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Author/s:

Münzenmayer, MA; Mariño, R; Hsueh, A

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PROF. MELISA MÜNZENMAYER (Orcid ID : 0000-0002-8780-8074)

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3. *Full names, degrees, and affiliation for each author:*

Melisa A. Münzenmayer, DDS, MPH

Instituto de Salud Pública

Universidad Austral de Chile

Valdivia

Chile

Rodrigo Mariño, PhD, MPH, CD

Melbourne Dental School

The University of Melbourne

Melbourne, Victoria

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Australia

Arthur Hsueh, PhD, MAE, MHSA, BPH
Melbourne School of Population and Global Health
The University of Melbourne
Melbourne, Victoria,
Australia

4. *Contact information for corresponding author:*

Melisa A. Münzenmayer, DDS, MPH
Instituto de Salud Pública
Universidad Austral de Chile
Casilla Postal 567
Valdivia-Chile
melisa.munzenmayer@uach.cl
Phone: +56 63 2221139, +56 63 2221282

Abstract

Objective:

To conduct a model-based cost-effectiveness analysis, from a health care system perspective, of using oral health professionals to provide oral hygiene services at Residential Aged Care Facilities (RACFs) in Victoria, Australia, compared to current practice (CP).

Background:

Increasingly dentate cohorts of older adults are entering RACFs, making urgent the need of further development and provision of oral health programs in ageing dentitions.

Materials and methods:

The model was based on 47,624 RACFs' places in Victoria over one year. The main outcome measured was 'cost per pneumonia case averted'. Four different scenarios of oral hygiene provision were compared to CP. Costs included were RACF staff training, professional salaries, program coordinator office expenses, dental equipment, and hospitalization costs. Effectiveness assumptions for each scenario were based on systematic reviews and randomized control trials.

Results:

All four scenarios were dominant strategies. The magnitude of negative Incremental Cost-Effectiveness Ratios was not informative; therefore, incremental costs and incremental effectiveness were used to present results. 'Professional oral health care (POHC) provision once every two weeks and current provision of oral health care the other days' was the most cost-saving alternative (AU \$896 per resident saved). The most effective alternative was 'POHC provision once a week and non-POHC provision by trained Nurse aids twice per day the other days' (6,779 pneumonia cases averted). One-way sensitivity analyses confirmed the robustness of results.

Conclusion:

The four scenarios were highly cost-effective compared to CP. These results could be a strong basis to implement new oral health programs in Australian RACFs.

Introduction

As in many countries, the population of Australia is ageing. Projections for the Australian population indicate that those aged 65 years and over will increase from 15% (3.7 million) in 2016 to 22% (9.0 million) by 2061 [1,2]. Furthermore, an increasing proportion of older people are living in rural and regional Australia and these communities are ageing more rapidly than their metropolitan counterparts [2]. Consistent with this increase, the number of residential aged care places (positions of residence available) has grown steadily since 1995, by an average of 2,553 positions per year (i.e., 1.4% over the previous year) [3].

Aged care residents have long been identified as a subpopulation at greater risk of developing oral diseases [4]. This is due to a combination of factors such as obstacles to accessing proper oral health care services, polypharmacy and compromised medical health, and cognitive and physical disabilities that affect the ability to maintain satisfactory oral hygiene, which leads to dependence on others to receive it [4,5]. Increasing evidence associates poor oral health with a range of medical conditions, including aspiration pneumonia, bacteraemia, cardiovascular disease, atherosclerosis, and stroke [6-9].

Pneumonia has been found to be one of the principal causes of infection in Residential Aged Care Facilities (RACF) [10]. The incidence of nursing home acquired pneumonia (NHAP) ranges from 0.27 to 2.50 cases per 1,000 patient-days, with 9% to 51% of residents transferred to hospital per year [10]. Pneumonia is also one of the leading causes of mortality in RACFs, accounting for 26–44% of all residents' deaths [10,11]. According to this, the presence of cariogenic and periodontal bacteria, which is a common finding in poor oral hygiene among RACFs residents, has been identified as a potentially significant risk factor for NHAP in older adults [12,13]. A possible mechanism of NHAP pneumonia could be the aspiration of oral pathogens into the lungs [14].

There is evidence that the progression or occurrence of respiratory tract disease in older people living in nursing homes can be reduced by better oral hygiene and regular professional oral health care (POHC) [6]. In fact, mechanical oral care combined with professional oral care can reduce by 0.61 times the risk of NHAP [15], and one in ten cases of death from pneumonia in nursing homes could be prevented by improving oral hygiene [16].

