

**THE PROFESSIONALS COMPLEMENTARY TO DENTISTRY:
SYSTEMATIC REVIEW AND SYNTHESIS**

John Galloway¹
Jean Gorham¹
Mark Lambert²
Derek Richards³
Daphne Russell²
Ian Russell²
John Welshman⁴

Dental Team Studies Unit, Eastman Dental Hospital¹
Department of Health Sciences & Clinical Evaluation, University of York²
Centre for Evidence-based Dentistry, Institute of Health Sciences, Oxford³
Institute for Health Research, University of Lancaster⁴

June 2002
(Revised January 2003)

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ACKNOWLEDGEMENTS

The review team would like to express their special thanks to Rob Munday who conducted the pilot searches for this study.

The team would also like to thank the following experts who responded to requests for information and assisted with translation:

Janette Colclough
Bill Crothers
Christine Godfrey
Ruth Holt
Asbjørn Jokstad
Stella Kwan
Sue Lloyd
Sally Mauriello
Raynor Mullins
Rob Schaub
Ted Seal
Bill Shaw
Aubrey Sheiham
Barbara Sherwood
Chris Stephens
Philip Young

We would particularly like to thank the staff of the British Dental Association Information Centre for their patience in copying published studies for us.

1. EXECUTIVE SUMMARY

1.1 The NHS Research & Development Programme in Primary Dental Care commissioned this systematic review of the effectiveness and cost-effectiveness of Professionals Complementary to Dentistry (PCDs). Our aim was to describe the extent and quality of the evaluation of the many models of service delivery used worldwide, and to draw conclusions about the effectiveness and cost-effectiveness in clinical, educational and related roles of individuals with different professional training.

1.2 We identified 5 key themes in the literature and set objectives for each:

1.3 Aims

1.3.1 **Diagnosis** – to assess whether PCDs can screen and diagnose dental conditions as effectively as dentists.

1.3.2 **Technical competence** – to assess whether PCDs can perform dental procedures, for example cavity preparation and fillings, as effectively as dentists

1.3.3 **Oral health promotion** – to assess whether PCDs can deliver oral health promotion as effectively as dentists.

1.3.4 **Acceptability** – to assess the acceptability of provision of dental services by PCDs.

1.3.5 **Productivity** – to assess the cost-effectiveness of PCDs.

1.4 Methods

1.4.1 We searched 12 electronic databases without language restrictions. We also hand-searched selected journals and tried to contact authors and other experts for further information. We included only studies that made direct comparisons between dentists and PCDs. We extracted the content of included papers using structured forms.

1.4.2 We synthesised information relating to each of the 5 key themes. Where appropriate we undertook meta-analysis. The quality of the 125 studies included was poor. We identified only one meta-analysis and 6 randomised controlled trials. The rigour of the remaining research designs and the quality of reporting were rarely better than mediocre. For example very few studies reported on inter-practice variability.

1.5 Results

1.5.1 **Diagnosis** – the majority of the 26 included studies in this section were from the 1990s. However despite this, the study designs were poor. There was a consensus that PCDs with appropriate training can perform screening and diagnosis as well as dentists. Only two papers disagreed with this assessment.

1.5.2 **Technical competence** – the 41 included studies were mainly conducted in the 1970s and are of poor quality. They assessed the technical competence of PCDs in a range of dental procedures, reversible and irreversible. With the exception of one paper on fissure sealant application they suggest that PCDs with appropriate training can perform a wide variety of dental procedures as well as dentists.

- 1.5.3 **Oral health promotion** – only 10 poor quality studies compared delivery of oral health promotion by PCD and dentists. Together they suggest that PCDs can do this as well as dentists, if not better.
- 1.5.4 **Acceptability** – the majority of the 13 included studies were questionnaire surveys. The quality was generally poor with response rates varying from 5% to 66%. Together they suggest that patients accept procedures carried out by PCDs.
- 1.5.5 **Productivity** – among the 53 studies included in this section there is a consensus that PCDs are cost-effective. To quantify this we focused on those studies from which it is possible to estimate the average increase in output achieved by adding one extended duty dental nurse (EDDN), one dental hygienist (DH) or one regular dental nurse (DN) to a single-handed dental practice previously without that PCD. Meta-analysis of 17 studies from 4 countries outwith the UK estimates that, relative to a typical single-handed dentist:
- Output of a marginal EDDN is 46% (95% confidence interval from 35% to 53%);
 - Output of a marginal DH is very *tentatively* 35% (95% CI 7% to 64%); and
 - Output of a marginal DN is very *tentatively* 18% (95% CI 11% to 25%).

