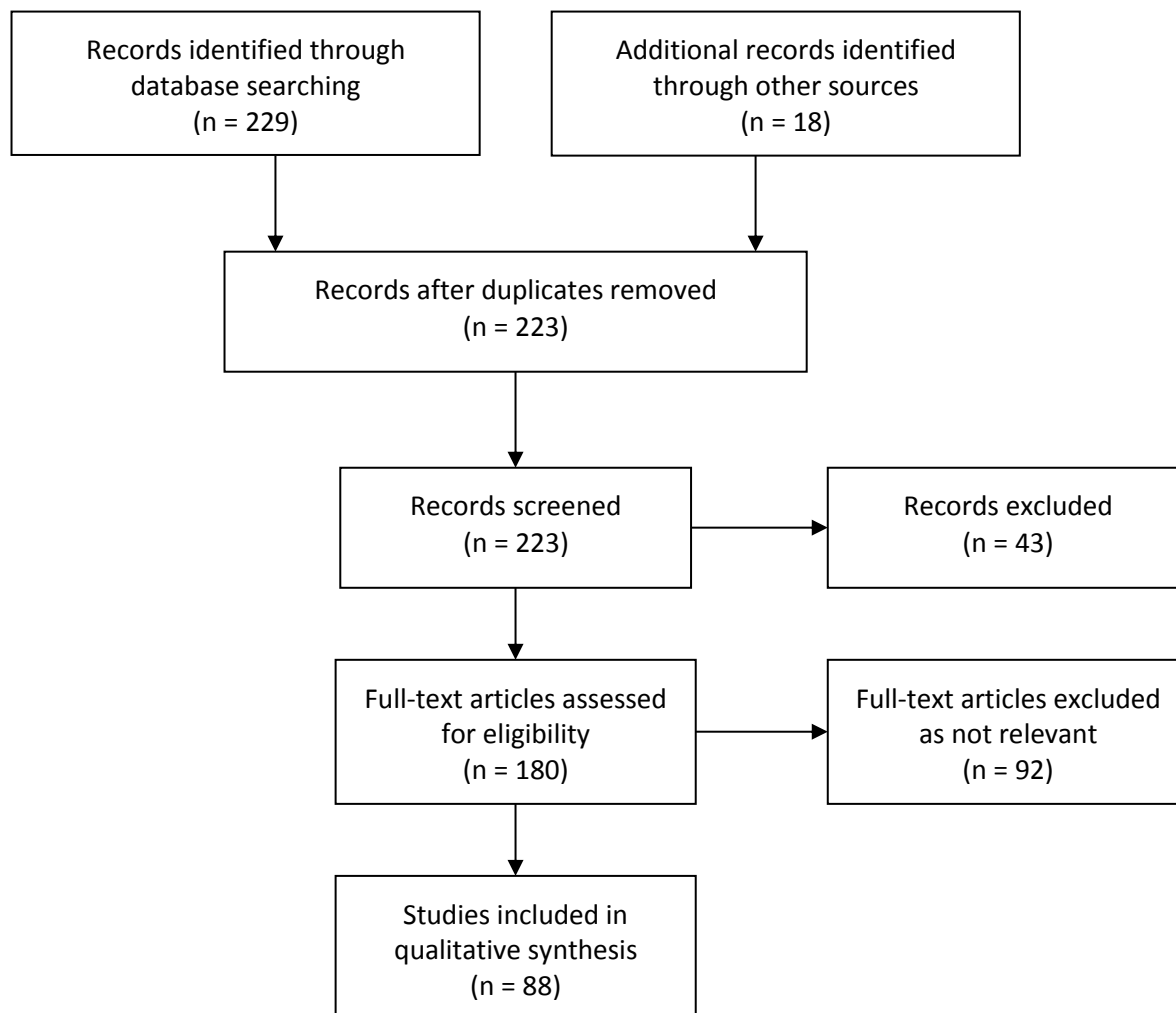
	<b>Population/Setting/Problem</b>	<b>Intervention</b>
1	dental/root/caries/cavit*/ cariou/caries*/cariou/ decay* /lesion*/ eminerali*/reminerali*	dentifrices/toothpastes/ fluoride/fluorid* /fluorin*/ flurin*/flurid*
2	dental/root/caries/cavit*/ cariou/caries*/cariou/ decay* /lesion*/ deminerali*/reminerali*	Mouthwash*/mouth-wash*/mouth- rins*/mouthrins*/oralrins*/oralrins*/toothpa ste*/tooth paste*/dentifrice*/toothbrush*/ tooth brush*/prevention/ varnish/ topical/
3	pneumonia/lung/respiratory tract infection/RTI/chronic obstructive pulmonary dis*/COPD disease*/infection*/condition*/dysphagia /aspirat*/ventil*/oral/dental/ health/hygiene/disease*/care/infection/ periodon*/gum/caries/tooth decay/DMFT/plaque/oral bacteria/respiratory pathogen/	oral hygiene/ mouthwash*/mouth- wash*/mouth-rins*/mouthrins*/ chlorhexidine/ oral rins*/ oralrins*/toothpaste*/ toothpaste*/dentifrice*/toothbrush*/ tooth brush*
4	homes for the aged/ nursing homes/ health services for the aged/ long-term care/	inservice training/ educat*/ oral hygiene/
5	homes for the aged/ nursing homes/ health services for the aged/ long-term care/	mouth/dental/oral hygiene/toothbrush*
6	disabled persons/ mentally disabled persons/ mentally ill persons/ vulnerable populations/intellectual disability/learning disorders/dementia/	health promotion/ dental health educat*/ healthy/ eating/ diet
7	aged/older adults/ elder*/ independent living/	community health work*/ community- based health work*/ health promotion/ community program*/ outreach/health educat*/ oral/ dental health/
8	"all aged (65 and over)"	"delivery of health care, integrated" primary health care/
9	"all aged (65 and over)"	denture* / denture identif*/ denture mark*
1	dental/caries/cavit*/ cariou/cari*/cariou/ decay* /lesion*/ deminerali*/reminerali*	water/ fluoridation/fluorid*/fluorin*/flurin* flurid*



Limits applied:

Age	Language	Study type	Time limit
For water fluoridation "all adult (19 plus years)"	English	Systematic review, review, RCT	Last 25 years
For other questions "all aged (65 and over)" humans			

## Appendix 2: Flow Diagram (PRISMA, 2009)



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097.