Improvements in oral health in Australia over the past 50 years have translated into a greater proportion of older individuals retaining more of their natural teeth [17], increasing the prevalence of dental caries and periodontal disease. As increasingly dentate cohorts of older adults are entering RACFs, further development and provision of oral health programs are urgently needed to address the challenges of maintaining oral health in ageing dentitions.

While Australia's National Oral Health Plan identified older people as one of the priority populations to promote and improve oral health [18,19], and many studies have identified strategies to improve health promotion and oral health care service delivery to RACFs' residents [20-22], these studies present insufficient information to health service programmers and planners for the implementation of programmes [23]. With increasing budgetary restraint around the world, programmers and planners must select the interventions with the highest evidence-based impact, and account for economic considerations when making decisions. Economic evaluations (EE) are an essential element in the process of decision-making about health programmes but no EE has been made of programmes aimed at improving oral hygiene or regarding the provision of POHC in Australian RACFs. The aim of this study is to conduct a model-based cost-effectiveness analysis, from a health care system perspective, of using oral

health professionals to provide oral hygiene services in Residential Aged Care Facilities in Victoria, Australia, compared to current practice.

Material and methods

A model-based cost-effectiveness analysis (CEA) was conducted to determine the potential costs and benefits of implementing a program using professional dental personnel to improve oral hygiene in Australian RACFs. There are several study formats in CEA; this study uses an aggregate model with a decision tree for cohorts [24].

Study setting and population:

The model simulates the experience of all RACFs' residents in Victoria by 30 June 2011 (n=47,624) [3]. The model was built based on 6,977 persons (15% of the total) living in three randomly selected Shires from regional/rural Victoria (Central Goldfields, Macedon Ranges, and Mount Alexander: 11 RACFs with 783 residents) [25], and five randomly selected metropolitan Councils from Melbourne, (Melbourne, Moonee Valley, Manningham, Knox and Frankston: 77 RACFs with 6,194 residents) [25].

Proposed interventions under examination in this model:

Figure 1 shows the model decision tree which outlines the different alternatives for professional oral health care (POHC) provision. POHC is defined as oral hygiene services conducted by an oral hygienist or oral health therapist. Non-POHC is the oral hygiene care conducted by a nurse, nurse aid, or any other non-professional oral health personnel.

The proposed interventions (arms in the tree) of this model are:

- Non-POHC provision by trained nursing aids (NA) twice per day (Scenario 1).
- POHC provision once a week and non-POHC provision by trained NAs twice per day on the other days (Scenario 2): Gold standard intervention, as it is the intervention that offers the best achievable results from the Systematic Review we are basing our model [15].
- POHC provision once a week and current provision of oral health care the other days (Scenario 3).
- POHC provision once every two weeks and current provision of oral health care the other days (Scenario 4).

The comparator was current provision of oral health care, which followed the “Better Oral Health in Residential Aged Care – Staff Portfolio” guidelines that all RACFs are following [26]. It consists of brushing the teeth and cleaning the tongue, palate, gums and oral mucosa with a soft mechanical toothbrush suitable for bending, using high fluoride toothpaste (5000 ppm), and an interdental brush. Full dentures are brushed using a denture brush, and partial dentures are cleaned also with a soft toothbrush suitable for bending [26].

Measurement of outcomes:

The main clinical outcome was measured by the cases of pneumonia averted. The reported annual incidence of pneumonia in long-term care residents ranges from 99 to 912 per 1,000 persons, with a median reported rate of 365 per 1,000 [10]. When applying this rate to our study population, we have a pneumonia-median annual incidence of 17,383 per 47,624 persons (range: 4,715 to 43,433). The average proportion of RACF residents with pneumonia transferred to hospital, is 30% (range: 9 to 51%). Therefore, 70% of cases would be treated in the RACF [10]. For residents transferred to the hospital, 30% would die (range: 20 to 40%) [10]. For residents treated in the RACF, 17% would die (range: 6 to 28%) [10].

Effectiveness of Interventions.

There is a wealth of literature providing evidence that pneumonia cases and deaths can be prevented with the provision of regular oral health care in RACFs [6,15,16,27]. The key clinical expected results of this model are based on a Systematic Review that indicated that the effect of mechanical oral care in combination with POHC reduces by 0.61 times the risk of nursing home-acquired pneumonia (RR, 0.61; 95% CI, 0.40-0.92) [15]. This intervention would be our gold standard (i.e., ‘Scenario 2’) and assumes that the 0.61 risk reduction will be the maximum amount of effectiveness that can be achieved (i.e., 100%). It was assumed that the response of ‘Scenario 2’ would be achieved immediately (1st month) after the provision of these oral health care services, conditional with compliance of RACFs with the guidelines of the program (see sensitivity analysis).

