Oral health for adults in care homes: economic report

Oral health: promoting and protecting oral health and ensuring access to dental treatment for adults in nursing and residential care homes. Economic report based on a cost-consequence analysis

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Summary

This report summarises an economic model based on a cost consequence analysis with a two year time horizon exploring interventions to improve the oral health of residents in nursing homes as follows:

Scenario 1

An education session of 1 hours duration is provided to nursing home staff in year one with a refresher session in year two of 1 hours duration. The cost of providing daily oral care to residents is estimated. Scenario 1 is based on a study carried out in England by Frenkel et al. (2001).

Scenario 2

An education session of 4 hours duration is provided to nursing home staff in year one with a refresher session in year two of 2 hours duration. The cost of providing daily oral care to residents is estimated. In addition the scenario includes development of six generic oral health care plans, an assessment of oral health needs (20 minutes) on admission to the nursing home and frequent monitoring of compliance with oral care throughout the two year period. Scenario 2 is based on a study carried out in Ireland by Samon et al. (2009).

Results

Consequences

The consequences in scenario 1 are derived from Frenkel et al. (2001) at a follow-up of 6 months following the educational intervention. At 6 months versus baseline the absolute mean decrease (improvement) in dental plaque index was a 0.28 scale points; in gingival score 0.29 scale points; and in denture plaque index 1.16 scale points.

The consequences in scenario 2 are derived from Samson et al. (2009) at a follow-up of 3 months following intervention. At 3 months versus baseline the absolute mean difference in mucosal plaque score was a decrease (improvement) of 1.5 scale points; the change in the percentage of subjects with an acceptable MPS score (of 2-4) was an increase of 39%.

In addition the Public Health Advisory Committee drafted a statement summarising likely benefits considered to arise from delivery of adequate oral care to people resident in care homes, for additional consideration relative to the costs of the interventions.

Costs

All costs are incurred to the nursing home over a two year period. The base case estimates the costs of Scenario 1 as £15,153.92 and Scenario 2 as £30,240.65. In both scenarios the costs of delivering the education sessions (£298.78 in Scenario 1, £719.41 in Scenario 2) are small relative to the cost of performing oral health care for nursing home residents (£14,855.15). In scenario 2 the activity of monitoring compliance with oral care is substantial, at £14,274.71.

Sensitivity analysis

In the one way deterministic sensitivity analysis the only parameters which, when varied, have a large effect on the total cost in either scenario are those which relate to consumption of a high volume of staff time. These are:

- The total number of residents (but dependent on the proportion of residents who require help with daily oral care)
- The proportion of residents who require help with daily oral care
- The level of individual (salary) tasked with monitoring compliance with oral care
- The time required to monitor compliance with oral care.

Of these the most modifiable factor is the activity of monitoring compliance. This cost could be substantially reduced if compliance checks were performed only on a proportion of residents' care notes.

Conclusions

The model suggests 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.

The model has estimated the cost of delivering an acceptable volume of routine, daily oral care activity. For care homes that already achieve this level of oral care, the cost of delivering oral care would not apply, since it would already be absorbed within the care home's expenditure. However there always exists the opportunity cost of performing oral care for residents because it competes for carers' time with all other care activities.

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1 Background

1.1 Commissioned work

The National Institute for Health and Care Excellence (NICE) has been asked by the Department of Health (DH) to develop a public health guideline for carers working in health and social residential care settings (including nursing homes and residential care homes) on effective approaches to promoting oral health, preventing dental health problems and ensuring access to dental treatment when needed. The final scope for the development of this guideline is available on the NICE website (NICE 2014).

In planning the development of the guideline, NICE commissioned the Specialist Unit for Review Evidence (SURE) at Cardiff University to conduct a review of the effectiveness (Review 1), best practice (Review 2) and the barriers and facilitators (Review 3) of the 'Approaches for adult nursing and residential care homes on promoting oral health, preventing dental health problems and ensuring access to dental treatment'.

In addition NICE commissioned Cedar to undertake three pieces of work:

- A review of published economic studies of the interventions to promote oral health, prevent dental problems and ensure access to treatment for adults in care home settings (Review 4).
- A review of studies to explore whether poor oral health has an adverse impact on general health and well being , and whether a rapid deterioration in oral health is observed when a person is admitted to a care home (Review 5).
- A *de novo* economic model of promoting oral health, preventing dental health problems and ensuring access to dental treatment for adults in nursing and residential care homes, based on the findings of Reviews 1, 4 and 5.

1.2 Interpretation of commissioned work

1.2.1 Review 1

The effectiveness review (Review 1) included 46 studies reporting data on a range of interventions relevant to the guidance scope. The studies reported as outcomes: changes in oral health indices in adults in care homes, changes in indices of the degree of knowledge about oral care possessed by care givers and changes in the compliance of care givers in delivering oral care. Some interventions and outcome measures were sufficiently homogeneous to permit meta-analyses; these are reported in Review 1. Review 1 also includes 17 evidence statements on the effectiveness of different interventions. Overall the evidence for different interventions is complex and often the findings are inconsistent.

However a salient, general finding of Review 1 is that the oral health of adult care home residents is improved by three types of intervention, which may work in synergy:

- Education of care home staff in the oral care of residents (Review 1, evidence statements 1 and 2)
- Introduction of a local protocol, guideline or policy to standardise oral care in the care home (Review 1, summarised in Evidence Statement 3): this may include the use of an oral health

assessment tool to determine the oral health needs of the resident and in response, individualised planning of oral health care.

- Use of an enhancement to the educational intervention (Review 1, Evidence Statement 4): this may represent periodic assessments to determine whether care home staff are providing effective oral care e.g. visits by a dental hygienist to measure the level of plaque on residents' teeth or dentures.