### Appendix 3: Tables summarising the key evidence

Paper/ study type	Groups & settings	Intervention details	Outcomes	Key results	Potential strengths & limitations
<b>1. Effective agents in toothpastes for older adults</b>					
Ekstrand 2016  Review of RCTs	9 studies, 2000-2015, cross-over or longitudinal design. Subjects: adults & children. Settings: various.	Higher F toothpastes (2,500, 2,800, 5,000ppmF) compared with 1,000-1,450ppmF.	Various outcomes:  Plaque levels; Buffering capacity; Bacterial counts; F levels.	Results for 5,000ppmF toothpaste suggest a Relative Risk 0.5 ie. halves risk of root caries in elderly.	- Few RCTs - Mostly indirect outcomes; - Included studies from non-elderly; - Elderly studies restricted to root caries excluding coronal & secondary; - No RCTs have shown effect of 2,500-2,800ppmF in elderly root caries;
Innes 2009, Literature review	6 papers & 1 PhD	Higher F toothpaste & fluoride varnish	Various: DMFS, lesions arrested, root surface hardness	Toothbrushing twice daily with a 2800 ppm fluoride paste, is likely to give improved caries control over standard toothpaste. Pts should be encouraged to spit not rinse. Although costly, consider applying 5% NaF varnish to the same population 3-4X per year.	Concern was expressed about 5000ppmF in frail elderly citing USA limits for ingestion.
Srinivasan 2014, Parallel multicentre RCT, 6 month duration	n = 130, mean age 55yrs, (18-75yrs), with root caries, independently living dental hospital patients	Comparison of 5,000ppmF toothpaste with 1,350 ppmF	Surface hardness scores on root caries	5000 ppm F paste used twice daily significantly improves the surface hardness of otherwise untreated root caries lesions	- pts not blinded but examiners were. - generalizability (fit, dental hospital pts) - underpowered significant difference only at the end of 6/12
Wierichs 2015, Systematic	Adults 20-101 yrs Settings: various	34 papers, 28 chemical agents	5,000 ppm F- and professionally	Regular use of dentifrices containing 5,000 ppm F- and	- very few well-conducted RCTs; - some bias;

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review with meta-analysis 1947-2014		(alone or in combination)	applied CHX or SDF varnish may inactivate existing and/or reduce the initiation of RCLs.	quarterly professionally applied CHX or SDF varnishes seem to be efficacious to decrease progression and initiation of root caries, respectively	- few over 2 yrs duration
Willumsen 2007, RCT double blind crossover 4 wks each	n=32 Elderly aged 82-98yrs	Comparison of 0.2% NaF and 0.4% stannous fluoride SnF2	Plaque & gingival index	GI ns PI 0.14 sign difference in plaque scores at some sites but not overall	- Lack of washout time - Reliability assessed Clinical significance?

<b>2. Programmes involving dental professionals applying varnish or solutions to the teeth to prevent dental caries</b>					
<b>Paper/ study type</b>	<b>Groups &amp; settings</b>	<b>Intervention details</b>	<b>Outcomes</b>	<b>Key results</b>	<b>Potential strengths &amp; limitations</b>
Ghezzi 2014, Narrative review of interventions for caries prevention in dentate elders	Dentate older adults.  Settings: various	Comparison of: fluoride, chlorhexidine, xylitol, casein phosphopeptide- amorphous calcium phosphate, ozone, and herbal liquorice	Various outcomes	Good evidence for fluoride modalities only.	Research needed on the development and evaluation of combinations of therapeutic interventions and dental caries management by risk assessment.
Powell 1999, RCT comparing different caries- preventive strategies	297 subjects (lower-income, ethnically diverse) aged 60+ randomized into 5 experimental groups  Setting: USA	0.12% CHX rinse wkly  DHE in groups of 6- 8, with a health educator. Groups: 1. Control. 2. DHE (2hrs in group of 6-8) 2X yearly. 3 DHE & CHX rinse weekly. 4 DHE & CHX rinse weekly & FV applied by hygienist 2x yearly 5 as 4 + scaling and root planing by a dental hygienist every 6 months  Groups 3, 4 and 5 had monthly	Outcomes assessed annually for 3 years  90% overall compliance (from monthly phone survey)	Groups 3, 4 & 5 had 27% reduction for coronal caries events ( $p = 0.09$ ) and 23% for root caries events ( $p =$ 0.15), when compared to the groups 1 & 2. FV did not give additional benefit.  When extractions were excluded there was no significant treatment effect among the experimental groups. The same trend was found in root caries.	Limitations: Details of examination, calibration and reliability unclear

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		reminders for regular use of chlorhexidine			
Raghoonandan 2011, Evidence review of on the use of fluoride varnish in elderly people living in long term care facilities.	Studies included 10 papers, 6 clinical trials, and 4 systematic reviews met the inclusion criteria. Subjects aged 65+ in care homes. Settings: care homes, several countries	Use of FV in long term care facilities	Various outcomes: caries increment, progression, microbiological	Effectiveness of FV in preventing coronal and root caries in individuals living in care homes; however, these findings are shown in elderly people who receive assistance with oral hygiene.	Findings may not apply if elderly have no help with oral hygiene. Many FV studies were in children and adolescents.
Weintraub 2003, evidence review to develop a community-based protocol for people with special needs or those who are caries susceptible	Studies included 19 review, 1 systematic review, 3 meta-analyses. Subjects – all ages. Settings: various	Fluoride varnish (FV)	Various outcomes: caries increment, progression, microbiological	If personnel are available, FV use is preferred to APF gel and may be preferable to 0.2% NaF mouthrinse. FV is more effective in optimally fluoridated communities.	Few FV studies among special need populations
Wierichs 2015, Systematic review of 34 papers	Subjects 20 to 101 yrs old Settings: various	28 chemical agents (alone or in combination)	Various measures of initiation & progression of root caries: caries increment, progression, root caries index	Regular use of dentifrices containing 5,000 ppm F- and quarterly professionally applied CHX or SDF varnishes seem to ↓ progression and initiation of root caries.	Based on 2-3 RCTs. per agent. Short follow-up (median 15 months).