Under these circumstances, the maximum amount of pneumonia cases averted in one year would be 6,779 ($17,383 \times 0.39$). This figure (i.e., 0.39) was used, instead of 0.61, because we wanted to know the final number of persons that remain after a risk reduction of 0.61 ($17,383 - (17,383 \times 0.61)$). It was assumed that each month would have the same maximum amount of cases averted, which would be 565 cases per month ($6,779/12=565$), as can be seen in “Scenario 2” of Table 1.

In Australia, “Better Oral Health in Residential Aged Care – Staff Portfolio” is supposed to be used by each RACF to develop their own oral health care guidelines [26]. As such, this was considered as the current practice for the purposes of this study. Regrettably, evidence shows that poor oral hygiene is prevalent among RACFs’ residents [4,5,13,17,20,28]. For this reason, and because many randomized controlled trials (RCTs) and systematic reviews (SRs) used the same current practice as the control group, it was assumed to have the baseline effectiveness value in the prevention of pneumonia cases (i.e., 0%) (See Table 1). This does not mean that current effort has zero or no effect on oral hygiene, but it represents the status-quo and provides the reference point for all of the interventions, so no change is expected.

For ‘Scenario 1’, a RCT that assess the effectiveness of a caregivers’ oral health education program delivered within RACFs was used [29]. The trial used dentures and dental plaque indexes as ways to assess oral hygiene status. It has been established that there is a positive correlation between the visual evaluations of oral hygiene and salivary micro-organisms [30,31]. Therefore, with an improvement in plaque indexes, there will be lower levels of micro-organisms

in saliva, which will consequently reduce the development of pneumonia cases, because the number of micro-organisms silently aspirated into the lower respiratory tract will be less [30,31]. Accordingly, it was assumed that there would be a direct relationship between oral hygiene status, based on the denture and dental plaque indexes, and the cases of pneumonia averted. However, as the study did not provide monthly data between the first and sixth months [29], a linear improvement in oral hygiene from the first to the sixth month, and from the seventh to the twelfth month, was assumed.

The effectiveness achieved by ‘Scenario 3’ and ‘Scenario 4’ were based on a RCT that measured the oral hygiene improvement rates in relation to the frequency of POHC intervention in RACFs [32]. In that RCT, the oral hygiene status was evaluated based on the detection of *Candida Albicans* using the Dentocult RCA® (Orion Co.). With lower levels of micro-organisms in saliva (*C. Albicans* included) pneumonia cases are reduced, because the amount of micro-organisms aspirated into the lungs is reduced [33]. Therefore, a direct relationship between oral hygiene status based on *C. Albicans* levels and cases of pneumonia averted was assumed.

Measurement of Costs:

All direct costs (indirect costs excluded) from a health care system perspective were identified and estimated. The reason for using the health system perspective is because the major costs are on health care costs, which are shared by the public (Medicare and public hospitals) and private health insurance. All costs in this model were adjusted to 2016 prices and reported in Australian dollars (1 AUD = 0.75 USD). Costs were grouped under the following categories:

Training.

The education and training program for nurses and care workers from the “Better Oral Health in Residential Care Portfolio” were followed [26]. An oral health professional (OHP) (dental

hygienist or oral health therapist) would provide a standardized 90-minute training session in daily oral hygiene provision to two registered nurses (RNs) per RACF and two NAs for every 20 residents per RACF [34]. To take into account the attrition of staff and the sustainability of the program during the year, retraining every six months will be included [34]. It was assumed that it would take 90 minutes for the OHP to prepare the standard training session and that 38 OHP would be needed to train the staff in the 761 RACFs in five working days, going to four RACFs per day. Training includes the travel costs of the OHP to the RACFs. The Australian Taxation Office “cents per kilometre” method was used to quantify the travel costs [35]. Average distances between the aged care facilities and towns and suburbs were applied to determine the travel expenses of the dental hygienist to train the RACFs’ staff. Time and distance travelled were determined using Google Maps®.

Salaries.

It was assumed that for the provision of POHC, a level 2c-OHP (AU\$41.96 [AU\$38.23–AU\$43.88]/hr) would be required [36]. For NAs, the salary was based on Australian Department of Health and Ageing recommendations (AU\$22.85 [AU\$17.39–AU\$25.31]/hr) [37]. For the salary calculations, it was assumed that the POHC provision would last 20 minutes per resident once a week, and that the non-POHC provision by trained NAs would last 10 minutes per resident and would be conducted twice every day.

It was also assumed that the program would require a RN as program coordinator in each RACF for coordinating and supervising the professional dental care provision. These duties were assumed to be carried out using 3 hours per week of the RN’s time. This model used a RN level 3 (AU\$34.29 [AU\$29.18–AU\$40.84]/hr) [37].

Program coordinator office.

