A Markov model assessing the impact on primary care practice revenues and patient's health when utilising mid-level providers, lesson learnt from the United Kingdom

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Abstract

Objective: To evaluate the cost-effectiveness of using mid-level providers for check-ups and treatment of caries in different NHS settings in the United Kingdom. Mid-level providers are non-dentist members of dental teams. They are a heterogeneous group composed of Dental Nurses, Dental Hygienists, Dental Hygiene-Therapists and Dental Therapists.

Methods: A Markov model was used to construct the natural history of caries development in adults that visit a dental practice every six months over a five-year period. Three cost perspectives are taken: those borne to dental healthcare providers in England and Wales, Northern Ireland and Scotland. These represent three separate forms of retrospective payment system that are currently in use in the United Kingdom. The cost outcome was the average amount of retained practice earnings required to provide healthcare per patient visit. The health outcome was the average length of time in a cavity-free state and the cost-effectiveness outcome was incremental cost for six months in a cavity-free state.

Results: No statistical difference was found between dentists and mid-level providers in the length of time in a cavity-free state but the use of the latter saved money in all three NHS health system jurisdictions. This ranged from £7.85 (England and Wales) to £9.16 (Northern Ireland) per patient visit ($10.20 to $11.90 respectively) meaning the incremental cost for six month in a cavity-free state ranged from £261.67 ($339.93) in England and Wales to £305.33 ($369.68) in Northern Ireland. Further, changes in baseline assumptions and parameter values did not change mid-level providers being the dominant service intervention.

Conclusion*:* In a time of limited funds for dental services, these results suggest that resources in public funded systems could be saved by using mid-level providers in dental practices, without any health risk to patients or capital investment.

Keywords:

- Mid-level provider
- Direct Access
- Cost-effectiveness
- Screening
- Economic evaluation
- Markov model

Introduction

Maximising health gain from available resources is an ethical imperative for health service managers internationally (1). In 2009, the Independent Review of NHS dentistry argued that some of the available public resources for NHS dental service provision in England were not being used effectively (2, P.41) and concluded that there is an overwhelming need to make best use of the whole dental workforce.

Mid-level providers are non-dentist members of dental teams. They are a heterogeneous group composed of Dental Nurses, Dental Hygienists, Dental Hygiene-Therapists and Dental Therapists. Terminology and scope of practice vary internationally although a common feature to all is a limitation to the number of clinical tasks that they can undertake. Based on each profession's scope of practice, some mid-level providers may perform a supplementary role (e.g. Dental Nurses) while others perform tasks otherwise undertaken by the dentist, known as role-substitution (e.g. Dental Hygienists, Dental Hygiene-Therapists and Dental Therapists) (3). When investigated empirically, mid-level providers have been found to be potential substitutes for dentists (4, 5) in the production of certain types of healthcare.

Role-substitution is already established in medicine, with the balance of the evidence showing that appropriately trained nurses can deliver high quality care that matches doctors' performance in preventive health care, routine follow-up of patients with long term conditions, and as the first contact for people with minor illnesses (6, 7). However, there impact on profits is less certain with reports of no consistent change in net revenues in NHS medical practices and clinics that employ nurse practitioners and physician assistants (8, 9).

In NHS dentistry, there is only limited evidence on the economic consequences of role-substitution (2, 10, 11, 12, 13,14). One study found that "Maximum Delegation" of dentist tasks to mid-level providers (100% examinations, 50% of radiographs, tooth restoration and children's extractions which constitutes over 60% of total clinical time) had the potential to reduction labour costs by 52% compared to using dentists alone (10). Another study found role-substitution in NHS dental practices was not associated with higher levels of efficiency in the production of dental healthcare (11). There is evidence that role-substitution efficiency improvements in NHS dental service provision may be limited to particular situations or contexts (12). In addition, the 2006 changes to NHS dentist remuneration appeared to dis-incentivise role-substitution (13). The practice income generated from

mid-level provider participation in practices has been found to not cover the cost associated with their use (14). This may explain why another UK study found that practice owners did not consider it profitable to employ more qualified mid-level providers (Dental Therapists) at their current salary levels and instead employed them as Dental Hygienists who are paid lower salaries and have a smaller range of delegated tasks (15). In other countries, role-substitution in dentistry has been found to increase efficiency and effectiveness in service provision (16) with potential to release resources and increase the capacity to care (17, 18, 19) although one Finnish study (20) found a high proportion of dental hygienists to dentists employed was associated ($p<0.001$) with allocative (cost) inefficiency.