<b>3. Oral hygiene regime to improve oral health and possibly reduce the risk of aspiration pneumonia</b>					
<b>Paper/ study type</b>	<b>Groups &amp; settings</b>	<b>Intervention details</b>	<b>Outcomes</b>	<b>Key results</b>	<b>Potential strengths &amp; limitations</b>
Linuma 2015, Cohort study	524 randomly selected older adults (aged 85-102) living independently. Followed up annually for 3 years until 1st hospitalization for or death from pneumonia.  Setting: Tokyo	Observation of : oral health status oral hygiene behaviours medical assessment, including blood chemistry.	Serious pneumonia event – death or acute hospitalisation	20 deaths & 28 acute hospitalizations were identified. Of 453 denture wearers, 186 (41%) who wore their dentures during sleep were at higher risk for pneumonia than those who removed their dentures at night (log rank P = 0.021, Risk Ratio 2.4).  Denture wearing during sleep is associated with oral inflammatory and microbial burden and with incident pneumonia.	Potential limitations: - May have underdiagnosed pneumonia - Aged group - Tokyo setting
Juthani-Mehta, 2015 Cluster RCT	834 participants, 86 mean age, screened +ve for poor OH & swallowing difficulty, 36 nursing homes, 2.5 year follow up planned. Setting: USA	Intervention: • manual brushing (+/- assistance) • 0.12% CHX rinse twice daily • upright positioning during feeding.	Clinical signs of Pneumonia or Lower Respiratory Tract Infection (LTRI)	No differences for pneumonia or LRTI. The trial was terminated at 1.1 years for futility.	Strengths: + Large cluster RCT + Well balanced at baseline + Compliance assessed & 88% for CHX. Potential limitations: - all Connecticut based - minor plaque assessment issue

Manger, 2017 Systematic review	5 studies relate to the population of interest – excluding ICU/hospital settings  Settings: USA, Japan	Interventions were combinations of: CHX, povidone iodine, toothbrushing after meals, Professional oral health care daily or weekly, electric toothbrushing	Pneumonia incidence & mortality; plaque indices; bacteriology – colonies of pathogens	Tooth brushing after each meal, cleaning dentures once a day, and professional oral health care once a week, reduced the incidence of aspiration pneumonia. Chlorhexidine rinse or gel may give additional benefit.	Limitations: most of the evidence is for patients who are critically ill in an intensive care unit. Most of the interventions include weekly professional care (ie. professional cleaning by a dentist or hygienist) or the use of chlorhexidine rinse or gel or povidone iodine or combinations of these interventions.
Van der Maarel-Wierink 2013, Systematic review of 5 studies	Elderly in care homes  Settings: care homes in Japan & USA	Mouth cleaning by carer.	Various outcome measures used.	2 studies showed that improvement of oral health care ↓ risk of developing aspiration pneumonia and the risk of dying from aspiration pneumonia directly. 3 studies showed that adequate oral health care ↓ amount of potential respiratory pathogens and suggested a reduction in the risk of aspiration pneumonia by improving the swallowing reflex and cough reflex sensitivity.	4 of the studies were all Japan based; varied measures; few studies
<b>4. Programmes of training in oral health care for care staff/carers</b>					
<b>Paper/ study type</b>	<b>Groups &amp; settings</b>	<b>Intervention details</b>	<b>Outcomes</b>	<b>Key results</b>	<b>Potential strengths &amp; limitations</b>
Day, 1998, de Baat, 1993, De Visschere 2011, 2012, 2013,	Various care settings. International studies.	Training programmes in oral health care for care staff/carers.	Various	Evidence appraised by NICE 2016: There is some evidence that education combined with active monitoring of	Not applicable



<p>Fjeld 2014, MacEntee 2007, NICE 2014, NICE 2016, Nicol, 2005, Peltola, 2007, Sjogren 2010, Sloane 2013, Van der Putten 2013, Weening-Verbree 2013, Zenthöfer 2013</p>				<p>compliance by care home staff or specific guideline introduction within the home, might be more effective [than education or guideline introduction alone]. Education was found to increase staff knowledge in the short term but evidence for long term retention of this knowledge was inconsistent. There was no clear indications as to whether intervention intensity (the number of hours of education) or specific components had an effect on clinical oral health outcomes.</p>	
<p>Kuo 2016 RCT</p>	<p>Family caregiver for stroke survivors  Setting: Taiwan</p>	<p>Experimental group 48 family caregivers who received the home-based oral care training programme, control group of 46 family caregivers who received routine oral care education.</p>	<p>The outcomes were measured by the Knowledge of Oral Care, Attitude towards Oral Care, Self-Efficacy of Oral Care and Behaviour of Oral Care before the training programme, and at one and two months afterwards</p>	<p>The findings demonstrated that the intervention group had more knowledge (<math>t = 8.80, P &lt; 0.001</math>), greater self-efficacy (<math>t = 3.53, P &lt; 0.01</math>) and better oral care behaviour (<math>t = 11.93, P &lt; 0.001</math>) than the control group at one and two months, with statistically significant differences in oral care knowledge, self-efficacy and behaviour outcome over time. The attitude of the intervention group towards oral care practice was generally positive (mean of</p>	<p>Limitations: Taiwan setting – may not be generalisable; short-term outcomes; no clinical outcomes assessed.</p>

				<p>baseline and two month = 12.9 and 14.7), but no significant difference in attitude change between the control and intervention groups (<math>t = 1.56</math>, <math>P = 0.12</math>). The treatment interaction effect was significant for the family caregivers' behaviour of oral care at one and two months of the intervention for both groups.</p>	
<p>Mariño 2014, Parallel RCT in a nursing home for elderly in Japan.</p>	<p>34 dentate elderly over 74 years 14/intervention 16/control Setting: Japan</p>	<p>Care package with training of carers in oral hygiene methods.</p>	<p>Changes in oral microbiological parameters (number of bacteria in unstimulated saliva; whole bacteria, Streptococcus, Fusobacterium and Prevotella: opportunistic pathogens detection: and index of oral hygiene evaluation [Dental Plaque Index, DPI]) within the intervention period. Each parameter was evaluated at</p>	<p>After the intervention the percentage of Strep. species increased significantly in the intervention group (Intervention, 86% [12/14]; Control, 50% [8/16]: Fisher's, righttailed, <math>P &lt; 0.05</math>). DPI significantly improved in the intervention group (Intervention, 57% [8/14]; Control, 13% [2/16]: Fisher's, two-tailed, <math>P &lt; 0.05</math>). The improvement in DPI extended for 3 months after intervention. No side effects were reported.</p> <p>Conclusion: The short-term professional oral health care can improve oral conditions in the elderly.</p>	<p>Limitations: Clinical relevance of microbiology; Short-term; Generalisability.</p>

			before and after intervention period.		
<b>5. Protocols for oral care in care settings</b>					
<b>Paper/ study type</b>	<b>Groups &amp; settings</b>	<b>Intervention details</b>	<b>Outcomes</b>	<b>Key results</b>	<b>Potential strengths &amp; limitations</b>
Ajwani 2017 Literature review of 26 papers	Stroke patients	Any interventions by non-dental staff and carers	Common findings: Staff lack knowledge & skills; Lack of evidence for staff training improving oral hygiene outcomes;	Lack of oral health knowledge by nurses and poor patient attitude are reflected in infrequent assistance with stroke patient oral hygiene. There is limited evidence for the benefits of nursing-driven oral hygiene programme in reducing pneumonia incidence, and only few studies show that involving nurses in assisted oral care reduces plaque. There are some suggestions that involving nurses and speech pathologists in oral rehabilitation can improve dysphagia outcomes.	This narrative review did not appraise the strength of evidence. Context is important and nonUK studies may not be generalisable to UK.
Fiske 2000, Guidelines for oral care for longstay patients & residents	Longstay patients & residents  Based on 51 sources international setting.	Not applicable	Not applicable	Guideline produced	Guideline produced 2000 – may need updating
Lewis 2015, Descriptive paper on	Elderly in care homes	Not applicable	Not applicable	Advocates: Oral assessment; Oral care plan;	Narrative paper