1.2.2 Review 4

Review 4 revealed that there is a paucity of published economic evidence to support the training of care home staff in oral care to improve the oral health of care home residents. Two cluster randomised trials were identified, which provided estimates of the cost of providing oral care education to care home staff, one based on direct training (Frenkel et al. 2001), and the other based on a 'train the trainer' approach (Mac Giolla et al. 2015). The Frenkel study has high applicability to the UK since it was conducted in Avon, England. The economic analysis by Mac Giolla was based on care homes for adults with intellectual disability in Dublin, Ireland. A draft manuscript was made available to the modelling team on an 'academic in confidence' basis but the results are not yet published in a peer-reviewed journal.

This small volume of economic evidence confirmed to NICE that a *de novo* economic model will be informative to guidance development.

1.2.3 Review 5

Review 5 identified evidence from systematic reviews of epidemiological studies which show that poor oral health may be associated with cardiovascular disease and respiratory disease (Blaizot et al. 2009, Lafon et al. 2014, Dietrich et al. 2013, Agado et al. 2012, van der Maarel-Wierink et al. 2011, van der Maarel-Wierink et al. 2013, Scannapieco 2003). However evidence is lacking to demonstrate that poor oral health directly causes either cardiovascular or respiratory disease. The risk factors for cardiovascular disease in the general adult population are understood to act over decades, rather than in the relatively short term over which a person is resident in a care home. Also many care home residents are likely to have numerous chronic health problems and polypharmacy, therefore extrapolation of findings from the general population to the adult care home population may be tenuous. For these reasons the review team, supported by NICE and the committee, opted not to include in the de novo economic model, systemic health states, but to restrict to measures of oral health.

In addition review 5 revealed than oral health in adults in care homes is generally poor, suggesting that potentially many residents have unmet oral health needs. However there was no reliable evidence to demonstrate that an adult's oral health deteriorates (rapidly or otherwise) following admission to a care home.

1.3 Decision making process

In discussion with the Public Health Advisory Committee (PHAC) and the NICE project team, the potential of all the commissioned work to inform the model was considered. It was agreed that the best available evidence to inform the economic model was identified in Review 1 evidence statements 3 and 4. These two evidence statements are based on a narrative synthesis of evidence

from 17 prospective published studies of effectiveness (Altabet et al. 2003; Amerine et al. 2014; Bellomo et al. 2005; Binkley et al. 2014; Budtz-Jorgensen et al. 2000; Chalmers et al. 2009; de Visschere et al. 2011; de Visschere et al. 2012; Lange et al. 2000; MacEntee et al. 2007; Pronych et al. 2010; Pyle et al. 1998; Samson et al. 2009; Sloane et al. 2013; van der Putten et al. 2013; Wardh et al. 2002; Zenthőfer et al. 2013), rather than on the meta-analyses in Review 1. This is because the meta-analyses were restricted to a small subset of the total number of included studies that examined the same interventions with the same outcome measures. Thus the results of the meta-analyses, though valid in their own right, did not reflect the general impression given by the narrative evidence statements (particularly evidence statements 3 and 4), namely, that three interventions (education, protocol use and checking that care home staff provide adequate oral care) can improve the oral health of care home residents.

1.4 Aim

The aim of the economic model is to estimate the costs and consequences of interventions (education, protocol use, compliance checking) shown to be effective in improving oral health of adults in care homes in review 1, evidence statements 3 and 4. In the absence of utility values for the clinical outcomes reported in the source studies, or an acceptable method for converting those outcomes to utilities, it was not possible to undertake a cost utility analysis.

2   Methods

We sought to model as interventions: direct education of care home staff, use of a protocol for planning and delivering oral care and compliance checking, based on evidence Statements 3 and 4 (Review 1). Due to study heterogeneity we did not attempt to define an intervention based on all 17 included studies, but rather sought to identify a minimum number of studies to represent the three interventions. The approach taken aimed to optimise a compromise considering the following study characteristics:

- Level of evidence (randomised trial being the ideal)
- Study quality
- Applicability to the UK
- Consistency of interventions with the draft recommendations being developed by PHAC
- Positive oral health outcomes (given some inconsistency in the studies cited for evidence statements 3 and 4: not all studies yielded a positive outcome, though the majority did).

Bearing these factors in mind two studies were selected, upon which to construct interventions in the model: a cluster randomised trial (with economic analysis) conducted in Avon, England (Frenkel et al. 2001), and an uncontrolled before-and-after study conducted in elderly care home residents in Norway (Samson et al. 2009).

The structure of the economic model comprises two distinct scenarios:

- Scenario 1 is based on the educational intervention studied by Frenkel et al. 2001 and models only education, but with direct applicability to the UK.

- Scenario 2 is based on the 5 interventions studied by Samson. These interventions represent the three elements of education, protocol use and compliance checking.

2.1 Population and setting

The scope describes the relevant population as "adults in care homes with or without nursing provision, including people staying for rehabilitation or respite care". In this guideline the term 'care home' covers homes that provide 24-hour residential care". The samples studied by Frenkel et al. (2001) and Samson et al. (2009) are described below. Both study samples are within the guidance scope but do not entirely reflect it because younger adults in care homes are not included in either study.

2.1.1 Scenario 1

The Frenkel study sample was elderly nursing home residents in Avon, England, with a mean age of 84.9 years, 81.1% were female and dental status was as follows:

- Natural teeth only (19.4%)
- Natural teeth plus partial dentures (5.5%)
- Complete dentures (75.1%)

Oral health status at baseline was as follows:

- Denture wearers:
    - Mean dental plaque (SD): 2.82 (0.86)
- Dentate clients:
    - Mean dental plaque: 2.13 (0.45)
    - Mean gingivitis: 1.36 (0.40)
    - Median calculus 0.33 (IQR 0.17, 0.50)
    - Mean root caries 0.04 (IQR 0, 0.08)
    - Mean tooth mobility 0 (IQR 0, 0.08)

2.1.2 Scenario 2

The Samson study sample was long-term care nursing home residents in Norway (excluding those who were both edentulous and without dentures (84% female). Mean mucosal plaque score (MPS) at baseline was 5.4 (SD 1.4).