In England, approximately 55% of patients who attend for a regular NHS dental check-up do not require any further treatment (21). These patients are seen by the practice's most expensive resource, the dentist, at an estimated cost to the NHS of £1 Billion per annum (21). This represents about a quarter of the total annual NHS expenditure on dental care (21). The use of mid-level providers as a front-line healthcare professional has the potential to improve the cost-effectiveness of current NHS provision and increase the capacity to care. Recent evidence from the United Kingdom (UK), has shown that mid-level providers are able to detect the most common dental diseases and recognise the difference between malignant and benign soft-tissue lesions (22, 23, 24). The aim of this study was to model the cost-effectiveness of using mid-level providers as a front-line healthcare professional in the NHS.

Methods

Model design

A Markov model was used to compare the cost and health effects of a service oriented intervention in three different NHS systems of dental provider remuneration in the UK. The service intervention is the use of mid-level providers to perform a check-up on patients, direct restorations and referral to a dentist for caries lesions that require endodontic treatment (outside the mid-level providers Scope of Practice in the UK). This was compared to usual care, which was defined as a dentist performing the check-ups, direct restorations and endodontic treatment. The intervention is evaluated for three jurisdictions of the UK: England and Wales, Northern Ireland and Scotland. England and Wales, Northern Ireland and Scotland represent three different types of retrospective payment system in the UK. The latter two are based on an itemised "fee-for-service" basis, where patients pay for the

care that they receive (with a further contribution from the NHS being paid to the dentist). Each item is individually charged for, based on nationally agreed Statement of Dental Remuneration (25, 26). The former (England and Wales) represents a banded payment system, constructed of three levels: check-ups, radiographs and simple periodontal treatment are counted as a single "Band One" payment, whilst direct and endodontic restorations and extractions are counted as a single "Band Two" payment (irrespective of how many teeth are restored or extracted). Patients who have had a check-up in England and Wales pay approximately £18 (with the NHS paying a further £7 to the dentist). Should patients also require a single or a number of direct restorations, patients pay £49 for the treatment (which also includes the check-up) and the NHS pays a further £26 to the dentist. Patients that receive indirect restorative treatments, for example, crowns, bridges and dentures, pay a single "Band Three" payment.

Markov models consist of a finite number of health states. Patients are assigned initial health states and over given time periods (known as "cycles"), they are transitioned to other health states according to transition probabilities. In this study, a Markov model was formed to simulate the development of caries lesions in 1,000 adults who attended bi-annual dental check-ups over a five year period (each patient received 10 check-ups). A bi-annual dental check is in line with the National Institute for Health and Care Excellence guidance which states that recall interval for routine dental care should be not be shorter than 3 months or longer than 24 months for adults (no longer than 12 months for children) (27). Caries was classified into three states of increasing severity: enamel caries, caries into dentine and deep dentinal caries resulting in pulpal involvement.

Virtual population

The virtual population consisted of adult patients who attended a dental practice appointment every 6 months. The prevalence of dental caries in this population at the start of the simulation (28.33 per cent) and the chance of developing a new cavity in the six-month period between check-ups (21.3 per cent) were informed by a study examining the feasibility of mid-level providers to screen for common dental diseases in a practice population in the UK (22). The patient group appears to be broadly representative of other UK patients in oral health status, as the prevalence of dental caries in the most recent Adult Dental Health Survey (undertaken every ten years in the UK) is just below 31 per cent (28).

Model processes and parameter values

Figure 1 illustrates the structure of the Makov model. At the start of the simulation, a patient had either sound teeth or one enamel caries lesion, based on the caries prevalence within the virtual population highlighted above. One round in the model begins with a check up and terminates six-months later at the date of their next check up. In the intervening period between check-ups caries can develop or progress. New enamel caries may develop, already existing enamel caries may progress into dentinal caries and existing dentinal caries may progress into deep dentinal caries. Parameter values for the likelihood of caries development were extracted from a recent evaluation of different approaches to detect and treat dental caries (29). At a dental check-up, there is a chance a dental provider will detect and treat each cavity. This is the front-line clinician's (dentist or mid-level provider) sensitivity as reported in a UK study, which examined the relative diagnostic test accuracy of different front-line clinicians at discriminating between different enamel caries lesions (classified according to the Incremental Caries Detection Assessment System) (23). This provided data on the True Positive and False Negative detection rate. Deep dentine caries lesions were modelled as being detected at the check-up appointment, given the extent of cavitation that primary lesions present with.