1.6 Conclusions

- 1.6.1 The studies included were not only poor, but also old. They date from the 1960s, with more coming from the 1970s than from other decades. Studies about diagnosis and health promotion include more from the 1990s. Few of these studies come from the UK. There is a need for rigorous British studies to improve the evidence about effectiveness and cost-effectiveness of PCDs. Over the past forty years dental practice, equipment and materials, and the roles of PCDs, and attitudes to them have all changed. Fortunately, despite the poor quality and the age of these studies, the evidence is remarkably consistent in time and space. These results, although consistent, should be treated with caution, as study designs used do not exclude the possibility of other explanations for the findings
- 1.6.2 PCDs can diagnose a range of dental and oral conditions as well as dentists.
- 1.6.3 PCDs with appropriate training can complete a wide range of dental procedures as well as dentists. However there is little to suggest the best type and length of training.
- 1.6.4 An extra expanded duty dental nurse can increase the productivity of a single-handed dental practice by at least 35%, possibly 58%. The optimal ratio of expanded duty dental nurses to dentists is close to one to one. The evidence about the marginal productivity of dental nurses and dental hygienists is much weaker.
- 1.6.5 The evidence supports the current use of PCDs to deliver oral health promotion.
- 1.6.6 There is weaker evidence that PCDs are acceptable to patients.
- 1.6.7 There is even less evidence about orthodontic PCDs and clinical dental technicians.

1.7 **Recommendations**

- 1.7.1 The NHS needs more and better research into the effectiveness of PCDs.
- 1.7.2 The NHS also needs research into the economics of PCDs, in particular the most cost-effective ratio of PCDs (excluding dental nurses) to dentists.
- 1.7.3 The NHS also needs research into the optimal type and length of training for PCDs.
- 1.7.4 Unless results of this new research contradict the conclusions of this review, the UK needs to give serious consideration to increasing the ratio of PCDs (excluding basic dental nurses) to dentists from its current level of one to 6, so that it is much closer to one to one.

2. INTRODUCTION

- 2.1 Judgements about the quality of oral health care and the delivery of dental services depend on a clear understanding of their overall aims and specific objectives. The success of a service is likely to be judged in terms of the effectiveness and efficiency of its delivery. Flexibility is one key - the willingness and ability to respond to change. A service must therefore be receptive to outside ideas and influences and have the means to use them. A service that is restrictive and inflexible tends to lose direction and focus on itself rather than on the patients it treats.
- 2.2 The “best” service would be widely accessible and affordable; offer choice to patients; and provide high quality care preferably with the emphasis on prevention of disease rather than only treating its effects. The Nuffield Foundation’s Report, *The Education and Training of the Personnel Auxiliary to Dentistry* (1993)¹, argued that one way to achieve such a service in the UK in particular was through a policy of wider employment of skills-mix.
- 2.3 The report based its conclusion on a number of observations:
- 2.4 In many developed countries, an appreciable proportion of dental care is already provided by the professionals complementary to dentistry (PCDs), sometimes working alongside dentists, but often not.
- 2.5 The majority of items-of-service funded in the NHS General Dental Services could be provided by clinically trained dental support staff; dental auxiliaries, now called professionals complementary to dentistry (PCDs).
- 2.6 The extent of the range of skills deployed by PCDs worldwide, including the UK was considerable. However in general it appeared that little attempt had been made to create a freestanding role. More often the choice of skills that could be deployed was haphazard and inconsistent. In some cases the addition of a small number of skills could greatly improve both quality of care and productivity.
- 2.7 The shorter the training period is for particular groups, the more responsive services employing that group can be to change. The length of training for dental hygienists and dental therapists was less than half that for dentists.
- 2.8 However the report noted that in general the evidence for its recommendations tended to be little more than circumstantial and anecdotal. It regretted the apparent absence of well-designed studies to evaluate specific instances of skills-mix and provide a reliable evidence base. A systematic search of the literature was not within the Inquiry’s terms of reference and in any event, beyond its scope. Furthermore in the absence of any clear government policy or strategy for the future of the UK’s dental services, there was little immediate incentive for others to fund or carry out such a review.
- 2.9 An unsuccessful attempt to secure funding for a review was made in 1996 by the former Oxford & Anglia Regional Office under the NHS’s ‘*Seizing the Opportunities*’ initiative. However limited funding was made available during summer 1996 for Rob Munday to carry out a pilot search of the literature. This provided the basis for the present work.

¹ *The Education and Training of the Personnel Auxiliary to Dentistry*. The Nuffield Foundation, 1993.