2.2 Interventions

2.2.1 Scenario 1

Scenario 1 is based on the intervention studied by Frenkel et al. (2001), who provided an estimate of the cost to the nursing home of the intervention as follows: 'an oral health care education (OHCE) session for caregivers employed in nursing homes was presented by a Health Promoter of 15 years' experience, with a Diploma in Dental Health Education, a Further Adult Education Teaching Certificate and a Certificate in Health Education. Each session lasted approximately 1 hour, and covered the role of plaque in oral disease, demonstrations of cleaning techniques for dentures and natural teeth, and practice of these techniques by caregivers using a manikin head, models and other teaching aids. Toothbrushes were distributed to all clients to encourage oral hygiene activity'

(Frenkel et al. (2001)). We included an additional refresher course of 1 hour's duration at 1 year following the initial education.

2.2.2   Scenario 2

Scenario 2 is based on the five-fold composite intervention studied by Samson et al. (2009), comprising:

1. Care home staff education (a four hour course, Samson et al. 2009): we modelled this in the same manner as scenario 1, but with 4 hours instead of 1 hour to deliver the teaching and as above, we added an additional refresher course 1 year following the initial education, of two hour's duration.

2. Preparation of '6 procedure cards' Samson et al. (2009), designed to form individually adapted oral care plans. We assumed that each care plan required two hours preparation time.

3. Distribution of tooth cleaning appliances / supplies.

4. Implementation of new routines in the care home: we considered this to represent the introduction of a local protocol for oral care in the care home. This includes assessing the oral health needs for every nursing home resident, and creating an individualised care plan based on a procedure card, described above. Ideally this would be done on admission for every new resident, but we have simply included one assessment per resident (at no specified time point), requiring 20 minutes to complete.

5. Regular checking of staff compliance with delivery of oral care: following discussion with PHAC and the technical team at NICE we did not model the approach described by Samson et al. (2009) based on regular visits to the care home by dental hygienist to examine the oral health of residents. Instead we agreed that compliance checking should be represented in the model by documenting in residents' care notes on a daily basis, the results of oral care assessments, relevant oral care planning and delivery of oral care.

2.2.3   Provision of oral care

In both scenarios we modelled the provision of oral care to residents who require it, using either electric or manual tooth brushes and tooth paste, and including care assistants' time spent on this task.

2.3   Comparators

For both scenarios 'doing nothing' with regard to oral care is the comparator. The comparator of 'doing nothing' is not a strategy that any commissioner of services would advocate in real life as it is inhumane. However use of a 'doing nothing' comparator estimates the full cost of the interventions modelled, whether they constitute oral care that is already performed routinely, or whether they represent new activity aimed at improving the overall standard of oral care.

2.4   Economic approach

2.4.1   Cost-consequence analysis

The economic approach is cost-consequence analysis (CCA) with a focus on oral health indices reported by the two source studies, and considering only direct costs of the interventions based on

care staff wages, capital equipment, consumables and travel costs. This provides a 'balance sheet' of oral health outcomes that decision makers can consider against the costs of the interventions (NICE 2013).

The consequences reported in the model (based on Frenkel et al. 2001 and Samson et al. 2009) are augmented by an evidence-based statement drafted by the Public Health Advisory Committee (PHAC), to emphasise additional benefits in terms of overall quality of life and wellbeing that are achieved by improving oral care (see section 2.6.3).

2.4.2   Perspective

The perspective of the model is a single nursing home. The total cost of providing the intervention in each scenario is broken down to reflect the national picture using proportions of different payment sources based on a market survey of care home providers in England by Laing and Buisson (2014) as follows.

- Total cost   100%
  - Self pay   44.1%
  - Local Authority plus top-up   13.5%
  - Local Authority no top-up   35.7%
  - NHS   6.7%

2.4.3   Time horizon

The time horizon of the model is two years based on the average length of stay for a resident reported in the literature. The consequences relate to the follow-up periods selected from the included studies: the observed improvements in oral health were achieved at 3 months (Samson et al. 2009) and 6 months (Frenkel et al. 2001). We assume that the achieved benefits are maintained for the remainder of the two-year time horizon.

2.4.4   Discount rate

A discount rate of 1.5% per annum is applied to all costs incurred after year 1 (NICE, 2012).

2.4.5   Salary on-costs

On-costs of 14% are added to salaries in line with the PSSRU recommendations (PSSRU, 2013).

2.4.6   Inflation of costs

Cost inputs to the model that predate the financial year 2013/14 are inflated to year 2013/14 costs using the Bank of England calculator (Bank of England, 2015).

2.4.7   Model platform

The model is constructed in Microsoft Excel.

2.5   Inputs to the model

2.5.1   User defined inputs

In the 'Model required' worksheet the user may define inputs to the model as follows:

- Specification of the number of residents in the nursing home in the model (range 0-100 residents, default value for base case, 40 residents). The base case value of 40 residents is based upon survey data (Royal College of Nursing, 2010).
- Specification of the percentage of residents in the model who require assistance with daily oral care (range 0%-100%, default value for base case, 83% (Frenkel et al. 2001)).
- Specification of whether residents have electric toothbrushes ('Yes'/'No', default value for base case, 'No' (i.e. manual toothbrushes); if 'Yes' is selected, the model assumes that all toothbrushes are electric).
- Selection of roles for completion of activities in the model as presented in Table 1.
- Specification of whether nursing home staff who attend oral health education require 'back filling' of their time to enable other staff to provide general care for residents while those being educated are away from normal duties ('Yes'/'No', default value for base case, 'Yes').
- Specification of how many education sessions are required in order to ensure that all relevant staff are trained (any value may be entered, default setting for base case, 1 session).