The model also incorporated the probability of the different front-line clinicians making an incorrect classification of a patient with a healthy tooth (False Positive). This is one minus the probability of front-line clinicians accurately classifying a tooth to be healthy (1 - specificity). It was calculated in the model by multiplying the probability of a False Positive with the chance that one tooth in the mouth looks borderline carious when it was actually sound. As no data was available on the likelihood of encountering such borderline teeth, their prevalence at the check-up was taken to be the same as a new enamel cavity (21.28%) and was tested with alternative values in a sensitivity analysis.

Table 1 outlines the parameter values used in the Markov model and 95% confidence intervals or range. The sensitivity values for diagnostic accuracy are slightly higher for mid-level providers than for dentists, although their specificity is lower. To introduce uncertainty in the parameters borrowed from the literature, transition probabilities and treatment times were randomly sampled at each round from a triangular distribution between the calculated 95% confidence interval or parameter range (30).

Table 1 here

Outcome measures

The health effect measure in the Markov model was the number of bi-annual check-ups prior to the development of a caries lesion. The cost perspective taken in this simulation were those borne by the practice owner of the dental practice. Rather than choosing the costs to the patient or the costs to the NHS, this decision was taken to avoid the ceiling and floor effects caused by the banded "fee-for-service" system in England and Wales highlighted above. The cost measure is the amount of retained practice earnings required to provide healthcare to the patient. Retained practice earnings are the revenue generated after the costs of staff, materials, rent and capital investment have been deducted. The measure is calculated by the amount of minutes the patient was in the dental chair for a check-up, restoration or root filling multiplied by the remuneration income (from retained practice earnings) per minute of the dental provider who worked on the patient.

Treatment times for dental providers are taken from a recent observational study (22)**.** A literature search found no data on the average time it takes a mid-level provider to perform a routine restoration. In this model, it was assumed to be the same as the dentist (24.8 minutes), given the extent of their training and utilisation in the UK (3, 14), but was tested in a sensitivity analysis (double to 49.6 minutes). Dental provider remuneration income is calculated for each health system jurisdiction and is the average salary for a Hygiene-Therapist (the only mid-level provider permitted to perform direct restorations in the UK) and the average share of gross taxable income received from the practice-owner dentist (25, 26, 31, 32). A summary of the retained practice earnings remunerated to dental providers and the amount required to provide each type of treatment is provided in Table 2.

Table 2 here

Analysis of effect

Average cost and health differences between the intervention (mid-level provider as the front-line clinician) and usual care group (dentist as the front-line clinician) were analysed in each of the three jurisdictions. Outcomes on the cost measure are calculated for each jurisdiction while the health measure outcome is presented once. This is because the model allows for variation across the jurisdictions in remuneration income per minute for the dental providers while diagnostic accuracy,

which determines health outcome, is the same in all jurisdictions. The latter is assumed to be the case because a standard set of skill competencies is required for qualification as a dental provider regardless of the area in the UK that they are employed.

A summary of the costs and outcomes was presented in a single measure: incremental cost-effectiveness ratio (ICER). This calculates the incremental cost associated with six-months in a caries -free state. Further incremental analysis such as the use of Cost-effectiveness Acceptability Curves (CEAC) was not considered necessary in this study context because one option was dominant. Also foundations of incremental analysis require a provider that would be willing to pay an amount of resources for units of health gain. This is difficult to conceptualise in this study context, given that the providers were dental practice owners and they are not required to make trade-offs between health gains to the patient accrued from treating caries and the cost incurred to the practice (treatment brings health gains and revenue to the practice).

Results are given as means and mean differences (standard errors) for normally distributed data. We used t tests assuming independent samples to compare the means differences between front-line clinicians (dentist or mid-level provider). The standard errors and mean values for the t tests were calculated from the simulation data (1,000 adults over 100 rounds). P values are two tailed and Bonferroni corrections were applied to correct significance values for multiple comparisons.