- 2.10 The position had started to change in 1995 with the NHS Executive's initiative on R&D Priorities in Primary Dental Care, which identified skills-mix as one of its top 3 priorities. The subsequent call for grant applications led to this present review being funded. However any further funding for research into specific aspects of skills-mix was deferred until its completion.
- 2.11 The need for research into skills-mix also appeared to become more apparent with the establishment of the General Dental Council's (GDC) Dental Auxiliaries' Review Group (DARG) in 1996. The Review Group broadly reiterated the Nuffield Foundation's recommendations in its consultation paper, *The Professionals Complementary to Dentistry*² in 1998.
- 2.12 A development which was interesting in terms of the provisions and the restrictions of the Dentists Act was a clause in the 1998 Primary Care Act which permitted dental therapists to work in the pilot schemes in the new Personal Dental Services (PDS). First wave pilots started in October 1998.
- 2.13 The government and Department of Health did not acknowledge the issue of skills-mix for some years following the Nuffield Report. It was first mentioned in Parliament in summer 1996 when the Minister of Health referred to skills-mix when he announced the end of the previous government's dispute with the dental profession³. At the British Dental Association's annual conference in 1998, Alan Milburn, Minister of Health in the new Labour government, stated that one of the 5 challenges facing NHS Dentistry "if it is to prosper into the next century" was "*to allow all members of the dental team to use their full potential to improve patients' services*"⁴.
- 2.14 The NHS Plan published in 1999 was followed in September 2000 by the publication of *Modernising NHS Dentistry – Implementing the NHS Plan*.⁵ The government stated that "it would meet its responsibilities for making NHS dentistry a modern and dependable service by (inter alia) consulting on how to make best use of the whole dental team ... maximising the role of dental therapists and dental hygienists."
- 2.15 In 2001 a review of the dental workforce started. The first such review since 1991.
- 2.16 One problem perceived in assessing skills-mix and drawing conclusions about its effectiveness and particularly cost-effectiveness is that both depend on how services are financed. This varies considerably among countries and within countries and appears to have 2 implications. Firstly, at best a systematic review will be able to identify some particular circumstances in which specific skills-mix configurations work effectively. Secondly, to take advantage of skills-mix, the way the dental service are funded will probably have to be changed. Arguments against increasing the deployment of skills-mix in the UK are often based on an assumption that funding that remains largely unchanged since the NHS was founded in 1948, will continue unchanged.
- 2.17 However there is always a possibility that information will be found that challenges the fundamental principles upon which the working relationships between PCDs and dentists are based, and which are widely held to be self-evident. If this were so then the implications would be more important. Such a finding would erode convenient

² *The Professionals Complementary to Dentistry*. The General Dental Council, 1998.

³ Hansard. Coll311/312. 12 June 1996.

⁴ DoH Press Release 97/151.

⁵ *Modernising NHS Dentistry – Implementing the NHS Plan*. Department of Health. 2000.

beliefs of the necessity for many aspects of dentistry to be carried out only by dentists and that no other member of the team can be trained to carry them out.

- 2.18 It must be emphasised that although the motivation for the present review was UK focused, the issue of skills-mix must be seen in an international perspective. The Nuffield Inquiry¹ expected that if there was a substantial literature on skills-mix, it must largely originate outside the UK, as otherwise there would have been knowledge of it. However in the last few years skills-mix in dentistry has attracted attention in a number of countries, both in terms of public policy for the provision of services, eg South Australia, and for the right of certain groups to practise legally or independently, eg Denmark and the Netherlands.
- 2.19 Furthermore the issue of the mobility of labour has to be recognised with problems both of legality of employment and wide variations in training programmes across the world in general and the EU in particular.
- 2.20 Despite interest in the extent to which PCDs can complement or substitute for dentists, the research literature relating to PCDs has not been properly evaluated. Decisions by clinicians and policy-makers should be based on scientific appraisal of the available evidence. The aim of the review was to discover whether any reliable conclusions could be drawn about the effectiveness of individuals with different professional training in clinical, educational or related roles.

3. METHOD

3.1 Systematic Reviews and Information Syntheses

- 3.1.1 The literature relating to the work of PCDs is extensive and diverse. The working group decided to carry out an “information synthesis” of skills-mix in dentistry that would compare the effectiveness, cost-effectiveness, technical quality and acceptability of all aspects of the work of PCDs^{6,7}. The empirical literature was systematically searched, appraised and evaluated.
- 3.1.2 An information synthesis was preferred to a more quantitative systematic review of one or two specific interventions by the working group because of the diverse range of the procedures carried out by PCDs, and the context in which they occurred.

3.2 Assumptions

- 3.2.1 Before undertaking this work, several assumptions were made.
- The work of those with formal dental training was regarded as the “gold standard” for clinical dental care. Usually this was the only standard available.
 - The quality of dental care undertaken by dental students was a proxy for standards of work among qualified dentists (many evaluation studies used them as the comparison group).
 - Technical ability of any professional group to undertake any clinical task was a necessary but not sufficient reason for advocating the adoption of these practices.
- 3.2.2 Before advocating any changes in policy a broad range of issues need to be addressed. These include acceptability to patients and others with an interest in different models of service delivery as well as their relative costs. These aspects of care vary and were agreed to be outside the scope of this review. The review primarily focused on outcomes related to clinical capability.

3.3 Comparisons

- 3.3.1 The following comparisons made were between PCDs and dentists (or dental students):
- Accuracy of diagnosis of dental pathology (from clinical and radiographic findings)
 - Quality of work
 - Oral health education and promotion, including the activities of PCDs that complemented the activity of dentists.
 - Acceptability to patients.
 - Productivity including costs

⁶ Marcus S H, Grover P L, Revicki D A. *The method of information synthesis and its use in the assessment of health care technology*. Int J Technology in Health Care 1987; 3: 497-508.