This includes rent, office furniture, computers and office services costs [38]. The oral health care program from our model would use the space, administrative staff, and office equipment from

each RACF; therefore, costs were calculated on the basis of a shared office 3 hours per week [39].

Dental equipment, instruments and supplies.

Dental equipment, instruments and supplies needed for the oral health care provision for proper dental and denture cleanings are detailed in Table 2. All costs for dental instruments, equipment, and supplies were calculated at market values [40-42].

It was assumed that:

- each OHP would have their own portable dental unit and portable chair,
- one dental sterilizer would be shared between four OHPs,
- each OHP would see a maximum of 20 residents per day,
- the electric, conventional, and denture brushes would need to be changed every three months [26],
- the active part of the interdental toothbrush would need to be changed every week [26],
- each tube of high fluoride toothpaste would last two months per resident [26], and
- oral health care would be provided using masks, gloves and eye protection.

Based on a study made in Victorian RACFs, it was also assumed that 54% of residents would be dentate, that 26% of dentate residents would wear partial dentures and that 37% of edentulous residents would wear complete upper and lower dentures [43].

Ambulance and Hospitalization costs.

Ambulance costs had a value per trip of AU\$1,174 on metropolitan roads and AU\$1,732 for regional and rural roads [44]. It was assumed that all ambulance calls would be made after a confirmed pneumonia diagnosis, when the patient required a level of care not available at the facility [10].

To differentiate the cases of pneumonia that were treated in a RACF from those treated at a hospital, it was assumed that cases in hospital were more critical than cases treated at a RACF

[10]. Therefore, pneumonia treatment in hospital would take longer than in a RACF. The literature indicates a mean stay of 7.0 to 18.7 days for hospital treatments and 5 days for RACF treatments [10,45].

Diagnosis-related group (DRG) codes chosen for pneumonia treatment were:

- For hospital pneumonia treatment, the code E62A (Respiratory Infections/Inflammations with Catastrophic Complications) has an average length of stay of 7.67 days, and an average total DRG cost of AU\$11,390 [46].
- For RACF pneumonia treatment, the code E62B (Respiratory Infections/Inflammations with Severe or Moderate Complications) has an average length of stay of 4.27 days, and an average total DRG cost of AU\$6,569 [46].

Cost Effectiveness Analysis:

The decision algorithm was based on the incremental effectiveness and the incremental costs of each proposed scenario. As this is a five-arm model, four incremental effectiveness and incremental costs values were calculated comparing the comparator (current practice) with the four different scenarios of oral health care provision.

Sensitivity Analysis:

A set of one-way sensitivity analyses was occupied to test the robustness of our study results. Due to the pragmatic design of our study, numerous assumptions were made to calculate the potential costs and outcomes adequately. The variables that were considered for sensitivity analysis included:

- Annual incidence of NHAP (ranges from 4,715 to 43,433 cases per 47,626 persons).
- Relative risk of NHAP (ranges from 0.40 to 0.92).
- Oral health care provision time provided by OHP and by trained NAs (ranges from 20 to 30 min for OHP and from 10 to 15 min for NAs).

- Percentage of residents that were transferred to the hospital for pneumonia treatment (ranges from 9 to 51%).
- Salaries from OHP, NAs, and RNs (ranges from \$38.23 to \$43.88 for OHP, from \$17.39 to \$25.31 for NAs, and from \$29.18 to \$39.41 for RNs).
- RACFs' grade of compliance with the programme guidelines measured with the 'effectiveness/cases averted' obtained from each scenario (ranges from 50% to 100% 'effectiveness/cases averted').

Microsoft Excel® was used to calculate costs and to input data. TreeAge Pro® was used to determine cost-effectiveness and perform sensitivity analysis.

Results

Table 2 shows all the costs from the different scenarios for oral health care provision. Salary costs are more influential than other costs (90% of total costs), followed by dental equipment costs, which make up at least 7% of the total costs of each scenario. As expected, 'Scenario 2' was the most expensive scenario, and 'Status quo' the cheapest, with a difference of AU\$550 per resident (i.e., \$3611 - \$3061).

Regarding pneumonia treatment costs, after adjusting ambulance costs for the metropolitan and rural percentages of our study population, and aligning the DRG costs with the Australian Health Consumer Price Index for 2016, the treatment costs per case of pneumonia are shown in Table 3. A large difference in costs between cases of pneumonia treated in hospitals and in RACFs can be seen (AU\$6,644). Moreover, pneumonia treatment costs per resident are significantly more expensive than any scenario of oral health care per resident.