Table 1 Selection of roles for activities in the model

Scenario	Activity	Base case input (default model setting)	Rationale for base case	Alternative roles available to select
1 and 2	Prepare the educational material	Organisation external to the model (no cost incurred to the nursing home)	Recommended by PHAC.	• Dental Nurse (AfC[1] Band 4) • Oral Health Educator (AfC Band 5)
1 and 2	Provide the teaching	Dental Nurse (AfC Band 4)	Recommended by PHAC.	• Organisation external to the model (no cost incurred to the nursing home), or; • Dental Therapist (AfC Band 6), or; • Oral Health Educator (AfC Band 5)
1 and 2	Receive the teaching (learners)	Care Assistants (national minimum wage)	The education would be delivered to the Care Assistants as a priority since they provide day to day oral care.	• Care Assistants (national minimum wage) *plus* Qualified General Nurses (AfC Band 5) *plus*; Nursing home manager (note: this option sums three roles representing the entire complement of nursing home staff)
1 and 2	Provide physical daily oral care	Care Assistants (national minimum wage)	Generally accepted by PHAC.	• None
2 only	Design generic (template) care plans	Organisation external to the model (no cost incurred to the nursing home)	Recommended by PHAC.	• Qualified General Nurse (AfC Band 5)
2 only	Assess oral health and plan care	Qualified General Nurse (AfC Band 5)	Represents a suitably qualified role; general nurses are typically available.	• Care Assistant (delegated lead) • Dental Nurse (AfC Band 4)
2 only	Monitor compliance	Qualified General Nurse (AfC Band 5)	Recommended by PHAC.	• Care Assistant (delegated lead) • Manager (salary based on Sammons Healthcare Survey, 2010)

[1]AfC: Agenda for Change (NHS Salary Scales)

2.5.2   Unit cost inputs

Unit costs in the model are as follows:

- Mileage costs for travel to the nursing home to deliver education sessions are calculated as 45p per mile, with an estimated 60 miles journey per visit (657 miles divided by 11 homes in Frenkel et al. (2001)). Mileage costs are not incurred if the user selects the option that the education is delivered by a 'provider external to the model'.
- The capital cost of the teaching aids used for the education session(s) (based on the cost in Frenkel et al. (2001)) is inflated from £165.00 (1999/2000 prices) to £255.40 (2013/2014 prices). The base case assumes that the provider of education owns the capital equipment, such that the nursing home does not bear this capital cost. However the model permits an option whereby the nursing home incurs this capital cost.
- The number of oral care workbooks used in the education session(s)(based on Frenkel et al. (2001)) issued to nursing home staff is equal to the specified complement of staff. The unit cost is £0.10 (1999/2000 prices; Frenkel et al. 2001), inflated to £0.15 (2013/2014 prices) per workbook. The model costs one work book per member of staff.
- The base case assumes that residents' families provide all tooth brushing materials such that no cost is incurred for consumables to the nursing home. However the model has an option to estimate the consumables cost. The unit cost per manual toothbrush costs is £0.33 (NHS Supply Chain), assuming a need for replacement every 3 months. Electric toothbrush unit costs (£8.35) are based on amazon.co.uk, and are assumed to require a battery of two cells (unit cost £0.40, based on £3.99 for a pack of 10 AA cells). The toothbrush requires two AA cells with battery life assumed to be 1 month. The toothbrush head is assumed to require replacement every 4 months (unit cost £16.99 for a pack of 3). Toothpaste costs assume that 1ml is used twice a day at a unit cost of £0.54 for 100ml (NHS Supply Chain).
- The unit cost of laminating generic care plans (Samson et al. 2009) is assumed to be £0.05.

2.5.3   Other inputs

The model has additional inputs as follows:

- The model assumes that there is only one manager for the nursing home, irrespective of its size in terms of number of residents. However for all other staff the model maintains a ratio as follows:

  Residents : Qualified Nurse : Care Assistants   =   40 : 1 : 6

- Scenarios 1 and 2:
  - The travelling time for the educator is assumed to remain the same for both the initial course and the refresher course at 2 hours.
  - If the capital cost of the teaching aids is applied, the equipment is assumed to last 10 years (Frenkel et al. (2001)) and therefore does not incur a cost in the second year.
- Scenario 2 only:
  - It is assumed that each generic care plan (Samson et al. (2009)) takes 2 hours to create. This is an option in the model, but is not applied in the base case.

- o Every nursing home resident undergoes an assessment of oral health needs on admission, resulting in a plan for their oral care (Samson et al. (2009)). This is assumed to take 20 minutes per resident.
- o For residents who require assistance with oral care the base case in the model assumes that a total of 5 minutes per day is spent performing oral care (2.5 minutes, twice daily).

2.6 Consequences

The consequences in the model are oral health outcomes defined as follows.

2.6.1 Scenario 1

The consequences in scenario 1 are derived from the intervention group in Frenkel et al. (2001) at a follow-up of 6 months following the educational intervention. At 6 months versus baseline the absolute mean decrease (improvement) in dental plaque index was a 0.28 scale points; in gingival score 0.29 scale points; and in denture plaque index 1.16 scale points.

2.6.2 Scenario 2

The consequences in scenario 2 are derived from the study sample in Samson et al. (2009) at a follow-up of 3 months following intervention. At 3 months versus baseline the absolute mean difference in mucosal plaque score was a decrease (improvement) of 1.5 scale points; the change in the percentage of subjects with an acceptable MPS score (of 2-4) was an increase of 39%.

