

O'Keefe, E. J., McMahon, A. D., Jones, C. M., Curnow, M. M. and Macpherson, L. D. (2016) Evaluation of dental therapists undertaking dental examinations in a school setting in Scotland. *Community Dentistry and Oral Epidemiology*, 44(6), pp. 515-522. (doi:[10.1111/cdoe.12244](https://doi.org/10.1111/cdoe.12244))

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Deposited on: 10 August 2016

**Evaluation of dental therapists undertaking dental examinations in a school setting in Scotland.**

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## Abstract

**Objective:** To measure agreement between dental therapists and the Scottish gold-standard dentist undertaking National Dental Inspection Programme (NDIP) examinations. **Methods:** A study of inter-examiner agreement between 19 dental therapists and the national gold-standard dentist was carried out. Pre-calibration training used the caries diagnostic criteria and examination techniques agreed by the British Association for the Study of Community Dentistry (BASCD). Twenty-three five-year-old children (Primary 1) and seventeen eleven-year-old children (Primary 7) children were examined. Agreement was assessed using kappa statistics on  $d_3mft$  and  $D_3MFT$  for P1 and P7 children, sensitivity and specificity values, and kappa statistics on  $d_3t/D_3T$  and  $ft/FT$ . Calibration data on P1 and P7 children from 2009-2012 involving dentists as examiners were used for comparison. Economic evaluation was undertaken using a cost minimisation analysis approach. **Results:** The mean kappa score was 0.84 (SD 0.07) ranging from 0.69 to 0.94. All dental therapists scored good or very good agreement with the gold-standard dentist. This compares with historic NDIP calibration data with dentists, against the same gold-standard dentist, where the mean kappa value was 0.68 (SD 0.22) with a range of 0.35 to 1.00. The mean sensitivity score was 0.98 (SD 0.04) (range 0.88 to 1.0) and mean specificity score was 0.90 (SD 0.06) (range 0.78 to 0.96). Health economic analysis estimated that salary costs would be 33.6% lower if dental therapists were substituted for dentists in the year 2013, with an estimated saving of approximately £103,646 per annum on the national budget. **Conclusion:** We conclude that dental therapists show a high level of inter-examiner agreement and with the appropriate annual training and calibration they could undertake dental examinations as part of the NDIP programme.

## Introduction

Dental therapists are reported to be established in over 50 countries<sup>1</sup> and the roles and responsibilities (skill mix) are dependent on a country's service and education models and regulations. The use of skill mix in medicine is more common and driven by quality, professional development and/or considerations relating to cost-effectiveness and efficiency<sup>2</sup>. A focus on value for money means that the re-distribution of tasks, through the appropriate use of members of the dental team, will continue<sup>3</sup>.

A recent review<sup>4</sup> found that dental therapists provide high-quality, safe and effective care that is equal to that of dentists working under the same conditions, and are generally cheaper. A study in Australia used dental hygienists to screen residents in a care centre for older people<sup>5</sup>.

In California, a study conducted on 5233 children, using four dentists and eight dental hygienists reported good agreement for the caries indices. Limitations included different training between the dentists and dental hygienists and the use of different indices and different equipment for examining the children<sup>6</sup>. Researchers in Sweden used teams of one dental hygienist and two dentists in the practice setting to look at caries in patients in three different age categories<sup>7</sup>. They found similar results between the dentists and dental hygienist, although agreement levels were not so high for early carious lesions. In the United Kingdom (UK) the remit of dental therapists is stated in the General Dental Council's recently reviewed 'Scope of Practice'<sup>8</sup>. There are limited studies investigating the use of dental therapists for dental epidemiology programmes in the UK. A pilot study undertaken in 1996<sup>9</sup> led to a feasibility study in 1998<sup>10</sup> to investigate the diagnostic ability of dental hygienists and therapists to carry out caries prevalence surveys in the school setting. The studies used a mixed sample of dental care professionals that limited the power of the studies. The standard dentist carried out the examinations in advance of the study so examining conditions might not have been similar, again limiting any conclusions. They concluded that dental care professionals could be trained and calibrated to an acceptable standard for examining five-year-olds, but required additional training to meet the national standards for agreement for twelve-year-olds.