Australia's first evidence based Nursing Home Oral and Dental Health Plan, introduced in 2010.	Setting: Australia			Support with daily OH; Use of skills mix; Minimal intervention for operative dental care	
NICE 2014 Guidance to LA on oral health	UK setting	Not applicable	Not applicable	NICE recommendations: Commission regular, training for frontline health and social care staff working with groups at high risk of poor oral health. This should be based on 'advice for patients' in Delivering better oral health. The aim is to ensure the needs of adults, children and young people in groups at high risk of poor oral health are addressed.	Not applicable
<b>6. Interventions promoting dietary change in community settings</b>					
<b>Paper/ study type</b>	<b>Groups &amp; settings</b>	<b>Intervention details</b>	<b>Outcomes</b>	<b>Key results</b>	<b>Potential strengths &amp; limitations</b>
Bull, 2014 Systematic review and meta-analysis of 35 RCTs and cluster RCTs (1995 to 2014)	Low-income adults  Setting: mostly USA	Interventions targeting dietary, physical activity and smoking. Content varied from provision of tailored self-help materials, individual counselling or group programmes, but was often complex and poorly	Mostly self-reported outcomes for dietary interventions	Effects were positive but small for diet (standardised mean difference (SMD) 0.22, 95% CI 0.14 to 0.29) but maintained over time for diet (SMD 0.16, 95% CI 0.08 to 0.25).	- Varied thresholds for low income - Most non-random - Non-blind assessment - Mostly self-reported outcomes - Most USA based - Interventions not clear in some

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		described. Delivery mode was 1 sessions to 2 years.			
Bully 2015 17 studies 13 RCT, 3 SRs & 1 observational study (2000-2012)	All adults Settings: various	Behaviour change interventions for lifestyle factors	Behavioural intervention in PHC with explicit statement of the theoretical model used.	Strong evidence of short-term benefit of PHC interventions based on Transtheoretical/ stages of change model (TTM) to promote healthy diet.	<ul style="list-style-type: none"> <li>- Variability of PHC definition</li> <li>- Heterogeneity of the interventions</li> <li>- Outcome measures vague or self reported</li> </ul>
Jones 2009 Literature review 1998 – 2008, 19 studies	Older people 50+ living in the community  Settings: international	Nutritional interventions also needs & barriers	Various	<p>Potential benefits from</p> <ul style="list-style-type: none"> <li>- Training peer educators as community nutrition assistants</li> <li>- Social eating eg lunch clubs or involving other family members</li> <li>- Home care workers allocated longer time slots to assist with nutrition</li> <li>- Packages of care including diet and activity may be more effective in improving the ability to perform activities of daily living, than diet alone.</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of evaluation of initiatives that may impact older people's diet</li> <li>• Lack of coordination of service provision</li> </ul>
Maderuelo-Fernandez, 2015 Systematic review (1990-2013) of 14 studies to evaluate the effects on	Primary care settings  Setting: USA, UK, Netherlands, Italy Spain	All adults	Reported dietary intake	7/10 studies which had a nutrition focus achieved significant increase in fruit & veg intake	<ul style="list-style-type: none"> <li>- Most 12-months follow-up or less</li> <li>- Self-reported outcomes</li> <li>- Excluded weight loss only studies</li> <li>- Heterogeneity of studies</li> </ul>

<p>healthy eating adherence achieved by interventions suitable for primary care settings.</p>					
<p>Marcus-Varwijk 2016 Qualitative study of 18 semi-structured 1 hr interviews using framework analysis method</p>	<p>Older adults (aged 55-98) living independently or in sheltered housing. Setting: Netherlands</p>	<p>Asked: what are the perspectives and experiences of older adults regarding healthy living and their interactions with professionals regarding healthy living?</p>	<p>Three themes emerged from the data— (a) healthy living: daily routines and staying active, (b) enacting healthy living: accepting and adapting, (c) interaction with health professionals with regard to healthy living:</p>	<p>Older adults experience healthy living in a holistic way in which they prefer to live active and independent lives. Health professionals should focus on building an equal relationship of trust and focus on positive health outcomes, such as autonomy and reciprocity. and self-sufficiency when communicating about healthy living.</p>	<p>- Mainly women - All Dutch – generalisability?</p>
<p>Michie 2009 Systematic review &amp; meta-analyses Systematic review of 122 evaluations of behaviour change (BC) interventions to promote physical activity &amp; healthy eating</p>	<p>Adults 18+ Settings: various</p>	<p>Interventions using cognitive or BC strategies (excluded those limited to information giving)</p>	<p>Self-monitoring explained most of among-study heterogeneity (13%). Interventions that combined self monitoring with at least one other technique derived from control theory sign. more</p>	<p>Clear support for including in interventions designed to promote healthy eating and physical activity:</p> <ul style="list-style-type: none"> <li>• self-monitoring of behaviour;</li> <li>• prompting intention formation; prompting specific goal setting;</li> <li>• providing feedback on performance;</li> <li>• prompting review of behavioural goals</li> </ul>	<p>- Small effect size (0.31). - Large heterogeneity. - No studies combined all 5 design features. + Sensitivity analysis suggests findings are robust.</p>

			effective (0.42 vs. 0.26)		
NICE 2014 Guideline for LA on oral health	3 studies of older adults – none directly relevant to this question	Not applicable	Not applicable	<p>NICE recommended ensuring all public services promote oral health by:                      Making plain drinking water available for free.                      Providing a choice of sugar-free food, drinks (water or milk) and snacks (including fresh fruit), including from any vending machines on site (see the NICE guidelines on obesity and obesity: working with local communities)                      This includes services based in premises wholly or partly owned, hired or funded by the public sector such as: leisure centres; community or drop-in centres; nurseries and children's centres; other early years services (including services provided during pregnancy and for new parents); schools; and food banks.                      Review other 'levers' that local authorities can use to address oral health and the wider social determinants of health, for example, local planning decisions for fast food outlets (see recommendation 11 in the</p>	Recommendations based on limited direct evidence but professional opinion and best practice for other age groups.