2.6.3 Statement provided by Public Health Advisory Committee (PHAC) on the benefits of effective oral care

The committee provided the following statement to describe anticipated benefits (in both scenarios) of delivering effective oral care based upon expert opinion and published evidence:

"There is evidence that oral health impacts on overall quality of life and wellbeing (Naito et al, 2006, Marino et al, 2008) and it seems self-evident that having a mouth which is comfortable and pain free with sufficient teeth to allow enjoyment of healthy food and consumption of a healthy diet, would be important to a person, and their close family and associates, regardless of the persons age or other impairments. This observation is supported by research (Sheiham et al 1999, Locker D 2002). In addition, having an appearance which is acceptable to others would be considered a social norm (Hassal, 2006) and an acceptable level of cleanliness of the mouth would be considered by most to be a basic part of normal social behaviour. All of these important outcomes are potentially compromised if the important preventive measure of daily plaque removal is neglected. If the mouth is not adequately cleaned gum inflammation, and its associated condition, irreversible periodontitis (gum disease), can cause bad breath tooth loss, abscesses and pain. Tooth brushing with a fluoride toothpaste also helps prevent the development of dental caries (decay). The effectiveness of plaque removal for slowing disease progression can be measured using plaque, periodontal, gingival and caries indices. These indices are measures of conditions which are known to be able to affect speech, taste, pain and discomfort, chewing ability, self-confidence, ability to socialise, and, sometimes, daily life, particularly in the elderly. The extent to which this occurs can be assessed using psycho social indicators such as the oral health impact profile (Locker and Jokovic 1996)."

Note: With the exception of clinical impacts, many of the benefits captured in the statement above are not included in the CCA due to an absence of data and should therefore be considered additional benefits.

3   Results: base case analysis

In all results the consequences are assumed to be static and as described above in sections 2.6.1 - 2.6.3. However different inputs to the model generate different estimates of the cost of achieving the consequences.

The base case analysis assumes that there are 40 residents in the nursing home, 83% of whom require assistance with oral care and that residents' families provide tooth brushes and paste. The nursing home is able to educate all of its care assistants in a single education session per year and is required to 'back fill 'the time of care staff who attend the education sessions. All activities are performed by the default health professional roles, defined in Table 1. This means that the care home pays a provider to deliver the education including the educator's time and travel costs and also the cost of the care home staff time spent attending the education. The care home does not pay for the capital training equipment, which belongs to the provider.

Results of the base case analysis are shown in Table 2.

3.1   Scenario 1 Education & oral care

Scenario 1 has a total cost of £15,153.92 (£378.85 per resident), incurred over two years. Of this, the education programme (1 hour in year one, 1 hour in year two) costs £298.78 (£7.47 per resident) and the remainder, £14,855.15 (£371.38 per resident), is the cost of providing oral care to the residents over two years.

3.2   Scenario 2 composite intervention & oral care

Scenario 2 has a total cost of £30,240.65 (£756.02 per resident), incurred over two years. Of this, the education programme (4 hours in year one, 2 hours in year two) costs £719.41 (£17.99 per resident). The cost of oral care is equal to that in Scenario 1 at £14,855.15 (£371.38 per resident). Performing a 20-minute oral health assessment on every resident costs a total of £391.09 (£9.78). A large component cost of the total in Scenario 2 is that of monitoring compliance of the care home in delivering oral care. The base case assumes this takes two minutes per resident per day of a qualified nurse's time, at a total of £14,274.71 (£356.87 per resident) over the two years.

Table 2 Base case analysis

This assumes: 40 residents in the nursing home, 83% of whom require assistance with oral care, with toothbrushes and paste supplied by residents' families. The nursing home receives a single education session and is required to 'back fill' care staff time to attend the education. All activities are performed by the default health professional roles, defined in table 1.

	Costs	Total (two years)	Per resident (two years)	Consequence
Scenario 1	**Total cost**	**£15,153.92**	**£378.85**	1. The consequences in scenario 1 are derived from the intervention group in Frenkel et al. (2001) at a follow-up of 6 months following the educational intervention. At 6 months versus baseline the absolute mean decrease (improvement) in dental plaque index was a 0.28 scale points; in gingival score 0.29 scale points; and in denture plaque index 1.16 scale points.

2. Statement on the benefits of effective oral care |
| **1** | **Care home staff education**
 -Nursing home staff attendance time
 -Nursing home staff attendance time backfilled
 -Educator's travel costs | **£298.78** | **£7.47** | |
| **2** | **Oral care**
 -Nursing home staff time | **£14,855.15** | **£371.38** | |
| **Scenario 2** | **Total cost** | **£30,240.65** | **£756.02** | 1. The consequences in scenario 2 are derived from the study sample in Samson et al. (2009) at a follow-up of 3 months following intervention. At 3 months versus baseline the absolute mean difference in mucosal plaque score was a decrease (improvement) of 1.5 scale points; the change in the percentage of subjects with an acceptable MPS score (of 2-4) was an increase of 39%.

2. Statement on the benefits of effective oral care |
1	**Care home staff education** -Nursing home staff attendance time -Nursing home staff attendance time backfilled -Educator's travel costs	**£719.41**	**£17.99**	
2	**Oral care** -Nursing home staff time	**£14,855.15**	**£371.38**	
3	**Preparation of generic care plans** -Nursing home staff time -Consumables	**£0**	**£0**	
4	**Introduction of a local oral care protocol** -Nursing home staff time	**£391.09**	**£9.78**	
5	**Checking of staff compliance with oral care** -Nursing home staff time	**£14,274.71**	**£356.87**	

4   Results: sensitivity analysis

We performed a one-way deterministic sensitivity analysis, summarised in Table 3. The effect of varying the input value of numerous model parameters is described as follows.

4.1   Number of education sessions required, and back filling

These parameters attempt to deal with the problem whereby if care home staff attend an education session, they are not, for the duration of the session, caring directly for the care home residents. This may require the care home to pay for other staff to cover this duty (back filling). In addition, it may be impractical to assemble the entire compliment of staff at once in order to attend the education session, therefore more than one session may be required to provide alternative dates for staff to attend.

The effect on the model of varying these parameters is small. Even when three education sessions per year were modelled with a requirement to back fill attendance, the total cost in Scenario 1 increased by £595.16 to £15,749.08 and in Scenario 2, by £1,141.94 to £31,382.56 (Table 3).