A more recent study<sup>11</sup> involved three dental therapists in a calibration exercise alongside 24 dentists, for a survey of five-year-olds. This study supported the findings of previous studies but the number of dental therapists was small and the calibration exercise involved only five-year-old children. Recently, a study<sup>1</sup> proposed that dental therapists could be used for dental screening programmes. Their study provided a five-minute training exercise and used clinical images. The findings suggest that different members of the dental team showed the potential to carry out inspections to a similar standard as dentists but further work *in vivo* is required. Overall the results are positive, especially in view of the minimal training delivered.

The Scottish National Dental Inspection Programme (NDIP) is carried out annually, where every primary one (P1 (five-year old)) and primary seven (P7 (eleven-year old)) child is invited to have a basic dental examination (BNDIP) and a representative sample of P1 or P7 children, randomised at class level, receive a detailed dental examination (DNDIP) on alternate years. These annual dental examinations are a core component of the public health function of the Public Dental Service within Scotland<sup>12</sup>. The main aim of the examinations is

to inform the parents/carers of their child's oral health by letter and convey the degree of urgency for which an appointment for dental attendance is required. Secondary aims are to support the child into appropriate care and to use anonymised results for planning services and evaluating oral health initiatives. Dental teams performing the examinations on an annual basis undertake the nationally agreed standardisation training programme for BNDIP in their local regions and attend a mandatory annual caries calibration exercise for DNDIP. The use of dentists in undertaking NDIP examinations is time consuming, costly and diverts them from direct clinical care. The potential to use dental therapists should present savings for the Public Dental Services (if there is sufficient substitution with dental therapists) and therefore an economic evaluation of changing the staff involved in NDIP was undertaken.

The objective of this study was to measure the level of agreement between dental therapists in undertaking NDIP basic and detailed examinations with the Scottish gold-standard dentist. The gold-standard dentist routinely achieved median results when analysing the inter-examiner reliability in the calibration events and has taken part in the Scottish calibration events for dental epidemiology programmes for the past 28 years with the exception of two years. Secondary objectives were to compare the intra-examiner agreement of the gold-standard dentist and dental therapists using a sample of images, not previously used on an online training tool ([www.ndip.scottishdental.org](http://www.ndip.scottishdental.org)). Also, historic data from four national calibration events where the gold-standard dentist was present were re-analysed for comparative and contextual purposes. An economic evaluation into the use of dental therapists in delivery of the NDIP programme was conducted.

## **Methods**

The study was approved by the East of Scotland Research Ethics Service (13-ES-0004) and NHS Tayside Research and Development Office. The children were recruited from two primary schools in Perth, Scotland. Informed consent was obtained from parents and carers for participating children and positive assent was also collected from participating children.

Prior to the study the dentist and the dental therapists underwent a standardisation training session for basic NDIP within their local geographic areas, based on a programme developed and used routinely on the NDIP website. Scribe training was delivered locally as part of the pre-training to ensure that there was consistent and reliable recording of data.

The study was similar to the NDIP training and calibration programme. On the first day there was a session to review the BNDIP criteria and an introduction to the detailed examination. The training covered inspection procedures, the use of tooth and surface codes, and the modified diagnostic criteria for NDIP based on criteria agreed by the British Association for the Study of Community Dentistry (BASCD)<sup>13</sup>. Thereafter the training involved the NDIP examinations on a small sample of P1 and P7 children; during this session data were reviewed and feedback provided to the participants.

Intra-examiner reliability, in relation to BNDIP, was assessed using a set of 30 printed clinical images, divided evenly into the two age groups. This method of testing for intra-examiner agreement was chosen as the children were going to be examined a large number of times by the examination teams, and it was felt that additional repeat examinations would be excessive. The dental therapists and gold-standard dentist performed the test at the end of the first day and then repeated the test at the end of the second day, using the same images. No additional training was received between the two tests.

The formal examinations for the study were carried out on the second day. The study group included the gold-standard dentist and the group of dental therapists. The study followed the standard BASCD criteria<sup>13</sup> with the children examined in a supine position on tables in the school hall. There were separate morning and afternoon sessions with different groups of children. Paper forms were used to minimise the risk of recording error or data loss during the study. The data were then typed onto an NHS encrypted laptop, double checked, inaccuracies corrected and sent for statistical analysis.