				NICE guideline on prevention of cardiovascular disease). Explore the possibility of linking with local organisations in other sectors (for example, local shops and supermarkets) to promote oral health. This could be part of a broader approach to promoting healthier lifestyles including helping people to reduce their tobacco and alcohol consumption.	
Sahyoun 2004, Literature search (1990-20013) on nutrition education interventions for older adults. 25 studies were included.	Older adults 55+  Setting: mainly USA	Community-based intervention articles with measurable outcomes or evaluation components	Although interventions tended to report limited success in behaviour change, certain features had positive outcomes.	Features of successful interventions: limiting educational messages to one or two; reinforcing and personalizing messages; providing hands-on activities, incentives, cues, and access to health professionals; and using appropriate theories of behaviour change. A theoretical framework was developed.	- Included studies general low quality: - Convenience samples in some - No power calculation - High attrition - Short duration
<b>7. Outreach programmes &amp; interventions to independently living older people eg mouthcare advice to groups</b>					
<b>Paper/ study type</b>	<b>Groups &amp; settings</b>	<b>Intervention details</b>	<b>Outcomes</b>	<b>Key results</b>	<b>Potential strengths &amp; limitations</b>
DeBaat 1993, Literature review 15 studies	Elderly living independently  Setting: various	Various community Based interventions	Various	Group session OHE can improve OH at 6/12; Confused (even mildly) show no benefit; mailed invitation to attend GDP – no effect; monitoring	Insufficient detail of studies to assess.



				& feedback improved OH.	
Hakuta 2009, Control trial	Independently living elderly (mean age 75yrs) 85%+ dentate, all females, test – 79; control – 62  Setting: Tokyo elderly activity centre setting.	6 x 2hr group sessions over 3months. Given oral health information and oral function exercise programme	Self assessed oral health; oral dryness; malodour; food debris; tongue coating; muscle function	All observations improved p<0.01 Self assessed chewing function also improved.	- No randomisation - Dubious basis for facial & tongue exercises and salivary gland massages - 25% drop-out - No calibration or training mentioned - Nonblind exam - High risk of bias Generalisability low
Hjertstedt 2013, Pre–post study design to assess the impact of educational intervention - community-based geriatric dentistry rotation on older adults' oral health literacy and oral hygiene – home visits	67 older adults, who resided in independent or assisted living apartments (mean age 84) Setting: USA	Community-based geriatric dentistry rotation involving multiple interactions with dental students: 1. oral health literacy (approx. 30 min, 1 visit) 2. importance and methods of oral hygiene (approx. 15 min/visit, 4 visits) 3. benefits of fluoride (approx. 15 min, 1 visit) 4. role of saliva in oral health (approx. 15 min/visit, 1 visit) 5. oral side effects of medications (approx. 15 min/visit, 1 visit)	Health literacy was assessed using the Rapid Estimation of Adult Literacy in Dentistry (REALD–30) test at baseline and on the final visit. Oral hygiene was measured on four visits using the O'Leary, Drake and Naylor Plaque Control Record (PI).	REALD-30 scores significantly increased, and PI scores significantly decreased for all subjects following participation in the programme (p < 0.001, and p < 0.01, respectively). Hierarchical multiple regression demonstrated that neither study subjects' individual characteristics nor their health literacy significantly predicted the change in oral hygiene.  Programme can, in the short term, significantly and positively impact older adults' oral health literacy and oral hygiene status.	Convenience sample; no control group; mainly white females;

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		6. oral-systemic connections (approx. 15 min/visit, 1 visit) 7. aspects of nutrition and diet related to oral health (approx. 15 min/visit, 1 visit).			
Hoogendijk, 2016, Evaluation of 3 programmes by randomised trials	Independently living frail older adults  Setting: Netherlands	Multidisciplinary approach, with personalised care based on comprehensive geriatric assessment undertaken by practice nurse at home visit	Various disease markers assessed from questionnaires and record reviews	Small effect shown in some aspects of 1 study. 2 studies failed to show effectiveness/cost effectiveness over conventional care.	Limitations: generalisability
Kim 2016, Systematic review on the role of Community-based health workers (CBHW) in general health, non-dental preventive roles.	61 RCTs included  Setting: mostly USA	Community-based health workers (CBHW) in preventive role in community setting, workplace or home visits	Various disease markers, compliance with screening	Interventions by CBHWs appear to be effective & cost-effective for certain health conditions, particularly when partnering with low-income, underserved, and racial and ethnic minority communities.	Future research is warranted to fully incorporate CBHWs into the health care system to promote non-communicable health outcomes among vulnerable populations.  Findings may not be applicable to mid- or high income populations.
Mariño 2013, Quasi-experimental design with a	Independently living elderly (mean age 72yrs). Test 74; Control	nondental peer educator 4x10min OHI 10x20 min sessions	plaque & bleeding scores; questionnaire	improved gingival bleeding & confidence in own ability in oral self care is more likely in test group	- No information about allocation of clubs to test group - No information on drop-outs - Calibrated, blind assessment

pretest–posttest nonequivalent control group	70. Setting: Australia, Melbourne, social clubs for Italian elderly.	on oral health issues		AVOVA controlled for baseline scores	
Marshall 2009, Programme description for ElderSmile, New York	Independently living aged 65+, mixed ethnicity group, living in low income area  Setting: USA	Outreach sessions at community settings using UG dental students for OHE and participants offered dental exam by staff and referral to community clinic	Descriptive of participants	55% rated oral health as poor or worse at the start. Issues identified. Further evaluation planned.	Limitation to the programme: <ul style="list-style-type: none"> <li>• Treatment costs for participants prompted to seek care;</li> </ul> Difficulties integrating OHE sessions & examinations into the timetable for the community centre.
NICE 2014 Guidance to LA on oral health	3 studies related to older adults one RCT (UK) and two cluster non-randomised controlled trials (Australia)  Setting: UK & Australia	Not applicable	Not applicable	NICE recommendations: Commission regular, training for frontline health and social care staff working with groups at high risk of poor oral health. This should be based on 'advice for patients' in Delivering better oral health. The aim is to ensure they can meet the needs of adults, children and young people in groups at high risk of poor oral health. Provide tailored interventions to help people at high risk of poor oral health who live independently in the community. This could include outreach services, for example, for people who are homeless or who	Recommendations based on limited direct evidence but professional opinion and best practice for other age groups.