Sensitivity Analysis

Sensitivity tests were undertaken to determine the robustness of the findings. One and Two-way sensitivity analyses were performed on the following parameters of Markov model:

- Test 1 used the sensitivity and specificity values at the lower bound value of the 95% confidence Interval for mid-level providers and upper bound for dentists.
- Test 2 used the sensitivity and specificity values at the upper bound value of the 95% confidence Interval for mid-level providers and lower bound for dentists.
- Test 3 used average (mean) sensitivity and specificity values of mid-level providers found in another UK based study (22).
- Test 4 excluded from the model restorations on sound teeth i.e. the potential of generating False Positives.

- Test 5 used a prevalence value that borderline tooth develop in a six month interval between check-ups of 31.3% i.e. an increase by 10 percentage points.
- Test 6 used a prevalence value that borderline tooth develop in a six month interval between check-ups of 11.3% i.e. a decrease by 10 percentage points.
- Test 7 used a routine restoration time for mid-level providers of 30.8 minutes and cost to £14.12 i.e. a 100% increase in treatment time of that procedure.
- Test 8 used remuneration income per hour for midlevel providers of £33.10 (20% increase) and £39.77 for dentists (20% decrease).

The first four tests were undertaken as these influence the health and cost outcomes, whilst the latter four tests affected the cost outcomes. For concision, outcomes of these tests are presented for England and Wales. The test results in other jurisdictions did not change the dominant intervention and are available upon request to the authors.

Results

Results are presented in Table 3 and sensitivity analysis in Table 4.

Table 3 here

The length of time a patient in the virtual practice population remained healthy (i.e. did not transition from health to disease) was not statistically different between the two groups i.e. there was no statistical difference between mid-level providers and dentists as front-line clinicians. The cost saving to the practice of utilising mid-level providers were statistically significant at a 5% level and amounts to £7.85 ($10.20) in England and Wales, £9.16 ($11.90) in Northern Ireland and £8.69 ($11.29) in Scotland per patient visit. The incremental cost per six-month gained in a cavity-free state amounted to £261.67 ($339.93) in England and Wales, £305.33 ($369.68) in Northern Ireland and £289.67 ($388.03) in Scotland. In each of the sensitivity tests, there was no significant difference on the health effect measure and the service intervention was cost saving at a 5% level.

Table 4 here

Discussion

No statistical difference was found in the number of new dental caries lesions that developed in the virtual population between mid-level providers and dentists. This suggests that mid-level providers could provide more of a leading role as front-line clinicians in the NHS (based on the parameters in the simulation model). Across three distinct NHS dental healthcare systems in the UK, the use of mid-level providers as a front-line clinician brings a cost saving to the practice owner, without any deterioration to patient's health. These findings remain even when the drivers of outcome differences in the model are parameterised at the extremity values found in the data. This was the case for True Negatives and False Positives values, which determine treatment decisions on healthy patients and was by far the most frequent health state for patients in the Markov model. Over a two-year period (ending in 30th July 2015) an average practice in England will have seen 4,040 unique patients (33). With the conservative assumption that each unique patient has visited the practice only once in the two year period then the £7.85 ($10.20) cost saving per visit found in England and Wales from the use of mid-level providers amounts to an average annual labour cost reduction to a practice of £15,857 ($20,606) and a potential annual saving to NHS dentistry in England of £117,845,990 ($153,142,042), if these costs could be released from the system.

The model is based on attending adults for bi-annual appointments. Extending the recall interval would improve the cost-effectiveness of mid-level providers if recall interval alters caries incidence significantly (34). This is because the difference between providers in their remuneration income (a staffing cost to the practice) for a check-up is smaller than if the check up requires a restoration, and latter event could be more likely with longer recall intervals. In addition, the greater opportunity to diagnose disease improves the comparative health effect of mid-level providers as they more accurately detect disease when it is present.