Data from four years' calibration courses for dentists were analysed and available for both P1 and P7 children; all datasets analysed featured the same gold-standard dentist. Sensitivity and specificity analyses were conducted using historic dentist calibration data from 2009-2012 using the same gold-standard dentist.

### *Statistical Methods*

The primary endpoint was  $d_3mf$  or  $D_3MFT$  (as appropriate for the age group concerned) and pooled into categories of no obvious decay ( $d_3mf/D_3MF=0$ ) or obvious dental decay ( $d_3mf/D_3MF>0$ ). The secondary endpoints were  $d_{3t}/D_3T$ ,  $mt/MT$ , and  $ft/FT$ , also categorised into no obvious decay or obvious decay. The BNDIP levels are defined by the three letters

called A, B and C that are given to parents following a NDIP examination (A= severe decay or abscess, seek immediate dental care, B= seek dental care in the near future and C= no obvious decay experience)<sup>14</sup>. Each endpoint was assessed for statistical agreement against the gold-standard dentist using the kappa statistic. Validity was measured using sensitivity and specificity. Weighted kappa analyses were used for BNDIP as the endpoint has three options and required a 3x3 table. Intra-examiner agreement was calculated using the data from the 30 clinical printed images, similar to the online training package.

A second analysis was carried out where the kappa statistics were calculated relative to the median of the group of dental therapists, instead of the gold-standard dentist. This process is part of the normal analysis when calibrating the dentists, thus facilitating a direct comparison with the previous published reports. The P1 and P7 subgroups were also analysed separately, to examine any differences by age group. All statistical analyses were carried out using the SAS System (version 9.3). All kappa statistics were summarised by the mean and the minimum and maximum values. The minimum agreement (for the worst performing dental therapist) is a more valid metric in this context than the lower bound of a 95% confidence interval.

### *Sample Size Calculations*

Two elements were considered when calculating the sample size of this study; the number of children to be inspected and the number of dental therapists to carry out the inspections.

The literature from psychology and psychiatry has explored the sample size calculations for the kappa statistic for two raters. Sample size calculations are possible<sup>15</sup>; however evidence<sup>16</sup> suggests that 'power estimation for kappa is not as firmly developed as for some other commonly used statistics'. Cantor<sup>17</sup> has further discussed sample size calculations and Hadzi-Pavlovic<sup>16</sup> looked at the relationship between power and sample size and considered the marginal frequencies, where they distinguished between the raters using a 2x2 table. Hadzi-Pavlovic<sup>16</sup> has published sample size calculations for kappa. Based on his findings the sample size needed was 40. Although previous work in this field for dental epidemiology programmes is fairly limited, BASCD<sup>18</sup> has recommended that 'a minimum of ten children of the appropriate age group with caries experience be included'. Based on the literature review and the available guidance the intention was to study 40 children, with at least 20 having caries experience, to be split evenly between P1 children and P7 children. This was done to facilitate subgroup analyses by age group.

An analysis of four years' data (2009-2012) from the annual national calibration exercises looked at the mean and standard deviation of kappa for dentists, to provide an approximate figure of possible results. A sample size of 19 for the P1s would give a two-sided 95% confidence interval for a mean that would extend 0.063 from the observed mean, assuming that the standard deviation was known to be 0.14. For the P7 calculation; a sample size of 19 would give a two-sided 95% confidence interval for a mean that extends 0.08 from the observed mean, assuming that the standard deviation is known to be 0.179.

### *Economic evaluation*

An economic evaluation of the potential savings of substituting clinical staff in the NDIP was undertaken. This modelled the effect of direct substitution of dental therapists for the existing dental staff; either clinical dental officers (CDOs) or senior dental officers (SDOs).

A cost minimisation analysis approach was used, which is possible when the two options under comparison are equivalent in terms of effectiveness<sup>19</sup>. A number of assumptions have been made; therefore the only difference between dentist and dental therapists is financial (salary plus on-costs). The methodology used was to contact each health board to get the number of sessions and staff grades of the dentists participating in the NDIP programme 2012-13. A session is defined as half a working day.