				frequently change location, such as traveller communities. Ensure services deliver evidence-based advice in line with the 'advice for patients' in Delivering better oral health.	
<b>8. Multidisciplinary integrated preventive approach in primary care for independently living older people</b>					
<b>Paper/ study type</b>	<b>Groups &amp; settings</b>	<b>Intervention details</b>	<b>Outcomes</b>	<b>Key results</b>	<b>Potential strengths &amp; limitations</b>
Looman 2016 Quasi-experimental design to assess cost-effectiveness of the Walcheren Integrated Care Model (WICM) after 12 months from a societal perspective.	184 frail elderly patients from 3 GP practices that implemented the WICM were compared with 193 frail elderly patients of 5 GP practices that provided care as usual.  Setting: Netherlands	Features of WICM: GP functions as care coordinator & partner in prevention; GP practice is a single entry point for the elderly, carers & health professionals; GPs assess all elderly for frailty; Home visits for fuller assessment if high score; multidisciplinary working & treatment planning using EB protocols; pt representation on steering group.	Effects were determined by health-related quality of life (EQ-5D questionnaire). Costs were assessed based on questionnaires, GP files, time registrations and reports from multidisciplinary meetings. Average costs and effects were compared.	Neither the WICM nor care as usual, resulted in a change in health-related quality of life. The average total costs of the WICM were higher than care as usual (17 089 euros v 15 189 euros). The incremental effects were 0.00, whereas the incremental costs were 1970 euros. WICM is not cost-effective at 1 year and the costs per quality-adjusted life year are high. The incremental cost-effectiveness ratio (ICER) was calculated, and bootstrap methods were used to determine its reliability. An ICER of 412 450 euros.	May have been baseline differences between groups; Difficulties in cost estimations.
Lowe 2007, RCT	Independently living subjects aged 75+, pts at 3	Clinical dental examination in GMP setting with referral	Assessed: 1.attendance at checks at GMP;	87% attended for an oral health check (no exam) 50% attended a subsequent	Excluded those with any cognitive impairment. Setting was affluent urban

	<p>general medical practices</p> <p>Setting: Cheshire, UK</p>	if needed.	2. attendance at GDP at 6 months from intervention.	<p>appt for exam at the GMP. 36% of these had not attended in 10yrs. 56% v 47% (sign.↑ ) had attended a GDP within 6/12 of the intervention. Offer of exam was taken up best by those with current oral problems or pain and those with no regular dentist.</p>	Cheshire.
<p>Siebenhofer 2017 Systematic review of cluster RCTs</p>	<p>29 papers</p> <p>Setting: Austria, studies international</p>	GP based complex interventions for varied ages & population groups & conditions	22 aspects of quality in design and reporting	85% of the studies failed to show benefit in predetermined primary patient based outcomes. 15 showed a significant effect size.	Review showed several common limitations in design & reporting of studies. It advocated better handling of missing data and improved statistical methods in cluster-RCTs
<p>Sin 2015, Descriptive paper of development of a Reference Framework for Preventive Care for Older Adults</p>	<p>Older adults living independently attending General Medical Practice (GMP).</p> <p>Setting: Hong Kong.</p>	Inclusion of oral health in preventive protocols used in GMP for all elderly & in a personal prevention plan which is monitored & reviewed,	Not applicable	Oral health is included within the framework and checklists which provide prompts to guide elderly care at any contact with GMP.	No evaluation yet of this intervention.
<p>Smith 2016 Cochrane systematic review of interventions for improving outcomes in patients with multi-morbidity in primary care and community</p>	<p>Subjects had 2 or more chronic conditions and were mostly older adults. 18 RCTs included.</p> <p>Settings: mostly USA, Canada (1) UK (1)</p>	12 studies were of change in organisation of care delivery, usually through case management or enhanced multidisciplinary team work. 6 studies were of patient-oriented	Included: clinical outcomes; mental health outcomes; patient-reported outcomes; mortality; health service use;	<p>There was little or no difference on:</p> <ul style="list-style-type: none"> <li>clinical outcomes (based on moderate certainty evidence).</li> <li>health service use (low certainty evidence),</li> </ul> <p>There was probably a small improvement in:</p> <ul style="list-style-type: none"> <li>patient-reported</li> </ul>	Overall good quality studies. Biases not fully reported by all. Varied interventions, difficult to group them. Definitions of multi-morbidity varied and did not allow studies to be combined. Difficulty identifying the most effective elements within complex interventions.

settings.		interventions, for example, educational or self-management support-type interventions delivered directly to participants.		<p>outcomes (moderate certainty evidence)</p> <p>The intervention may slightly improve</p> <ul style="list-style-type: none"> <li>• medication adherence (low certainty evidence)</li> <li>• patient-related health behaviours (moderate certainty evidence)</li> <li>• provider behaviour in terms of prescribing behaviour and quality of care (moderate certainty evidence).</li> </ul> <p>The intervention improved:</p> <ul style="list-style-type: none"> <li>• mental health (based on high certainty evidence)</li> </ul> <p>One study showed a reduction in mortality at four year follow-up (Intervention 6%, Control 13%, absolute difference 7%).</p> <p>Cost data were limited.</p> <p>Effectiveness more likely where interventions can be targeted at risk factors such as depression, or specific functional difficulties in people with multi-morbidity.</p>	
<b>9. Routine denture identification marking</b>					
<b>Paper/ study type</b>	<b>Groups &amp; settings</b>	<b>Intervention details</b>	<b>Outcomes</b>	<b>Key results</b>	<b>Potential strengths &amp; limitations</b>
Cunningham	63 denture	Denture marking	Recorded	86% felt denture marking	Potential biases:

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1993 Questionnaire survey	wearers selected from 6 nursing homes. Setting: Greater Manchester	was explained. Subjects were asked about denture marking.	answers to 5 survey questions.	would be useful. None objected.	<ul style="list-style-type: none"> <li>Care homes were chosen because staff there had asked for denture marking.</li> <li>Random selection of subjects but no details of selection beyond "able to give coherent answers".</li> </ul>
Fiske 2000, Guideline for oral health in long stay patients and residents	Not applicable	Not applicable	Not applicable	Recommendation that denture labelling be provided, subject to the patient consenting.	Recommendation based on professional opinion and best practice.
Kalyan 2014, Literature review with opinion piece	Reviewed limited literature of pt, & clinicians views & current practice. Setting: UK, Scandinavia, Australia	Not applicable	Denture marking noted as compulsory in Sweden & Iceland	Calls for denture marking to be standard practice. Potential cost saving from fewer replacement dentures. Forensic benefits too. Additional cost is disincentive	Narrative review & opinion piece
Richmond 2007 Questionnaire survey	100 randomly selected edentulous pts (mean age 65) Setting: Manchester	Shown 7 photos of different denture marking styles	Agreement to marking. Satisfaction with different types of marking.	99% agreed to marking. Favourite was transponder. No effect of age or sex.	Potential biases <ul style="list-style-type: none"> <li>Subjects were pts at dental hospital</li> </ul>