The cost perspective taken in this study was the revenue implications to the practice i.e. the amount of retained practice earnings required to provide healthcare to the patient. Alternative measures within the same cost perspective would have been practice profit or NHS remuneration revenue from treatments provided to patients. However, both are not a valid metric in this study context, given that an outcome of the intervention across different UK healthcare systems was sought. NHS remuneration income for treatment delivered in Northern Ireland and Scotland is in pound sterling whilst for England and Wales, it is a unique metric known as Units of Dental Activity (UDAs). Dentists get paid one UDA for a Band One treatment (equates to approximately a £18 patient fee), three for a Band Two treatment and twelve UDAs for a Band Three treatment. Whilst patient fees are fixed by the Government, the monetary value of a UDA for the practice is not fixed, but set by each dental

practice in negotiation with the local NHS Local Area Team. Further, only dentists are able to generate UDAs for the practice and so the income accrued from mid-level providers cannot be measured directly. This was found to be a key limiting factor in a recent study looking at the efficiency of role-substitution in the UK (11). Second, a measure of revenue received from delivering healthcare is influenced by differing incentives to the provision of treatment in the three NHS jurisdictions. For example, England and Wales but not Northern Ireland or Scotland have an annual limit to the amount of dental activity that can be redeemed by a dental practice from the NHS each year. This means that there is a cost-containment for practices operating within England and Wales and a ceiling to UDA generation (11).

Our finding that mid-level providers increase the efficiency of resource use in dental practices contrasts with the finding in two studies that their contribution to service delivery is not sufficiently large to offset their cost (14, 20). A review of international research literature that investigated the impact a specific type of mid-level provider (dental therapists) has on productivity and finances concluded their use does not increase practices' net revenues (35). However, in the UK, many of these factors related to the constraints within the existing system, rather than the performance of the mid-level provider per se (11).

The model presented in this paper is limited by a number of simplifying assumptions. First, the dental provider's diagnostic accuracy of photographs of enamel caries in controlled conditions, which is the basis in our model of differences between providers in cost and health outcomes, is a suitable indicator for how they perform in a typical workday . We might expect diagnostic accuracy to be worse in a clinical environment since teeth may not dry and an examination of the entire mouth may mean less time is taken with each tooth. This is an unavoidable limitation although we find mid-level providers remained the dominant intervention after a reduction in diagnostic accuracy for mid-level providers and simultaneous increase in accuracy for dentists and in a second sensitivity test where the diagnostic accuracy of mid-level providers is based on a judgement task on the entire mouth of actual patients in a clinical environment.. Equally, the results of an in-vivo practice based study suggest that mid-level providers can operate to a high standard of diagnostic test accuracy compared to dentists (22). This study is the largest practice-based study undertaken to date to examine diagnostic test accuracy. A second simplifying assumption in is that there is no health state memory in the model, which has the consequence that the development of dental caries in one tooth does not influence the development of dental caries in other teeth. This assumption is unlikely

to have had a large effect on the results of the cost effectiveness findings. This is because our model results show the short-term impact of the intervention (a time perspective of 5 years) and evidence suggests that cohort trends in caries experience are explained by the amount of incurred treatments and disease (36). In low-risk patients, caries appears to remain as a relatively isolated phenomena and the bulk of the projected costs in the future relate to the management of regularly attending "low-risk" patients (37, 38).

A limitation of the model is the absence of the possibility of restoration failure, which may differ between dentist and mid-level provider and would affect patient health and treatment cost. However, the limited empirical evidence suggests that any effect from restoration failure on our study findings would be small and not lead to a change in the cost-effectiveness dominance of the intervention (39, 40). The two studies that have compared the standard of restorations of mid-level providers with dentists found substantial restorations to be infrequent and at a similar level in each group e.g. the prevalence of amalgam restorations that were deemed to be sub-standard was approximately 22% from dentists and 12% for mid-level providers (41, 42).

The quality of care received and patient's satisfaction with treatment is not accounted for in the model. These factors may differ between dentists or mid-level providers and could be expected to effect the likelihood patients make or attend future appointments that in turn may affect the likelihood caries develop between appointments. However, in a descriptive study which examined the attitudes of new patients to mid-level providers working independently to dentists, they found 98 percent of responding patients were satisfied with their mid-level provider care, and 80 percent attended an dental appointment within the next 12 months (43). This concurs with other studies, which found that patients who have a high degree of satisfaction with their experience with mid-level providers (11, 39, 44, 45, 46).