In terms of the maximum number of pneumonia cases that could be averted in one year (i.e., Effectiveness), 'Scenario 1' would be averting 2,133 cases; 'Scenario 2' 6,779 cases; 'Scenario 3' 6,480 cases; and 5,858 cases for 'Scenario 4' (Table 1). Thus, 'Scenario 2' was the most effective alternative, followed by 'Scenario 3' and 'Scenario 4'. 'Scenario 4' reached 100% effectiveness a few months later while 'Scenario 1' never surpassed 40% of effectiveness. In

addition, non-POHC would never reach 100% effectiveness because its level of oral health care provision cannot be compared with the professional one.

Cost-effectiveness Analysis:

When the incremental cost is negative (i.e., cost saving) and incremental effectiveness is positive, this is a dominate condition and the negative Incremental Cost-Effectiveness Ratio (ICER) obtained is not applicable in this situation because it is misleading and not informative. Therefore, the alternative with the largest number of pneumonia cases averted is the bench mark for cost-effectiveness in this study. Cost saving is the associated impact from the effectiveness, thus, it is a secondary gain. In the present study, this alternative is 'Scenario 2', with 6,779 cases averted and savings of AU\$752 per resident compared with 'Current practice' (Table 4). This scenario is followed by 'Scenario 3' and 'Scenario 4', with 6,480 and 5,858 pneumonia cases averted, respectively and savings of AU\$810 and AU\$896 per resident, respectively. The alternative that provides the least number of pneumonia cases averted is 'Scenario 1' (=2,133), savings AU\$294 per resident.

The incremental cost-effectiveness plane (Figure 2) shows that all four alternatives of oral health care are dominant strategies. They are more effective and less costly than current practice. Additionally, the three alternatives providing POHC are dominant strategies over 'Scenario 1'.

Sensitivity Analysis:

The sensitivity analyses indicate that the most influential variables were the annual incidence and the relative risk of NHAP, and RACFs' grade of compliance with the program. The other variables included did not influence the costs in a critical way (see Table 1 of supplementary material).

When employing the maximum incidence of NHAP reported in the literature (43,433 per 47,624 persons), all of the alternatives increased their cost-effectiveness compared to the assumptions in the base model (e.g., AU\$2,583 vs. AU\$896 of cost- savings and 14,638 vs. 5,858 of cases averted for 'Scenario 4'). Conversely, when employing the minimum incidence of NHAP (4,715

per 47,624 persons), 'Scenario 1', 'Scenario 2', and 'Scenario 3' had cost increases from AU\$ 4, AU\$197, and AU\$97, respectively, but still prevented cases of pneumonia.

Regarding the percentage of risk reduction for NHAP, the analysis indicates that when using a risk reduction of 0.92, all alternatives decrease their cost-effectiveness, with Scenario 1', 'Scenario 2', and 'Scenario 3' having cost increases instead of cost-savings (AU\$31 vs. AU\$-294, AU\$286 vs. AU\$-752, and AU\$179 vs. AU\$-810, respectively). On the other hand, when employing a risk reduction of 0.40, all alternatives increase their cost-effectiveness (AU\$- 1,502 vs. AU\$-896 of cost-savings and 9,013 vs. 5,858 of cases averted for 'Scenario 4', for example).

After reducing RACFs' grade of compliance with the program to 50% in all arms, all scenarios continue saving money and averting cases of pneumonia.

Despite the adjustment for uncertainties in the sensitivity analysis, the four alternatives of oral health care provision are still the dominant option in almost all scenarios, and when they are not, the costs increases are very low to turn the alternatives scenarios into non-beneficial ones. This indicates that the results of this study are robust and the likelihood of those alternatives becoming not cost-effective is low.

Discussion

Findings showed that each of the scenarios proposed for oral health care would be cost-effective when compared to current practice. Furthermore, options including POHC were dominant over the non-POHC alternative. Our findings show that POHC is a cost-effective option, with cost savings ranging from AU\$752 to AU\$896 and pneumonia cases averted ranging from 5,858 to 6,779 among the three POHC alternatives. This strengthens the argument for a permanent OHP presence in RACFs. Moreover, OHPs, apart from providing POHC to the residents, can add more benefits to the oral health of residents by checking and reinforcing the daily work of NAs in oral hygiene care.

This model used dental hygienists or oral health therapists for the POHC provision. These professionals are less expensive, but are ideally suited to providing preventive and periodontal

care to residents. They are also qualified to assist in health promotion and education activities for the staff of RACFs, areas which are critically lacking at present [5].

These findings offer important new information supporting the visits of OHP to RACFs as a viable option for the delivery of oral hygiene services to residents. This is in line with the many calls to implement programs that include oral hygiene in the long-term-care setting, as part of the daily routine [47]. Additionally, this study reviewed the health care system costs to give a more accurate reflection of the financial benefits that POHC can offer.