<b>10. Water Fluoridation</b>					
<b>Paper/ study type</b>	<b>Groups &amp; settings</b>	<b>Intervention details</b>	<b>Outcomes</b>	<b>Key results</b>	<b>Potential strengths &amp; limitations</b>
Do 2017 Secondary analysis of data from Australian National Survey of Adult Oral Health 2004- 2006.	4090 persons aged 15-91 years randomly sampled by a stratified, multistage probability method.  Life-time access to fluoridated water (LAFW) was calculated.  Setting: Australia	Mailed questionnaire, interview & clinical exam.	DMFS	Multivariable regression log-link models.  % LAFW was significantly associated with DMFS score in the two younger age groups, but not in the others. Multivariable regression models showed that the highest % LAFW quartile had significantly lower DMFS count than the lowest quartile in the two younger age groups (mean ratios: 0.67 and 0.78, respectively), controlling for other covariates.	Uncertainties in assessing disease & exposure.  Limitations: Under-estimate of effect size because of halo effect; Recall bias; Possible variations in F exposure over decades; Inaccuracies in water F group allocation; DMF saturation; Loss of teeth to other causes; Changing diagnostic thresholds for restoring caries; Low response rate (34%);
Griffin 2007  Systematic review 1966- 2004	9 studies of water fluoridation, published 1979- 2004. Groups: lifelong residents of fluoridated and non-fluoridated	1 prospective cohort trial that examined caries increment among randomly selected subject. 8 cross-sectional studies: 7 compared caries	Caries increment as DMFT/S, root caries increment, life- time caries increment assumed 28 teeth/128	Combined results of the 9 studies (7853 participants) showed effectiveness of water fluoridation at $p < 0.001$ .  To eliminate heterogeneity results were pooled from 5 studies of lifelong residents	Limitations: Non-blind assessment; Under-estimate of effect size because of halo effect; Recall bias; Possible variations in F exposure over decades; Inaccuracies in water F group allocation;



	communities Setting: mostly USA, also UK, Sweden, Canada, Australia	prevalence, 1 used linear regression analysis to estimate averted caries increment attributable to 1 yr of water fluoridation.	surfaces	of control or fluoridated-water communities (2530 participants) prevented fraction was 27.2% (95%CI: 19.4%–34.3%).	DMF saturation; Loss of teeth to other causes; Changing diagnostic thresholds for restoring caries.
Moore 2017  Economic analysis based on estimations of effects from literature.	From the literature a 40% reduction in child caries experience was assumed and 27% for adults based on NZ & Australian survey data.	Time horizon was 20 years (the expected life of capital investment in water plants). Costs included: set-up and capital; ongoing operational costs including fluoride. Five sizes of plant were used. Lowest cost combination of capital and fluoride type for each plan was assumed.	QALY estimated from multiplying the difference in the proportion of people in health states, forecast the age distribution, and then applied QoL values. Estimation of costs averted used average costs of a child or adult restoration from NZ Dental Association survey, and average time till replacement. Discounted rate used 3.5%pa.	Over 20 years, net discounted saving from adding fluoride to reticulated water supplies would be NZ\$1401 million (1:9 cost: benefit) for populations over 500 and 8800-13,700 quality-adjusted life years gained. Cost effectiveness unlikely for populations smaller than 500.	Limitations: Uncertainties in estimations; Costs estimated were conservative & excluded endodontics & indirect restorations.

			Cost of caries-associated hospitalisation was also included.		
O'Sullivan 2015  Cross-sectional study of bone health & oral health status in relation to lifetime exposure to fluoridated water	4,977 aged 50+, sampled from subjects in The Irish Longitudinal Study on Ageing. Response 62%  Setting: Ireland	Water F was area-based data (% of households in the electoral district with fluoridated water) from the 2006 Census of Ireland	Self-reported status as presence of teeth and /or dentures.  Bone mineral density in non-dominant foot.	It was found that the greater the percentage of households with a fluoridated water supply in an area, the higher the probability that respondents had all their own teeth. No significant relationship between the proportion of households with a fluoridated water supply in an area and bone mineral density.	Uncertainties in assessing disease & exposure. Limitations:  Limitations: Under-estimate of effect size because of halo effect; Recall bias; Possible variations in F exposure over decades; Inaccuracies in water F group allocation; Loss of teeth to other causes; Changing diagnostic thresholds for restoring caries; Inaccuracies in self-reported oral status.
Parnell 2009  Summary of evidence from systematic reviews	59 publications Identified, 3 systematic reviews (SR) & 3 guidelines were included which represented a total of 244 original studies	Griffin 2008: 8 cross sectional 1 cohort  NHMRC, 2007: 1 SR, 1 before & after study  McDonagh 2000: 23 before/after	DMF/dmf and adverse effects in some.	Griffin 2008 found prevented Fraction ( 95% CI) * 27.2% (19.4 to 34.3)  Others: Median Diff in % caries free (range) 14.6% (5.0%-64%) Median Diff in dmft/DMFT (range) 2.25 ( 0.5-4.4)	Most studies are of children. Risk of fluorosis does not apply to adults.  Limitations: Under-estimate of effect size because of halo effect; Recall bias; Possible variations in F exposure over decades;