### **Results**

There were 19 dental therapists from across Scotland, all working for the Public Dental Service (PDS). This represented approximately 25% of the total PDS dental therapist workforce in Scotland. Eleven dental therapists had qualified in the past ten years, the majority having a diploma in Dental Hygiene and Dental Therapy.

As planned, 40 children were examined on the final day of the study. The numbers were slightly unbalanced between the two age groups due to logistical difficulties. There were 23 P1 children (mean age 5 years 10 months) and 17 P7 children (mean age 11 years 9 months). A summary of their caries experience is in Table 1. [Insert table 1] The mean  $d_3mft/D_3MFT$  was 1.2 overall, 1.4 in the P1 group and 0.8 in the P7 group. The overall percentage of children with obvious decay experience was 35%, and 30% and 41% respectively for the P1 and P7 groups. This compares with the local published findings in the national annual reports,

for P1s in 2012<sup>20</sup> where 31% experienced obvious dental decay and for P7s in 2011 the figure was 35%<sup>21</sup>.

All 19 dental therapists successfully completed the trial. Each dental therapist had their own kappa statistic calculated to measure their agreement with the gold standard. The individual kappa values are pooled and summarised in a meta-analysis in Table 2. [Insert table 2]. Although the sample size is 40 for the number of children, the meta-analysis is of the 19 kappa values. For the primary endpoint of  $d_3mft/D_3MFT$  being greater than zero the mean kappa was 0.84, with the individual values ranging from 0.69 to 0.94. The available guidelines state that a kappa of 0.84 is within the highest level of statistical agreement<sup>22</sup>. The mean kappa for the secondary endpoints were; 0.67 for  $dt/DT$  (range 0.42 to 0.83), 0.83 for  $ft/FT$  (range 0.52 to 1.00) and 1.0 for  $mt/MT$  with no disagreement. The primary endpoint was also analysed by age subgroups, and the mean kappa was 0.93 for the P1 group (range 0.79 to 1.00) and 0.64 for the P7 group (range 0.34 to 0.84). The lower value of 0.64 is scored as 'substantial' or 'good' according to published guidelines. The agreement analysis was also repeated using the median score of the dental therapists as the standard, and this analysis produced a mean kappa of 0.87 (range 0.69 to 1.00) which is similar to that found when compared against the gold-standard dentist. The intra-rater analysis compared the basic NDIP scoring of the printed clinical images from the first day of study to that from the second day. The mean weighted kappa of the 19 dental therapists was 0.86, ranging from 0.66 to 0.96.

For comparative and contextual purposes the historical data from the training and calibration courses of dentists were re-analysed, including sensitivity and specificity. The mean  $d_3mft/D_3MFT$  was 2.0 (standard deviation 3.0) based on a sample size of 44 children [Table 1], the mean of the historical kappa statistics was 0.68 (range 0.35 to 1.00) against the gold-standard dentist and was 0.79 (range 0.42 to 1.00) against the median score for the dentists. It is clear that the results of the trial for the dental therapists are no worse than the typical result for dentists.

The overall mean sensitivity for the dental therapists against the gold standard was 0.98 (range 0.96 to 0.1) and specificity 0.90 (range 0.87 to 0.92). In comparison, the overall mean sensitivity for the historic dentist data was 0.81 (range 0.76 to 0.87) and specificity 0.90 (range 0.85 to 0.95).

The intra-rater analysis compared the basic NDIP scoring of the printed clinical images from the first day of study to that from the second day. The mean weighted kappa of the 19 dental therapists was 0.86, ranging from 0.66 to 0.96.

### *Economic evaluation*

In 2012, 40 Community Dental Officers (CDOs) and eight Senior Dental Officers (SDOs) calibrated successfully to undertake the detailed NDIP examinations in 2012/13<sup>23</sup>. In addition there were reported to be another 62 dentists doing only basic (BNDIP) examinations.