⁷ Slavin R E. *Best evidence synthesis: an intelligent alternative to meta-analysis*. J Clin Epidemiol 1995; 48 (1): 9-18.

3.4 Search Strategy

3.4.1 A preliminary search was carried out to assess what material might be available. (See 2.9). This was based on a search of 3 databases without any date limit: Medline, CINAHL and SIGLE. The twelve keywords used were:

- dental assistant
- dental assistants' education
- dental assistants' standards
- dental assistants' utilisation
- dental auxiliary
- dental care economics
- dental care manpower
- dental hygienist
- dental nurse
- dental technician
- dental therapist
- patient care team

3.4.2 Bibliographies of review articles were also searched. These processes identified 572 references.

3.5 Electronic Database Searches

3.5.1 The full search built on this by extending the keyword searches and by applying explicit exclusion criteria. (See Appendix 1 Medline Search Strategy). Evidence from any country and any language was considered although priority was given to English language publications. On the specific issue of identifying randomised controlled trials, the search strategy put forward by Dickersin, Scherer & Lefebvre⁸ was followed as amended in the York Centre for Reviews and Dissemination guidelines for Ovid software⁹. Information from the electronic search was used to target which journals to hand search and to identify experts who might be contacted.

3.5.2 The following electronic databases were searched:

- BIDS (Bath Information and Data Services) Science Citation Index
- BIDS Social Sciences Citation Index
- CCTR (Clinical Controlled Trials Register) Cochrane Library
- CINAHL (Cumulative Index to Nursing and Allied Health Literature)
- Cochrane Oral Health Group Specialised Register
- DARE (Database of Abstracts of Reviews of Effectiveness)
- EMBASE
- HMIC (Health Management Information Consortium) Dhdata
- HMIC HELMIS
- HMIC King's Fund
- Medline
- SIGLE (System of Indexing Grey Literature in Europe)

⁸ Dickersin K, Scherer R, Lefebvre C. *Identifying relevant studies for systematic reviews*. BMJ 1994; 309: 1286-91.

⁹ University of York NHS Centre for Reviews and Dissemination. *Undertaking Systematic Reviews of Research on Effectiveness: CRD Guidelines for Those Carrying Out or Commissioning Reviews*: CRD Report Number 4. University of York, 1996.

3.5.3 Medline was searched in January 1999; the other databases in March and April 1999 using detailed strategies. The Cochrane Oral Health Group Specialised Register was searched in January 2000.

3.5.4 Secondary searches were undertaken of reference lists of identified reports, primary studies and reviews. (216 additional studies identified)

3.6 Hand Searching

3.6.1 Two high yield journals, Community Dental Health and Community Dentistry and Oral Epidemiology were hand searched, as they were not well indexed. As a result 10 additional studies were included.

3.7 Contacting Experts

3.7.1 Ten experts were contacted and asked to identify studies that were unpublished or in press. (See Acknowledgements). The value of contacting experts when conducting literature searches for systematic reviews has been questioned¹⁰. However, in our case seven responded and 2 additional references were included.

3.8 Updating the Search

3.8.1 At the outset the working group agreed that no studies published after December 1998 would be included in the review. However the searches were updated in January 2002. Only two further studies were found that met the inclusion criteria.

3.9 Inclusion Criteria

3.9.1 A study was included in the review if all the following criteria were met:

- It described the work of PCDs. This included dental nurses, dental hygienists, dental therapists, dental technicians, dental assistants and any variations in nomenclature used in studies carried out in countries other than the UK.
- It presented data on the outcomes of the work of PCDs and dentists. Specific areas of interest were diagnosis (disease recognition), quality, technical, competence, productivity including costs, oral health, oral health education and acceptability to patients.
- It compared the work of PCDs when complementing or substituting for dentists.

3.10 Exclusion Criteria

3.10.1 A study was excluded if:

- It only examined tasks that had no direct (measurable) effect on oral health status or on the quality of the functioning dentition. Oral health status was defined as “the standard of health of oral and related tissues which enables an individual to eat, speak, and socialise without active disease, discomfort and embarrassment, and which contributes to general well-being.”¹¹

¹⁰ McManus R J, Wilson S, Delaney B C, Fitzmaurice D A, Hyde C J, Tobias R S, Jowett S, Hobbs F D R. *Review of the usefulness of contacting other experts when conducting a literature search for systematic reviews.* BMJ 1998; 317: 1562-3.

¹¹ *An Oral Health Strategy For England.* Department of Health, 1994.

- It was concerned with the health of dental professionals rather than their contribution to clinical activities.
- Editorials, letters, news and comments and papers that did not present a comparison between the work of dentists and PCDs.

3.11 Assessment of Studies for Relevance

3.11.1 All the studies identified from the searches were assessed for relevance by a single reviewer (JW). A second reviewer (ML) checked a sample of 200 from Medline to ensure that the inclusion and exclusion criteria were being met. Disagreements being resolved by discussion.