In this study mid-level providers have been found to be cost-effective based on average provider costs for a single practice in each country. However, the cost-effectiveness of the use of mid-level providers would be expected to differ in regions of the country where the remuneration incomes of providers are smaller or larger than the national average taken in our analysis. In rural areas of a country, where the regional population is smaller, there are a smaller number of practices (47). These seek fewer providers from the local labour market, with a consequence that income required

to attract those providers into employment is less than in areas where demand for providers is high (25, 26). Another determinant of provider income is the amount of practice revenue available to remunerate their providers. The size of retained profits depends on regional overhead costs (e.g. rent of land), which are larger in London and the south East of England than in Wales and other areas of England, and the remuneration income a practice receives for providing treatments, which also varies across regions of England and Wales. In those countries of the UK, the NHS remuneration income for dental activity provided by a practice is set in a contract negotiated between the practice owner and local NHS commissioning body and the latter is more likely to provide a higher amount in areas where there are fewer practices available to meet the care needs of the patient population.

A limitation of the analysis is that provider performance and costs may depend of the healthcare settings they are employed in. Small practices with a single dentist or very limited surgery space may not use mid level providers in the same way as large practices, which in turn would be different from their use in settings such as NHS community dental services (e.g. hospitals, specialist health centers, mobile clinics and home visits or visits) and private sector dentistry. Provider performance and costs may also change when adopted more widely in any care setting. If the national demand for mid-level providers were to suddenly rise, perhaps in response to a policy change that allows them to perform tasks previously undertaken by dentists, then mid-level providers would be in a stronger bargaining position to negotiate with practice owners for an increase in their wages. The concurrent increase in the recruitment of mid-level providers from relatively stable pool of labour could pull into employment consecutively worse performers on average, if we assume practice owners are able to detect to some degree the work performance of unemployed mid-level providers (and hence would 'cherry pick' the most productive first). The performance of dentist might also improve, as their caseload will lighten when more mid-level providers are employed to provide care. These scalability and generalizability factors hypothetically serve to reduce the cost-effectiveness of mid-level providers although to estimate the actual extent this may occur is a difficult task and requires a different methodological approach, for example a general equilibrium model. In addition, the importance of role-substitution from a policy perspective may also be less important for systems that are not state-funded.

Future evaluations of the cost-effectiveness of mid-level providers might broaden the scope of the evaluation beyond the treatment of dental caries to include other dental diseases such as oral

cancer. This should ideally take the form of a definitive trial investigating the effectiveness of using mid-level providers to maintain the health of routine “low-risk” patients in practice, with a parallel cost-effectiveness evaluation. The trial should be designed to capture all possible health gains from receiving a dental check-up such as the detection of periodontal disease or changes in the patient’s education, motivation and behaviour in oral self-care and follow patients or extrapolate the health and cost effects into the long term. A feasibility study exploring this has recently been completed in the UK (46).

In summary, we find mid-level providers can effectively detect and treat dental caries while reducing overall staffing costs for dental practices. If this model of care is adopted widely, it appears to have the potential to release resources in public funded systems to address changes in population need.

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Tables to be included in the text

Table 1: Input parameters for the Markov model

Item	Enamel	Dentate	Deep dentate
Initial caries prevalence	28.3%	0%	0%
Probability of new cavity development	21.3%	0%	0%
Progression from	Mean (range)		
Enamel caries lesion	95.5% (73% - 98.8%)	4.5% (1.2% - 27%)	-
Dentinal caries lesion	-	55% (20% - 91%)	45% (9% - 80%)
*Probability of a borderline tooth**	21.3%		
Sensitivity and Specificity	Mean (95% Confidence interval)		
Dentist sensitivity	83 (73.2, 92.8)		
Dentist specificity	68.9 (62.4, 75.4)		
Mid-level provider sensitivity	84.2 (75.2, 93.3)		
Mid-level provider specificity	66.2 (58.7, 73.6)		
Mid-level provider sensitivity/ specificity (mean averages) based on feasibility study data (7)	82/85.1		