4.2   Preparation of educational material & purchase of educational aids

The base case assumes that the education is provided by a paid provider and that the care home does not have to pay in addition for preparation of the educational material. In the study by Frenkel et al. (2001) the cost of preparing the educational material was estimated. If the cost of four hours of an oral health educator's time is included in the model at a salary of AfC Band 5 there is only a modest increase in the cost of the cost of the education intervention alone. In scenario 1 this increases from £298.78 (base case) to £357.88. The corresponding increase in scenario 2 is from £719.41 (base case) to £778.51. The total cost (all activities) to the care home incurred over two years becomes £15,213.02 for scenario 1 and £30,299.75 for scenario 2.

If in addition to above the care home needs to buy, as capital equipment, the educational aids used in the Frenkel et al. (2001) study at a cost (inflated to 2013/14 prices) of £255.40, then the cost of the educational intervention alone becomes £613.28 in scenario 1 and £1,033.91 in scenario 2 (a simple increase of £255.40 in each case). Corresponding total costs in the model (all activities) incurred over two years are £15,468.42 in scenario 1 and £30,555.15 in scenario 2 (again, a simple increase of £255.40 in each case).

4.3   Change of role: providing the oral health education

Changing the profession tasked with delivering the oral health education session does not have much effect on the model. The base case utilises a Dental Nurse (AfC Band 4). If this is changed to an Oral Health Educator (Band 5) the total costs change negligibly to £15,168.88 (Scenario 1) and £30,270.57 (Scenario 2 (Table 3)).

4.4   Change of role: recipients of the oral health education

If the recipients of the education sessions are changed from care assistants alone to the entire complement of care home staff (care assistants, qualified nurses and managers) the impact on the total cost in the model is small: total cost increases to £15,302.62 in Scenario 1 and to £30,693.81 in Scenario 2 (Table 3).

4.5   Designing oral health care plans

This change applies to Scenario 2 only. The base case assumes that the six generic care plans based on the study by Samson et al. (2009) are supplied to the care home by a provider external to the model. If the cost of designing the six care plans is born by the care home, we assume this to take two hours per care plan of a qualified nurse's time plus a cost of printing and laminating the cards at £0.05 per care plan. This results in an additional cost of £177.60, raising the total cost (all activities) in scenario 2 to £30,417.95, incurred over two years.

4.6   Number of residents in the care home

Changing the total number of residents living in the home has a large effect on the model, simply by defining its size. Expert advice from PHAC suggests that care homes that care for 80 residents are common. If the number of residents is increased from 40 (base case, based on survey data (RCN 2010)) to 80, the overall cost in scenario 1 rises from £15,153.92 to £30,180.91. The corresponding increase in Scenario 2 is from £30,240.65 to £60,281.03. If the total number of residents is increased to 100, the total costs for Scenarios 1 and 2 are £37,694.55 and £75,301.37, respectively. Reducing the total number of residents relative to base case has similar large reductions in total cost (Table 3).

The model does not demonstrate a significant economy of scale whereby if the number of residents is increased, other costs are spread more thinly. This is because there are few capital or 'one off' costs that are distributed across the total number of residents and corresponding complement of staff. The only such costs are the educator's teaching and travel time, and if included in the model, preparation time for the educational material and capital cost of educational aids and designing oral health care plans (see above). All of these costs are small compared to the labour-driven costs (oral care and monitoring compliance).

It should be noted that the number of residents drives other model parameters, most importantly the costs of providing oral care. In the base case 83% of residents require assistance with oral care, which means that the absolute number of residents drives cost to a large degree.

4.7   Number of residents requiring assistance with oral care

This parameter has a large effect on the model. The base case value is set at a high proportion of 83% based on Frenkel et al. (2001). If the proportion is increased to 100%, the total costs for Scenarios 1 and 2 increase to £18,196.54 and £33,283.27, respectively (Table 3). If the proportion is reduced as low as to 40%, respective total costs for Scenarios 1 and 2 are £7,457.88 and £22,544.61 (Table 3). Therefore the activity of providing oral care accounts for a high proportion of cost in the model. The impact of consumable costs for oral care is low; the main driver of cost of oral care being staff time.

4.8   Time spent on oral care

For residents who require assistance with oral care the base case in the model assumes that a total of 5 minutes per day of a care assistant's time per resident is spent performing oral care (2.5 minutes, twice daily).In the base case the costs of providing oral care alone for scenario 1 and scenario 2 are equal at £14,855.15. If this quantity of care assistant's time is doubled to a total of 10 minutes per day (5 minutes, twice daily) the costs of providing oral care alone for scenario 1 and scenario 2 remain equal but double to £29,710.29. This cost reflects the opportunity cost of care

assistants' time only, and not consumables (assuming that residents' families pay for toothbrushes and paste). Therefore the time spent providing oral care on a daily basis has a large effect on the model.

4.9 Cost of consumables for oral care

The base case assumes that residents' families pay for tooth brushes and paste. Changing the model to assume that the care home must provide manual toothbrushes and toothpaste for 100% of the residents results in only a modest decrease in overall cost: to £15,571.77 in Scenario 1 and to £30,658.50 in Scenario 2 (Table 3). If the care home provides electric toothbrushes instead of manual toothbrushes, respective total costs for scenarios 1 and 2 are £18,239.59 and £33,326.32. Electric toothbrushes were issued in the Samson (2009) study, although PHAC members report that electric toothbrushes are not very well tolerated by some nursing home residents.

We also modelled the scenario where 10% of the cost of oral care consumables is incurred to the care home, based on the estimation by the committee that 10% of residents do not have visiting family. On this basis and assuming that manual toothbrushes are used, the costs of Scenarios 1 and 2 are £15,195.71 and £30,282.75, respectively. If electric toothbrushes are used, the costs of Scenarios 1 and 2 are £15,462.49 and £30,549.22, respectively.