3.11.2 Of the studies identified as relevant, 20 could not be obtained on inter-library loan or from other sources (See Appendix 2)

3.12 Assessment of Studies for Inclusion

3.12.1 All relevant studies retrieved were assessed for inclusion and exclusion by JW with a sample of 200 being assessed by the other 5 reviewers (JGa, JGo, ML, DRi, IR). This sample did include papers, which had previously been assessed by 2 reviewers. Consequently, 37% of the relevant papers had been assessed by at least 2 reviewers.

3.12.2 Out of the 200 studies assessed by the 5 reviewers there were 42 disagreements (21%). Only 6 of these 42 were subsequently included. The majority of disagreements were resolved through consensus. A small number of disagreements were clarified once full data abstraction was performed. The dental member of the group (DRi) was the final arbiter.

3.13 Data Abstraction and Tabulation

3.13.1 JW conducted data abstraction for all the included studies using a standard abstraction form (See Appendix 3). A sample of 75 studies (37%) was also data extracted by the other 5 reviewers (15 each). This indicated substantial agreement on data items abstracted and on the judgements formed by the reviewers.

3.13.2 During data abstraction some disagreements about the nature of the comparisons were recognised. Following further discussions within the review group all studies passed for data abstraction were reviewed by JW. This resulted in 73 further studies being excluded for not offering a valid comparison.

3.13.3 Data recorded on the data abstraction forms were summarised in tabular form by JW following the 5 main themes of diagnosis, technical competence, productivity, oral health education and acceptability. The names of professionals were standardised using a glossary developed by JGa and JGo. (See Appendix 4).

3.13.4 Following tabulation JGa, JGo, DRi and JW met and reviewed each of the included studies to ensure they were allocated to the most relevant section of the review with some studies appearing in more than one section. IR and DRu also reviewed the studies in the Productivity Section.

3.13.5 At this stage, 15 further studies were rejected principally because of lack of information detailing the comparison.

3.13.6 In studies where multiple papers reported progressively longer follow-up of the same group, the most recent study only was included.

3.13.7 In cases where there were multiple reports of the results, the study with the most comprehensive data was included.

3.14 Outcome Measures

3.14.1 A range of outcome measures was determined for the 5 main themes set out below.

3.14.2 Outcome measures for diagnosis included comparisons between dentists and PCDs of mean dmft; sensitivity and specificity in recognising abnormalities, as well as degrees of agreement summaries using kappa scores, correlation coefficients and percentage correct answers or diagnosis for either caries or periodontal diagnosis or any other dental or oral condition eg oral cancer.

3.14.3 Outcome measures for technical competence included comparisons of the quality of dental restorations and other dental treatments such as periodontal disease, fissure sealants, prosthodontic, orthodontic and other intra-oral procedures. This ranged from detailed assessment of the quality of treatment with several criteria for each procedure, eg for restorations, inclusions might be marginal adaptation, smoothness, contact points, levels of the contact point and anatomical form of the restoration, to simple comparisons, eg rating restorations as excellent, acceptable or unacceptable. Comparison of fissure sealant retention rates and restoration survival were also acceptable, as were comparisons of forces applied during scaling of teeth and removal of calculus, stain and other material from the teeth.

3.14.4 Outcome measures for oral health promotion included comparisons relating to attitudes of patients towards health education and promotion and the delivery of oral health education and promotion carried out by dentists or PCDs, eg asking patients about tobacco use or advising patients to stop using it.

3.14.5 Outcome measures for acceptability included patient and professional attitudes towards treatment by PCDs. This included overall satisfaction as well as satisfaction with technical work.

3.14.6 Outcome measures for productivity included ranged from simple cost or output comparisons to complex production functions and computer simulations. Examples included practice costs or cost per patient either net or gross over any time frame (hour, week or year), cost-benefit ratios, cost-benefit analysis (CBA) or cost-effectiveness analysis (CEA), number of patients examined or treated, number or type of procedures provided, time, surgery time, and personnel utilisation costs in standardised units eg. relative value or time units (RVUs or RTUs).