The total annual mid-point salary costs, plus on-costs of employing the existing 110 dentists (eight SDOs and 102 CDOs) was estimated at £6,084,237 at 2013 salary scales (see Table 3). [Insert table 3] Replacing all dentists with dental therapists gave an estimate of £4,042,760; an estimated annual saving of £2,041,477 (33.64%). Note that this is the full direct salary costs of the SDOs and CDOs spending some of their duties working in the NDIP, not salary costs of the NDIP. These 110 dentists undertake many other duties throughout the working year in addition to the NDIP examinations and the same would apply to dental therapists.

### *Costs savings based on reported NDIP sessions*

Health boards were asked to submit information in relation to the number of NDIP sessions undertaken in 2012/13 in order to understand the savings relevant to NDIP, this amounting to 2122 sessions. Therefore it can be estimated that 1,061 days would be required by the 110 staff, or 9.65 days per person. An additional two days are added for training and calibration giving 11.65 days on average, by each dentist or dental therapist. The proportion of their total time spent on NDIP is  $11.65/230 = 0.0507$ .

Applying this proportion to the total costs estimated above ( $0.0507 * £6,084,237$ ) gives a total salary cost for dentists undertaking the NDIP of £308,471, using the estimate of a saving of 33.6% on the annual costs. Applying this saving to the total NDIP salary costs gives an estimated saving of £103,646 (€142,375, \$159,413) <http://www.xe.com/currencyconverter/>. Table 4 [Insert table 4] shows the different cost savings that could be made if certain percentages of dentists are substituted by dental therapists.

## **Discussion**

Overall, the findings from this study suggest that dental therapists have the ability to calibrate to carry out detailed NDIP in the P1 and P7 age groups. Their overall score is as good as or better than dentists that had annually calibrated against the same gold-standard dentist. The study followed the same format as the annual programme and the dental therapists conducted a greater number of inspections than normal calibration events. Therefore additional training time is not necessary and no extra costs would be associated with training dental therapists.

Subgroup analyses of Primary 1 and Primary 7 children show a good level of agreements with the gold-standard dentist; this is similar if not better than the dentists. This study showed that there is better kappa agreement in the Primary 1 children, which is also true of dentists and agrees with the work of Kwan<sup>10</sup> who found that dental hygienists and therapist had better kappa scores in the primary dentition as opposed to the mixed dentition. The lower kappa scores in the P7 subgroup could be due to the more complex decision making required when examining the mixed dentition. The historic data relating to dentists also showed that scoring DMFT did not achieve as high kappa scores as dmft.

The costs associated with NDIP include the staff costs of both the dental examiner and the scribe. Substituting dentists with dental therapists would result in a cost saving for the Public Dental Service as salary plus on-costs (national insurance and superannuation) are lower for dental therapists. Currently the skill mix in the Scottish Public Dental Services would not allow for complete substitution of dentists by dental therapists, but a transition could be promoted as more dental therapists become available to the Public Dental Service. For this reason there may not necessarily be a 'cost saving' to the NHS, although on paper, there would be for NDIP. Rather value for money through role substitution results in a more efficient use of staff resources. The cost minimisation analysis only considers the salary costs (salary plus on-costs) of the dentist or dental therapist whilst undertaking NDIP. If all of the modelling assumptions are met then the saving on salaries for the NDIP is 33.6%.

#### *Implications for workforce planning*

The outcome of the study enables health boards to modify the workforce involved in core public health function of school dental inspections. Other factors will influence the role substitution, including the availability of dental therapists and handling the existing dental teams (dentists). The findings from this study support the extended role of dental therapists. This could potentially increase productivity by ensuring that staff spend more time working

at an appropriate level for which they are qualified. It will be hard to calculate the true cost savings of role substitution but if all employees work to their competencies the service can become more efficient and effective.

We conclude that dental therapists show a high level of inter-examiner agreement, and with appropriate annual training and calibration they can undertake dental inspections as part of the national programme with concomitant cost savings.

**Acknowledgements:** We would like to thank the dental teams for taking part in the study, NHS Tayside for hosting the research, and to the staff and children involved, without whose co-operation and willingness the study could not have taken place. We acknowledge the help, advice and expertise of Maura Beaton and Neil Craig, health economists at NHS Health Scotland. The study was supported by the Chief Dental Officer, Scottish Government.