4.10 Change of role: assessing resident's oral health and planning oral care on admission

This change applies to Scenario 2 only. Changing the profession tasked with performing the single 20-minute oral health assessment including planning oral care for each resident (envisaged as on admission) from Qualified Nurse to other professions has little effect on the model. The total cost in Scenario 2 when this task is performed by a Care Assistant (in a designated lead role) decreases by only £194.94 to £30,045.71 (Table 3).

4.11 Change of role: monitoring compliance with oral care requirements

This change applies to Scenario 2 only. Changing the profession tasked with the daily (or weekly, though calculated in the model as daily) activity of checking in residents' notes that oral care has been planned and delivered correctly has a large effect on total cost in the model. This is because, like delivering oral care, this activity occurs frequently and consumes staff working time on a daily basis. Changing this role from Qualified Nurse to Care Assistant results in a total cost of £23,125.05, and changing the role to Care Home Manager results in a total cost of £39,315.98 (Table 3).

4.12 Change in Care Assistants' wage

The model assumes that care assistants are paid at the National Minimum Wage. Whilst this is a parsimonious wage, care assistants provide oral care in the model, accounting for a high proportion of total model costs. However a large percentage wage increase is required to substantially affect the model: a 10% increase results in a total cost of £16,656.41 in Scenario 1 and £31,777.90 in Scenario 2 (Table 3).

4.13 Monitoring compliance

This change affects only Scenario 2. Related to 4.8 above, changing the volume of time spent on this activity has potentially a large effect on the model. Estimating the value for this parameter is subject

to considerable uncertainty and values explored in sensitivity analysis were derived from discussion with committee members. The base case assumes that 2 minutes per resident per day are spent (by the care home manager) on this activity. The minimum value proposed, 0.7 minutes per resident per day results in a total cost in Scenario 2 of £20,962.09 (Table 3). The maximum value proposed, 5 minutes per resident per day (3 hours per 7 day week) results in a total cost in Scenario 2 of £51,652.71 (Table 3).

Table 3 Effects on overall cost (all activities) of one-way deterministic sensitivity analyses.

'One way' means changes (from base case) described in the 'Change' column are made one at a time. The base case is shown in the first row for reference.

Change	Total (Scenario 1)	Per resident (Scenario 1)	Total (Scenario 2)	Per resident (Scenario 2)
Base case	**£15,153.92**	**£378.85**	**£30,240.65**	**£756.02**
Care home incurs cost of preparation of educational material	£15,213.02	£380.33	£30,299.75	£757.49
Care home incurs cost of preparation of educational material plus capital cost of educational aids	£15,468.42	£386.71	£30,555.15	£763.88
No back filling required (1 education session per year)	£15,069.05	£376.73	£29,981.98	£749.55
No back filling required (2 education sessions per year)	£15,281.75	£382.04	£30,294.25	£757.36
No back filling required (3 education sessions required)	£15,494.45	£387.36	£30,606.53	£765.16
Back filling required (2 education sessions required)	£15,451.50	£386.29	£30,811.61	£770.29
Back filling required (3 education sessions required)	£15,749.08	£393.73	£31,382.56	£784.56
Reduce number of residents to 20	£7,640.58	£382.03	£15,220.61	£761.03
Increase number of residents to 60	£22,667.57	£377.79	£45,260.99	£754.35
Increase number of residents to 80	£30,180.91	£377.26	£60,281.03	£753.51
Increase number of residents to 100	£37,694.55	£376.95	£75,301.37	£753.01
Increase percentage of residents requiring daily oral care assistance to 100%	£18,196.54	£454.91	£33,283.27	£832.08
Reduce percentage of residents requiring daily oral care assistance to 60%	£11,037.44	£275.94	£26,124.17	£653.10
Reduce percentage of residents requiring daily oral care assistance to 40%	£7,457.88	£186.45	£22,544.61	£563.62
Increase time spent providing oral care to 10 minutes per day (5 minutes twice daily)	£30,009.07*	£750.23	£45,095.80*	£1,127.39
Care home incurs 100% of cost of manual toothbrushes and tooth paste	£15,571.77	£381.82	£30,658.50	£748.47
Care home incurs 100% of cost of electric toothbrushes and tooth paste	£18,239.59	£448.52	£33,326.32	£815.17
Care home incurs 10% of cost of manual toothbrushes and tooth paste	£15,195.71	£372.42	£30,282.44	£739.07
Care home incurs 10% of cost of electric toothbrushes and tooth paste	£15,462.49	£379.09	£30,549.22	£745.74
Change the educators role from Dental Nurse (Band 4) to Oral Health Educator (Band 5)	£15,168.88	£379.22	£30,270.57	£756.76
Change the recipients of the education from Care Assistants alone to Care Assistants plus Qualified Nurses plus Care Home Manager(s)	£15,302.62	£382.57	£30,693.81	£767.35
Care home is required to design oral health care plans	NA	NA	£30,417.95	£760.45