3.15 Process

3.15.1 A summary of the review process indicating the stages at which studies were excluded is shown below.

REVIEW PROCESS

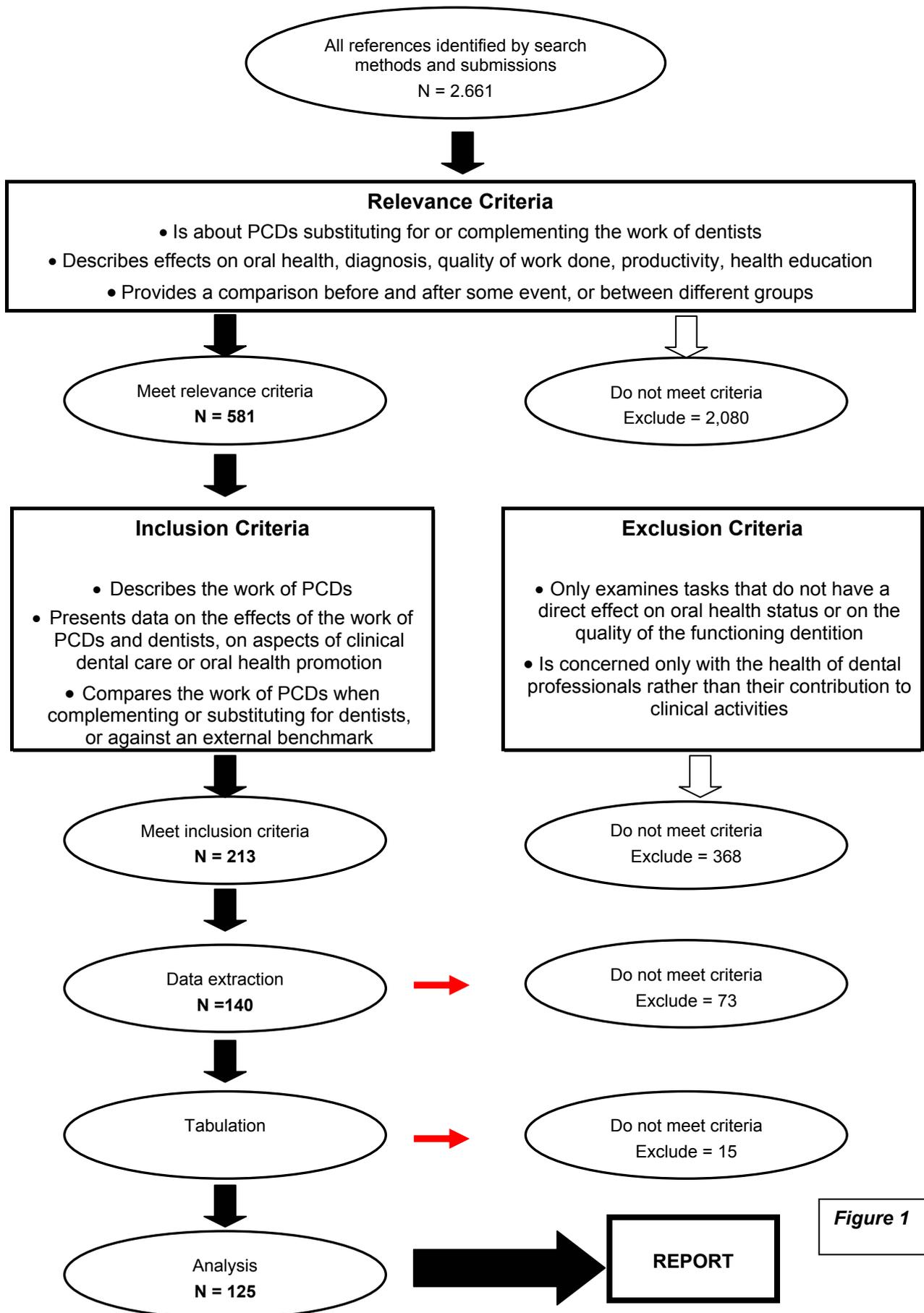


Figure 1

3.16 Data Synthesis

3.16.1 Due to the variability of quality of studies and the outcome measures reported a descriptive assessment of the included studies was undertaken.

3.17 Results

3.17.1 The searches identified over 2,661 papers from various sources (See Table 1) of which 581 met the relevance criteria. 213 of these studies were initially considered to meet the inclusion criteria. However through an iterative process during the stages of data extraction and tabulation into the 5 main themes of the review it was finally considered that only 125 fully met the criteria for inclusion. The process is illustrated in Figure 1.

DATABASE	STUDIES IDENTIFIED
BIDS (Bath Information and Data Services) Science Citation Index	11
BIDS Social Sciences Citation Index	2
CCTR (Cochrane Library)	11
CINAHL (Cumulative Index to Nursing and Allied Health Literature)	467
Cochrane Oral Health Group Specialised Register	44
Contact with Experts	2
DARE (Database of Abstracts of Reviews of Effectiveness)	19
EMBASE	71
Hand Searches	216
High Yield Journal Search	10
HMIC (Health Management Information Consortium) DHdata	66
HMIC HELMIS	13
HMIC King's Fund	10
Medline	1,714
SIGLE (System of Indexing Grey Literature in Europe)	5

Table 1

3.17.2 26 of the included studies address diagnosis, 41 technical competence, 10 oral health education, 13 acceptability and 53 productivity. 18 papers are represented in 2 or more sections, with 15 in 2 sections and 3 in 3 sections. The results are considered under these 5 main themes.