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**Table 1: Mean d<sub>3</sub>mft/D<sub>3</sub>MFT and % obvious decay experience using the gold-standard dentist (child level)**

		N	d <sub>3</sub> mft		Mean (SD)	% Decay*	
			Min,	Max		N	(%)
<b>Therapists</b>	<b>Overall</b>	40	0,	7	1.2 (2.1)	14	(35%)
	<b>Primary 1</b>	23	0,	7	1.4 (2.6)	7	(30%)
	<b>Primary 7</b>	17	0,	3	0.8 (1.0)	7	(41%)
<b>Dentists (Historical Data)</b>	<b>Overall</b>	44	0,	11	2.0 (3.0)	24	(55%)
	<b>Primary 1</b>	23	0,	11	2.9 (3.8)	14	(61%)
	<b>Primary 7</b>	21	0,	4	0.9 (1.3)	10	(48%)

\* % decay = % with obvious decay experience as calculated by d<sub>3</sub>mft > 0

**Table 2: Mean kappa statistics for dental therapists and historical data for dentists (examiner level)**

	N	Min,	Max	Kappa Mean	(SD)
<b><u>Primary Endpoint (d<sub>3</sub>mft/D<sub>3</sub>MFT&gt;0)</u></b>					
Overall v Gold Standard	19	0.69,	0.94	0.84	(0.07)
Primary 1 Subgroup* v Gold Standard	19	0.79,	1.00	0.93	(0.08)
Primary 7 Subgroup* v Gold Standard	19	0.34,	0.84	0.64	(0.15)
Overall v Median Score	19	0.69,	1.00	0.87	(0.09)
<b><u>Secondary Endpoints v Gold Standard</u></b>					
Decayed teeth d <sub>3</sub> t/D <sub>3</sub> T	19	0.42,	0.83	0.67	(0.12)
Missing teeth mt/MT	19	1.00,	1.00	1.00	(0.00)
Filled teeth ft/FT	19	0.52,	1.00	0.83	(0.15)
<b><u>Dentists (Historic Data)</u></b>					
Overall v Gold Standard	40	0.35,	1.00	0.68	(0.22)
Primary 1 Subgroup v Gold Standard	21	0.50,	1.00	0.80	(0.18)
Primary 7 Subgroup v Gold Standard	19	0.35,	1.00	0.55	(0.17)
Overall v Median Score	44	0.42,	1.00	0.79	(0.18)

\* Subgroups are based on separate analyses of the 23 primary one children and the 17 primary seven children, rather than the full group of 40.

**Table 3: Costs and potential savings substituting dentists by therapists**

<b>Role</b>	<b>Actual number dentist</b>	<b>100% substitution by therapists</b>	<b>Annual pay (mid-point) (£)</b>
Senior Dental Officer	8	0	61,826
Community Dental Officer	102	0	43,450
Band 6 Therapist	0	110	29,759
SDO costs	£494,608	£3,273,490	
CDO costs	£4,431,900		
<b>Total</b>	<b>£4,926,508</b>	<b>£3,273,490</b>	
On-costs @ 23.5%	£1,157,729	£769,270	
Annual costs	£6,084,237	£4,042,760	
Savings		£2,041,477	
Savings percentage		33.6%	

**Table 4: Staff costs and potential savings for substituting dentists by therapists to deliver NDIP in Scotland**

<b>% Substitution of dentists by therapists</b>	<b>Staff costs (£)</b>	<b>Savings (£)</b>	<b>Savings (%)</b>
0	308,471	0	0
10	298,106	10,365	3.36
25	282,658	25,813	8.4
50	256,645	51,826	16.8
100	204,825	103,646	33.6

## Figure legends

**Table 1: Mean  $d_3mft/D_3MFT$  and % obvious decay experience using the gold-standard dentist (child level)**

**Table 2: Mean kappa statistics for therapists and historical data for dentists (examiner level)**

**Table 3: Staff costs and potential savings for substituting dentists by therapists**

**Table 4: Staff costs and potential savings for substituting dentists by therapists to deliver NDIP in Scotland**