	1940-2005 (inc 5SRs).  Settings: various	3 cohort		NNT 6 Australian & USA guideline's recommended continuation and extension of water fluoridation as a safe, effective, efficient and socially equitable. The Scottish guideline was superseded in 2014 & focused on dental clinical management.	Inaccuracies in water F group allocation; DMF saturation; Loss of teeth to other causes; Changing diagnostic thresholds for restoring caries.
Peres 2016 Population-based cohort study (natural experiment where water fluoridation was implemented in stages, 1982 and 1996, to different parts of the city)	1,720 participants aged 20-59 yrs were identified in 2009 and 1,140 were interviewed & examined at home in 2012.  Setting: a city in S. Brazil.	Exposure to water fluoridation from age 7 yrs onwards. Recommended water F level is 0.8ppmF.	DT & DMFT used. Multiple regression to adjust for confounders and sensitivity analysis used.	Participants living between 50% and 75% and <50% of their lives in fluoridated areas presented a DFT mean of 1.34 (95% CI, 1.02–1.75) and 1.47 (95% CI, 1.05–2.04), higher than those with access to fluoridated water for >75% of their lifetime, respectively. Adjusted final model showed dose-response relationship between proportion of lifetime access to fluoridated water and dental caries indexes.	Limitations: Under-estimate of effect size because of halo effect; Recall bias; Possible variations in F exposure over decades; Inaccuracies in water F group allocation; DMF saturation; Loss of teeth to other causes; Changing diagnostic thresholds for restoring caries.
Ran 2016 Economic analysis based	10 studies included from 564 identified published	Community water fluoridation (CWF).	Comparison of estimated benefits of DALY (Disability	The review concluded that the economic benefits of CWF exceeded the intervention costs, and that	Detailed findings cannot be directly transferred to England because of the different dental care systems & costings.

<p>on systematic review 1995-2013</p>	<p>1995-2013.  Studies from USA, Canada, Australia and New Zealand,</p>		<p>adjusted life years).</p>	<p>the cost-benefit ratio increased with the size of the population served.  Cost-benefit ratio range 1:1.12 to 1:135 and increased with community population size. CWF was cost beneficial for communities with no fewer than 1,000 people.</p>	<p>Limitations: Uncertainties in estimations; Limitations of the original studies; Few studies on smaller populations, fewer than 1000 people.</p>
<p>Spencer 2017 Longitudinal study</p>	<p>1,221 subjects aged 20-35yrs were followed up from 1991/92 cross-section of South Australian children (then aged 5-17yrs) achieving a 50% loss to follow-up.  Setting: South Australia</p>	<p>Residential history used to compute percent lifetime access to fluoridated water (%LAFW).</p>	<p>DMFS from clinical examination</p>	<p>Mean DMFS 5.57. Adjusted RR of DMFS for %LAFW (Birth-2006) 0-75 percent against 100 percent was 1.26 (1.01-1.57).</p>	<p>Uncertainties in assessing disease &amp; exposure. Limitations: Under-estimate of effect size because of halo effect; Possible variations in F exposure over decades; Inaccuracies in water F group allocation; DMF saturation; Loss of teeth to other causes; Changing diagnostic thresholds for restoring caries. Less recall bias and improved accuracy of %LAWF because of study design. The low exposure group had nearly 50% life exposure so the strength of association is likely to be underestimated.</p>

## Appendix 4: Tables summarising the evidence & recommendations

<b>Nature of intervention</b>	<b>Target population</b>	<b>Strength of evidence</b>	<b>Likely impact on inequalities</b>	<b>Implementation issues</b>	<b>Overall recommendation</b>
1. Use of dentifrices containing 2,800 or 5,000 ppm F	Universal	Strong evidence of effectiveness	Likely/uncertain depending on compliance	Deliverable. Needs prescription or Patient Group Directions (PGDs).	Recommended. There must also be effective toothbrushing in addition.
Further information  Publications reviewed	Daily use of higher fluoride containing toothpaste will prevent or arrest caries in dentate vulnerable older people.  Ekstrand 2016, Innes 2009, Srinivasan 2014, Wierichs 2015, Willumsen 2007				

<b>Nature of intervention</b>	<b>Target population</b>	<b>Strength of evidence</b>	<b>Likely impact on inequalities</b>	<b>Implementation issues</b>	<b>Overall recommendation</b>
2. Programmes involving dental professionals applying varnish to the teeth to prevent dental caries.	Care homes/ community settings	Strong evidence of effectiveness	Likely/uncertain depending on compliance	Deliverable. Additional benefit is given by application of fluoride varnish by dental professionals.  Costs can be contained by use of a suitably trained dental care professional (need not be a dentist).	Recommended. There must also be effective toothbrushing in addition.
Further information          Publications reviewed	There is good evidence for the effectiveness of quarterly application of fluoride varnish. There needs to be daily oral cleaning too – application of varnish is not a substitute for brushing.          Ghezzi 2014, Powell 1999, Raghoonandan 2011, Weintraub 2003, Wierichs 2015				

Nature of intervention	Target population	Strength of evidence	Likely impact on inequalities	Implementation issues	Overall recommendation
3. Oral hygiene regime to improve oral health and possibly reduce the risk of aspiration pneumonia	Universal	Sufficient evidence of effectiveness	Likely/uncertain depending on compliance	Deliverable	Recommended
Further information  Publications reviewed	<p>Maintaining oral hygiene is crucial to maintaining patient’s dignity and their oral health. In addition, there is evidence that oral hygiene interventions reduce the risk of pneumonia in community-living and hospital-based patients. But caution is needed about the interpretation of this result. Most of the evidence is for patients who are critically ill in an intensive care unit. Most of the interventions include weekly professional care (ie. professional cleaning by a dentist or hygienist) or the use of chlorhexidine rinse or gel or povidone iodine or combinations of these interventions. Reducing dental plaque levels by assisted toothbrushing alone, has not been shown, in a well-designed trial, to impact the incidence of pneumonia. van der Maarel-Wierink’s team summarise their conclusions as “oral health care consisting of tooth brushing after each meal, cleaning dentures once a day, and professional oral health care once a week, seems the best intervention to reduce the incidence of aspiration pneumonia”. Chlorhexidine rinse or gel may give additional benefit. Clearly further research is needed to establish an oral hygiene protocol that is effective in reducing the risk of pneumonia.</p> <p>linuma 2015, Juthani-Mehta 2015, Manger 2017, van der Maarel-Wierink 2013, NICE 2016</p>				











Nature of intervention	Target population	Strength of evidence	Likely impact on inequalities	Implementation issues	Overall recommendation
8. Comprehensive geriatric assessment & multidisciplinary integrated preventive approach in primary care for independently living older people including integration of oral health into primary care & opportunistic assessment of need	Independently living older people	Inconclusive evidence of effectiveness	Uncertain	Deliverable/uncertain	Emerging evidence
Further information  Publications reviewed	<p>Limited evidence and small but important effects. Examples are:</p> <ul style="list-style-type: none"> <li>• A checklist for older adults can act as a trigger for primary care practitioners to check on aspects of older people’s health including oral health.</li> <li>• Offering a dental appointment can increase care uptake among those with no regular source of care.</li> </ul> <p>Lowe 2007, Siebenhofer 2017, Sin 2015, Looman 2016, Oliver 2014, Smith 2016</p>				





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