4. DIAGNOSIS AND SCREENING

4.1 Introduction

- 4.1.1 Dental hygienists and dental therapists are the only 2 clinical operators apart from dentists currently recognised legally in the UK. They are not permitted to carry out dental examination and diagnosis. However clinical operators elsewhere in the world are permitted to screen, diagnose and treat patients. New Zealand dental nurses have been allowed to assess the oral health status of schoolchildren and provide appropriate treatment since their introduction in 1923. In England during the First World War some local authorities appointed “dental dressers”, probably forerunners of New Zealand dental nurses. They examined children for dental caries. Dentists checked their diagnosis and they were then treated by a second dresser^{12,13}.
- 4.1.2 In some parts of the world dental hygienists work in wholly independent practice, for example The Netherlands, Norway, Switzerland (4 cantons), Sweden and Denmark. Their patients do not have to have been seen by a dentist. In other countries including the UK, dental hygienists can work in their own practices, but can only accept patients referred by a dentist. Dental hygienists have participated as “screeners” in epidemiological surveys in the United States¹⁴ and the Netherlands, notably in research on water fluoridation.
- 4.1.3 Clinical dental technicians work independently in many parts of the world including Australia, Canada, Denmark, Finland, the Netherlands, Sweden and some states in the USA. Apart from Maine in the USA, they are permitted to provide complete dentures to the public without a certificate of oral fitness from a dentist. In some countries clinical dental technicians can also provide partial dentures independently, for example the Netherlands and some Canadian provinces.
- 4.1.4 No studies of the work carried out by PCDs who work independently met the inclusion criteria for this project. The studies on New Zealand dental nurses are essentially historical narratives^{15,16,17,18}.
- 4.1.5 All PCDs are taught to recognise abnormalities in teeth and the oral cavity. In many countries, after appropriate training, dental nurses, dental hygienists and dental therapists are able to take radiographs.
- 4.1.6 In studies in India and Sri Lanka^{19,20,21} primary health care workers with minimum training have been shown to be capable of detecting oral cancer and pre-cancer.

¹² Smith H. *School Dentistry Today and Tomorrow*. Brit. J. Dental Science 1919; 62: 4-10.

¹³ Barwise S. *Public Health Dentistry in Derbyshire*. Brit. J. Dent. Science. 1922; 65: 6 - 11, 38 -43.

¹⁴ Hughes J T, Rozier G R, Ramsey D L. *Natural History of Dental Diseases in North Carolina 1976 - 77*. Carolina Academic Press, Durham, North Carolina 1982.

¹⁵ *New Zealand Dental Nurses Report of United Kingdom Dental Mission*. London HMSO, 1950.

¹⁶ Gruebbel A O. *Report on the study of dental public health services in New Zealand. Parts I - III*. JADA 1950; 41: 275-283, 422-436, 574-589

¹⁷ Fulton, J T. *Experiment in Dental Care. Results of New Zealand's use of school dental nurses*. WHO Geneva, 1951.

¹⁸ Saunders J L. *The New Zealand School Dental service, Its initiation and development 1920-1960*. R E Owen Government Printer, Wellington. 1963.

¹⁹ Warnakulasuriya S, Pindborg J J. *Reliability of oral precancer screening by primary health care workers in Sri Lanka*. Community Dent Health 1990 Mar;7(1):73-9.

4.1.7 26 studies from the countries outlined in Table 2 met the inclusion criteria for diagnosis and screening. Details of all the studies included in this section can be found in Appendix 5.

COUNTY	NUMBER OF STUDIES
USA	11
Great Britain	7
Scandinavia	6
Australia	1
Norway and Australia	1

Table 2

4.2 Dental Caries

4.2.1 Fifteen studies looked at diagnosis and screening for caries.

4.2.2 In a study of decision-making based on radiographs, Haugejorden²² compared the performance of both dental students and dental hygienists in constructing standards for primary approximal caries diagnosis based on the radiographs of 40 children. He found that dental students and dental hygienists were able to achieve an acceptable level of agreement for ranking, with ranking scores, using the Spearmans Rank Correlation Coefficient, of +0.81 to +0.94 for dental students and +0.86 to +0.94 for dental hygienists.

4.2.3 In a controlled before-and-after study, Howat & Cannell²³ tested the ability of a dental hygienist to obtain similar diagnostic results to dentists. They found that the re-test reliability co-efficients for clinical cavitation diagnosis, caries prevalence and incremental data was similar for both the dentist and the dental hygienist.

4.2.4 Hughes¹⁴ reported very close agreement between dentists and dental hygienists for caries and plaque index in a calibration exercise prior to a large epidemiological survey in North Carolina in 1976 where dental hygienists acted as survey examiners.

4.2.5 In the early 1990s, the North Carolina Caries Prediction Project generated evidence on the relative performance of different members of the dental team. Mauriello et al²⁴ used a large scale prospective cohort study of 5,233 children in Aiken, South Carolina and Portland, Maine to assess the degree of agreement between 4 dentists

²⁰ Warnakulasuriya K A, Nanayakkara B G. *Reproducibility of an oral cancer and precancer detection program using a primary health care model in Sri Lanka*. *Cancer Detect Prev* 1991;15(5):331-4.

²¹ Sankaranarayanan R. *Health care auxiliaries in the detection and prevention of oral cancer*. *Oral Oncol*, 1997 May, 33:3, 149-54.

²² Haugejorden O. *The construction and use of diagnostic standards for primary radiographic caries*. *Acta Odont Scand* 1976; 34: 69-77.

²³ Howat A P, Cannell S J. *Value of operating auxiliary personnel for caries diagnosis in dental epidemiology*. *Community Dent Oral Epidemiol* 1979; 7: 165-169.