As mentioned, the use of an ICER is uninformative and misleading when both cost-savings and cases averted are combined [48,49]. This is because when many cases are being prevented, the denominator for the ICER increases. Therefore, the more effective the model is, ironically the smaller the cost-saving per case averted. For this reason, results were presented as incremental cost-savings and incremental cases averted, separately (Table 4).

The global impact of NHAP is sobering: globally there are more than 4 million new cases annually, at a median rate of 1.0-3.2 cases per 1,000 bed-days and 600,000 emergency admissions [50,51]. In Australia, permanent RACF residents accounted for 31,760 acute hospital admissions for pneumonia during the 2008-2009 financial year [52], with a mean hospital length of stay of 7 days for pneumonia, which amounts to 222,320 hospital bed-days, or 609 fully occupied hospital beds for patients with NHAP [53]. Taking into account that hospitalization costs were the most significant expenses in our models, the potential economic impact of preventing NHAP cases would be substantial.

However, present findings need to be assessed in view of the limitations of this study. The most important limitation is the outcome measurement used. Pneumonia cases averted is just one of all measurable benefits that POHC can bring to RACFs residents. For example, improved oral hygiene can also help prevent other systemic diseases (e.g., cardiovascular disease, atherosclerosis, diabetes, and stroke) [6-9,54-57]. Additionally, improved oral health reduces oral pain, and can improve nutrition status [58-60], which would lead to resident's improved quality of life. Poor oral health has a significant impact on quality of life and the ability of an individual to go about their daily routines [61,62]. Previous studies have measured these benefits as outcomes for oral health care improvement [63,64], however, they were not included in the

current model. If these benefits had been included, the impact would have been even greater. It should also be noted that patients in RACFs are often complex patients with specific needs and poor levels of functioning. Their management requirements are increasingly complex with large numbers suffering from multi-morbidities and cognitive decline, so they cannot be considered as a homogenous group. Their health status improvement cannot only be performed by using one clinical end point [65]. Results of the implementation of preventive or curative strategies in RACFs will be more significant if we measure the impact of the intervention on the quality of life of these patients. Future studies including other outcome measures, such as oral health related quality of life would assist in providing better information to evaluate the cost-effectiveness of POHC.

Another limitation was the reliance on a model for implementation, rather than a real-life operation of POHC to RACFs residents. For example, it was assumed that all RACFs were following the same oral care guidelines and had the same level of effectiveness. Also, effectiveness assumptions were made as no specific threshold of oral hygiene level to prevent pneumonia cases exists. A direct relation between the improvement in oral hygiene status and the cases of pneumonia averted were assumed based on the effectiveness of a different measurement of oral hygiene. Each oral hygiene index has advantages and disadvantages; hence, the effectiveness might have been over or underestimated. Additionally, DRG codes utilised for the pneumonia treatment costs were averages. DRG codes did not provide detailed costs for the treatment realised to each patient, so some hospitalization or RACFs treatment costs may have not been included, or may have been over or underestimated. We accounted for these uncertainties by conducting one-way sensitivity analysis. Whilst the results were robust under many scenarios, there may be unknown factors that may influence the real-life operation of POHC to RACFs and, thus the costs and number of pneumonia cases averted.

Nonetheless, while our data may have limitations, we believe that due to the size of our sample and the breadth of data collection, our study is representative of the state. This is because the model was constructed using both, rural and metropolitan data from Victoria. Information about RACFs and costs were based on Australian Government sources, and information about effectiveness was based on systematic reviews and RCTs. Because of the use of these sources,

results can be generalized across Australia, with minor adjustments of assumptions on travel distances, for example.

Conclusions

Since oral diseases are largely preventable, the focus of dental services should be on disease prevention via the provision of adequate oral health care in older adults. While further analysis would help policy makers and researchers to better understand the benefits of POHC in RACFs, these findings indicate that, for the situations prevailing in Victoria, there are significant health and economic benefits to be gained by providing POHC in RACFs, compared to the current practice of using non-Oral Health Professionals, from a health care system perspective. Thus, the use of OHP is a potentially cost-effective and an efficient use of society's financial resources.

Access to oral health professionals is generally low in RACFs; however, the four scenarios modelled in this study were highly cost-effective compared to current practice. POHC once a week and trained nursing aids could be the best among the four cost saving strategies because it can lead to the highest number of cases averted and achieve relatively high cost savings. These results could be a strong basis for the implementation of new oral health programs in Australian RACFs. Although this model is imperfect due to its reliance on a range of assumptions, it is expected that present findings would generate useful information for planning, monitoring, and evaluating oral health programs in RACFs. It is also expected that information coming from this analysis will identify opportunities to reinforce the benefits of POHC in RACFs and make more informed decisions regarding this important health service delivery.