*A tooth that looks carious when is sound

Table 2: Treatment costs and dental provider remuneration by jurisdiction

Treatment type	Mean time in minutes (Standard deviation)	Mean cost in England and Wales (Standard deviation)	Mean cost in Northern Ireland (Standard deviation)	Mean cost in Scotland (Standard deviation)
Check-up by a dentist	12.2 (5.77)	£10.14 (£4.88)	£10.29 (£4.95)	£9.02 (£4.34)
Direct restoration by a dentist	24.8 (8.33)	£20.51 (£6.89)	£20.80 (£6.98)	£18.24 (£6.12)
Endodontic treatment by a dentist	35.3 (13.25)	£29.23 (£10.97)	£29.65 (£11.13)	£26.00 (£9.76)
Check-up by a mid-level provider	15.4 (7.19)	£7.06 (£3.77)	£6.52 (£3.57)	£5.36 (£3.12)
Direct restoration by a mid-level provider	24.8 (8.33)	£11.38 (£3.82)	£10.52 (£3.53)	£8.65 (£2.91)
Mid-level provider remuneration per hour	-	£27.59 (£4.96)	£25.50 (£4.95)	£20.97 (£4.73)
Dentist remuneration per hour*	-	£49.71 (-)	£50.43 (-)	£44.21 (-)

*The standard deviation or other variation measures of average dentist remuneration was not available.

Table 3: Economic effect of the service intervention

	Average number of dental visits before a carrier develops			Average cost of a dental visit		
	Intervention; Usual Care	Mean difference (standard error)	P value of difference	Intervention; Usual Care	Mean difference (standard error)	P value of difference
England and Wales	2.98; 3.01	- 0.03 (0.09)	0.71	£13.16 ($17.10); £21.01 ($27.31)	- £7.85 (£1.53) - $10.20 ($1.99);	<0.01
C/E ratio	£261.67 ($339.93)					
Northern Ireland	2.98; 3.01	- 0.03 (0.09)	0.71	£12.16 ($15.80); £21.32 ($27.71)	- £9.16 (£2.90) - $11.90 ($3.77)	<0.01
C/E ratio	£305.33 ($369.68)					
Scotland	2.98; 3.01	- 0.03 (0.09)	0.71	£10.01 ($13.01); £18.70 ($24.30)	- £8.69 (£2.46) - $11.29 (£3.20)	<0.01
C/E ratio	£289.67 ($388.03)					

*An asterisk indicates the mean difference between groups is statistically significant at a 5% level.

Table 4: Sensitivity of the results to changes in the model parameters

	Average number of dental visits before a carrier develops			Average cost of a dental visit		
	Intervention; Usual Care	Mean difference (SE)	P value	Intervention; Usual Care	Mean difference (SE)	P value
Test 1: Diagnostic accuracy at lower bound for Intervention group and upper for Usual Care	3.33; 2.86	- 0.47 (0.10)	<0.01	£13.48; £20.83 $17.52; $27.07	- £7.35 (£1.50) - $9.55 ($1.95)	<0.01
Test 2: Diagnostic accuracy at upper bound for Intervention group and lower for Usual Care	2.85; 3.34	- 0.49 (0.11)	<0.01	£12.91; £21.29 $16.78; $27.67	- £8.38 (£2.43) - $10.89 ($3.16)	<0.01
Test 3: Alternative diagnostic accuracy data for Intervention group	3.02; 3.01	0.01 (0.12)	0.99	£13.04; £21.01 $16.95; $27.30	- £7.97 (£1.54) - $10.36 ($2.00)	<0.01
Test 4: Without False Positive occurrences.	2.98; 3.01	- 0.03 (0.09)	0.71	£12.01; £19.78 $15.61; $16.95; $25.70	- £7.77 (£1.53) - $10.10 ($1.99)	<0.01
Test 5: prevalence of borderline teeth increased by 10%	2.98; 3.01	- 0.03 (0.09)	0.71	£13.54; £21.95 $25.70; $17.60	- £8.41 (£1.54) - $10.93 ($2.00)	<0.01
Test 6: prevalence of borderline teeth decreased by 10%	2.98; 3.00	- 0.03 (0.09)	0.71	£12.78; £20.07 $28.52; $16.61	- £7.29 (£1.54) - $9.47 ($2.00)	<0.01
Test 7: 100% increase in routine restoration	2.98; 3.01	- 0.03 (0.09)	0.71	£20.22; £21.01	- £0.79	<0.01

time for Intervention group				\$26.28; \$27.30	(£0.16) - \$1.03 (\$0.21)	
Test 8: 20% increase (decrease) in remuneration income for Intervention group (Usual Care)	2.98; 3.01	- 0.03 (0.09)	0.71	£15.79; £16.81 \$20.52; \$21.84	- £1.02 (£0.13) - \$1.33 (\$0.17)	<0.01

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