Change	Total (Scenario 1)	Per resident (Scenario 1)	Total (Scenario 2)	Per resident (Scenario 2)
Change the role of assessing residents' oral health and planning care from Qualified Nurse (Band 5) to Dental Nurse (Band 4)	NA	NA	£30,174.18	£754.35
Change the role of assessing residents' oral health and planning care from Qualified Nurse (Band 5) to Care Assistant (national minimum wage)	NA	NA	£30,045.71	£751.14
Change the role of monitoring compliance from Qualified Nurse (Band 5) to Care Assistant (national minimum wage)	NA	NA	£23,125.05	£578.13
Change the role of monitoring compliance from Qualified Nurse (Band 5) to Care Home Manager	NA	NA	£39,315.98	£982.90
Care Assistants' wage increase by 10%	£16,656.41	£416.41	£31,777.90	£794.45
Care Assistants' wage increase by 20%	£18,158.90	£453.97	£33,315.15	£832.88
Care Assistants' wage decrease by 10%	£13,651.43	£341.29	£28,703.40	£717.59
Care Assistants' wage decrease by 20%	£12,148.94	£303.72	£27,166.15	£679.15
Change 'monitoring compliance time' from 2 minutes per resident per day to 0.7 minutes per resident per day	NA	NA	£20,962.09	£524.05
Change 'monitoring compliance time' from 2 minutes per resident per day to 1 minute per resident per day	NA	NA	£23,103.30	£577.58
Change 'monitoring compliance time' from 2 minutes per resident per day to 3 minutes per resident per day	NA	NA	£37,378.01	£934.45
Change 'monitoring compliance time' from 2 minutes per resident per day to 4 minutes per resident per day	NA	NA	£44,515.36	£1,112.88
Change 'monitoring compliance time' from 2 minutes per resident per day to 5 minutes per resident per day	NA	NA	£51,652.71	£1,291.32

* The component cost of providing 10 minutes per day oral care alone is £29,710.29 in Scenario 1 and in Scenario 2.

5   Discussion

5.1   Base case

The base case suggests that the costs of Scenario 1 total £15,153.92 and Scenario 2, £30,240.65. In both scenarios the costs of delivering the education sessions (£298.78in Scenario 1, £719.41 in Scenario 2) are small relative to the cost of performing oral health care for nursing home residents £14,855.15).

In scenario 2 the cost of assessing oral health/planning oral care for residents on admission (£391.09) is small relative to the total cost. However, the activity of monitoring compliance with oral care is a substantial cost in scenario 2 (£14,274.71).

5.2   Main drivers of the model

In the one way deterministic sensitivity analysis the only parameters which, when varied, have a large effect on the total cost in either scenario are the frequently performed, labour-driven activities. These are:

- The total number of residents (but dependent on the proportion of residents who require help with daily oral care)
- The proportion of residents who require help with daily oral care
- The level of individual (salary) tasked with monitoring compliance with oral care
- The time required to monitor compliance with oral care.

5.3   Performing oral care

We have estimated the cost of providing oral care for nursing home residents, assuming that this takes 5 minutes per day per resident needing help (where evidence suggests that the majority of residents do: 83% in Frenkel et al. (2001)). Our model estimates that for a care home of 40 residents this costs a total of £14,855.15 in a two-year period, based entirely on care assistants' time. In reality the nursing home must pay its staff their wages irrespective of how they allocate their time to different care activities and in a busy nursing home delivery of oral care competes with all other activities performed by nursing home staff. Therefore in addition to the estimated cost of £14,855.15, the *opportunity cost* of delivering oral care should be considered. That is to say that if nursing home staff are providing oral care while on duty, they are not doing other care activities which require doing.

5.4   Monitoring compliance

In our model we considered the activity of monitoring compliance to comprise checking documentation on a daily or weekly basis to determine whether daily oral care has been assessed, planned and delivered to a satisfactory standard. We have not considered compliance checking to mean that an oral health professional visits residents to perform an oral health examination (as reported by Samson et al. 2009), though the cost of either approach may be quantified in staff time. In our base case monitoring compliance incurs a large cost: £14,274.71 in total over two years, or £356.87 over two years per resident. The cost is driven by a qualified nurse spending two minutes per resident per day on this activity and is roughly equal to the cost of performing oral care. On this

basis the quantity of time allocated to this activity in this model may be impractical to replicate in practice: the cost could be reduced substantially if compliance checks were performed only on a proportion of residents' care notes.

The cost of compliance checking is sensitive to the individual doing the activity and the time spent on the activity (Table 3). Our base case assumes that a qualified nurse monitors compliance to avoid the scenario where an individual performs a check of their own individual activity. There is likely to be a limitation in terms of risk of biased reporting if monitoring compliance is undertaken only within the care home complement of staff i.e. with no external element.

5.5 Assessing and planning oral care

In the model, changing the staff level (salary) of the individual who assesses and plans care has a small effect on overall cost. In contrast both the staff level and staff time required for compliance checking both have a large effect on overall cost.

Arguably, the activities of assessing and planning oral care on admission and compliance checking could be thought of as related activities, or even part of the same thing: both are intended to ensure the quality of oral care delivered to residents. In the model assessing and planning oral care was assumed to be a one-off activity (typically performed on admission) whereas compliance checking is a frequent, ongoing activity. In reality assessing and planning oral care may be more of a frequent, on-going activity. Also a drawback is that our sensitivity analysis did not vary the time spent on assessing and planning oral care (a one-off activity of 20 minutes duration).

5.6 Consequences not modelled

The consequences reported in the model are restricted to improvements in oral health indices reported by two studies (Frenkel et al. 2001, Samson et al. 2009), and in addition, a qualitative statement drafted by PHAC to describe the value to people in care homes of having satisfactory oral health.

There is uncertainty around the possible wider effects of the interventions modelled, owing to a lack of clear published evidence, and also their wider health economic impact. For example if staff in the care home have increased vigilance to detect oral health problems in residents, then the effect may operate in two ways. Firstly care home staff may detect oral health problems sooner, leading to prevention of further deterioration which would otherwise develop over time: prompt identification of problems may reduce the amount of dental treatment required, and its cost. Conversely increased vigilance may simply detect oral health problems that are already present, prompting additional dental treatment and incurring its cost.

6 Conclusions

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.

In the model 'one-off' (or infrequent) activities incur small costs relative to frequent activities, over the two year model time horizon. 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.

The model has estimated the cost of delivering an acceptable volume of routine, daily oral care activity. For care homes that already achieve this level of oral care, the cost of delivering oral care would not apply, since it would already be absorbed within the care home's expenditure. However there always exists the opportunity cost of performing oral care, since it competes with all other care activities for carers' time.

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