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Table 1. Effectiveness' calculations for each arm.

	Current Practice	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1st month					
% Effectiveness	--	25	100	62	30
N° Cases averted	0	143	565	350	169
2nd month					
%Effectiveness	--	26	100	85	42
N° Cases averted	0	149	565	480	237
3rd month					
%Effectiveness	--	28	100	100	84
N° Cases averted	0	155	565	565	475
4th month					
%Effectiveness	--	29	100	100	86
N° Cases averted	0	162	565	565	486
5th month					
%Effectiveness	--	30	100	100	95
N° Cases averted	0	168	565	565	537
6th month					
%Effectiveness	--	31	100	100	100
N° Cases averted	0	175	565	565	565
7th month					
%Effectiveness	--	32	100	100	100
N° Cases averted	0	181	565	565	565
8th month					

%Effectiveness	--	33	100	100	100
N° Cases averted	0	187	565	565	565
9th month					
%Effectiveness	--	34	100	100	100
N° Cases averted	0	194	565	565	565
10th month					
%Effectiveness	--	35	100	100	100
N° Cases averted	0	200	565	565	565
11th month					
%Effectiveness	--	37	100	100	100
N° Cases averted	0	206	565	565	565
12th month					
%Effectiveness	--	38	100	100	100
N° Cases averted	0	213	565	565	565
Total cases averted	0	2,133	6,779	6,480	5,858

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Table 2. Detailed total costs per alternative of oral health care provision.

	Current Practice	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Training costs					
OHP ^a training session preparation	0	4,784	4,784	0	0
OHP ^a delivery of training sessions	0	95,794	95,794	0	0
OHP ^a travel costs	0	31,154	31,154	0	0
RNs ^b and NAs ^c training time costs	0	508,640	508,640	0	0
Total	0	640,372	640,372	0	0
Salary costs					
Program coordinator (RN ^b level)	0	4,070,772	4,070,772	0	0
NAs ^c time providing non-POHC ^d	135,046,662	135,046,662	115,807,138	115,807,138	125,426,900
OHP ^a time providing POHC ^d	0	0	35,329,998	35,329,998	17,664,999
OHP ^a travel costs	0	0	809,983	809,983	404,992
Total	135,046,662	139,117,434	156,017,891	151,947,119	143,496,891
Program coordinator office costs					
Office rent	0	780,558	780,558	0	0
Office expenses	0	4,821	4,821	0	0
Total	0	785,379	785,379	0	0
Dental equipment and supplies costs					

Manual and electric toothbrushes	251,455	251,455	251,455	251,455	251,455
Interdental brushes and handles	530,695	530,695	530,695	530,695	530,695
High fluoride toothpaste	1,448,894	1,448,894	1,448,894	1,448,894	1,448,894
Denture brushes	330,568	330,568	330,568	330,568	330,568
Electric toothbrushes	0	0	1,156,878	1,156,878	1,156,878
Sponge brushes	0	0	1,010,886	1,010,886	505,443
Portable dental unit and chair	0	0	1,144,780	1,144,780	573,580
Ultrasonic scaler tips and trays	0	0	86,860	86,860	43,860
Saliva ejectors	0	0	53,358	53,358	26,679
Autoclave and sterilization supplies	0	0	349,283	349,283	174,283
Gloves, masks, and safety glasses	8,171,110	8,171,110	8,177,849	8,177,849	8,174,486
Total	10,732,722	10,732,722	14,541,503	14,541,503	13,232,394
Total POHC^d alternative costs	145,779,384	151,275,907	171,985,145	166,488,622	156,729,285
Total costs per resident	3,061	3,176	3,611	3,496	3,291

^aOHP: Oral health professional

^bRN: Registered nurse

^cNAs: Nurse Aids

^dPOHC: Professional oral health care

Table 3. Pneumonia treatment costs.

	Hospital Treatment (AU\$)	RACF ^a Treatment (AU\$)
DRG ^b Hospitalization costs	12,408	7,156
Ambulance costs	1,392	0
Total treatment costs per pneumonia case per resident	13,800	7,156

^aRACF: Residential Aged Care Facility

^bDRG: Diagnostic Related Group

Table 4. Cost-effectiveness analysis.

	Costs	Incremental Costs	Effectiveness ^a	Incremental Effectiveness	ICER ^b
Current Practice ^c	6,401	---	0	---	---
Scenario 1	6,106	-294	2,133	2,133	NA ^d
Scenario 2	5,648	-752	6,779	6,779	NA ^d
Scenario 3	5,591	-810	6,480	6,480	NA ^d
Scenario 4	5,505	-896	5,858	5,858	NA ^d

^aPneumonia cases averted

^bIncremental cost-effectiveness ratio

^cComparator

^dNot applicable

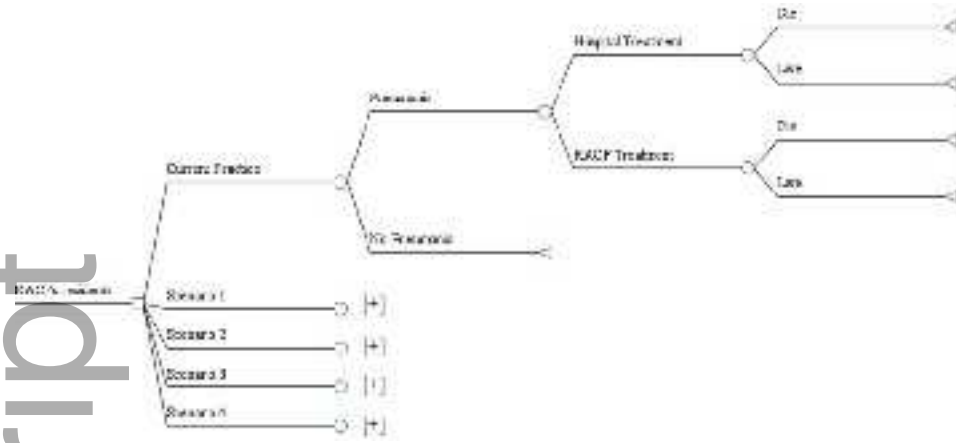
Figure 1. Simplified schematic representation of decision model.

Legend: The “Scenario 1”, “Scenario 2”, “Scenario 3”, and “Scenario 4” arms extend in identical format to the “Current Practice” arm. RACFs: Residential aged care facilities.

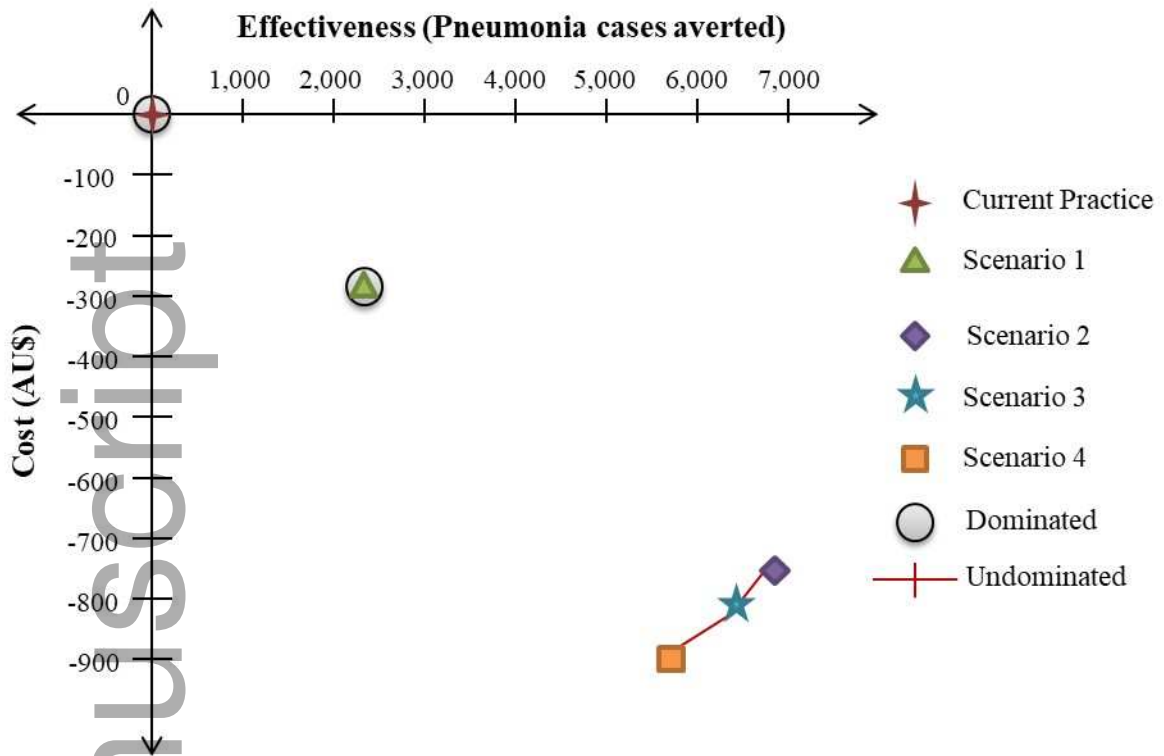
Figure 2. Incremental cost-effectiveness plane.

Legend: The three alternatives providing professional oral health care (Scenario 2, 3, and 4) are non-dominant strategies.

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