²⁴ Mauriello S M, Bader J D, Disney J A, Graves R C. *Examiner agreement between hygienists and dentists for caries prevalence examinations*. *J Public Health Dent* 1990; 50 (1): 32-37.

and 2 dental hygienists for caries prediction. They concluded that for the purpose of determining caries prevalence, the use of dental hygienists was a reasonable alternative to the use of dentists. From data collected in the same study, Disney et al²⁵ compared caries prediction by 4 dentists with screening by 2 dental hygienists. They concluded that the prediction of children at high risk of caries could be conducted by dental hygienists instead of dentists with no loss of precision.

- 4.2.6 Katz et al²⁶ conducted a randomised controlled trial in the US Virgin Islands to determine the prevalence of nursing caries in 3-year olds and to assess the reliability of examiners with different backgrounds. One dentist, one dental hygienist and 23 lay people examined a random sample of children aged 3 to 5 for prevalence of nursing caries. Diagnosis by lay people was poor, but there was “strong-to-good” diagnostic agreement between the dentist and dental hygienist.
- 4.2.7 Using replies to a questionnaire, Riordan et al²⁷ compared decisions based on radiographs by dentists and dental therapists in Western Australia. In total, 45 dentists and 207 dental therapists offered opinions about their diagnosis of approximal caries and their use of radiographs. The results indicated that 53% of all operators would intervene while caries was confined to the outer enamel. The difference between dentists and dental therapists was not great. A subsequent prospective observational study by Espelid et al²⁸ compared radiographic diagnoses of caries and the treatment decisions of clinicians in Norway and Western Australia. This comprised 433 dentists in Norway and 62 dentists and 108 dental therapists in Western Australia. The results indicated that there was little difference between the 3 groups in terms of the mean number of restorations proposed. However the proportion of surfaces proposed to be treated did differ significantly. Both dentists and dental therapists in Western Australia had more of a “watch and wait” philosophy than dentists from Norway.
- 4.2.8 Wang & Riordan²⁹ estimated whether the quality of care was affected by individual recall examinations being conducted by dental hygienists. Using dentists and dental hygienists, recall intervals were increased from 12 months to between 16 and 18 months. These changes did not affect quality of care in the short term but there is the possibility of the result being confounded by time.
- 4.2.9 In a pilot study of 24 5-year old children in Leeds, Kwan et al³⁰ investigated the diagnostic reliability of dental hygienists and dental therapists in epidemiological surveys for caries prevalence. They compared the findings of dentists, dental therapists and dental hygienists to those of a standard examiner who was an

²⁵ Disney J A, Abernathy J R, Graves R C, Mauriello S M, Bohannon H M, Zack D D. *Comparative effectiveness of visual/tactile and simplified screening examinations in caries risk assessment.* Community Dent Oral Epidemiol 1992; 20: 326-32.

²⁶ Katz L, Ripa L W, Petersen M. *Nursing caries in Head Start children, St. Thomas U.S. Virgin Islands: Assessed by examiners with different dental backgrounds.* J Clin Paediatric Dent 1992; 16 (2): 124-128.

²⁷ Riordan P J, Espelid I, Tveit A B. *Radiographic interpretation and treatment decisions among dental therapists and dentists in Western Australia.* Community Dent Oral Epidemiol 1991; 19: 268-71.

²⁸ Espelid I, Tveit A B, Riordan P J. *Radiographic caries diagnosis by clinicians in Norway and Western Australia.* Community Dent Oral Epidemiol 1994; 22: 214-9.

²⁹ Wang N J, Riordan P J. *Recall intervals, dental hygienists and quality in child dental care.* Community Dent Oral Epidemiol 1995; 23: 8-14.

³⁰ Kwan S Y L, Prendergast M J, Williams S A. *The diagnostic reliability of clinical dental auxiliaries in caries prevalence surveys - A pilot study.* Community Dent Health 1996; 13: 145-149.

experienced dental epidemiologist. The mean group dmft values of the standard examiner, dentists, dental therapists and dental hygienists were all within 95% confidence intervals of the group mean. The authors concluded that it was possible to train and calibrate dental therapists and dental hygienists to an acceptable diagnostic standard for caries prevalence surveys of 5-year olds. Subsequently, Kwan & Prendergast³¹ examined the feasibility of using dental therapists and dental hygienists as examiners in caries prevalence surveys. Thirty-two 5- and 32 12-year-old children were examined by 4 dental hygienists, 4 dental therapists and a standard examiner. The results confirmed the findings of the pilot study for 5-year olds and the authors concluded that dental therapists and dental hygienists could be used as examiners in caries prevalence surveys of 5-year old children. However agreement was poor for 12-year olds.

4.2.10 Ohrn et al³² investigated whether dental hygienists could examine and record caries with the same accuracy as dentists. Using 7 teams comprising one dental hygienist and 2 dentists, they found that accuracy in diagnosing dental caries was comparable for dentists and dental hygienists. Similarly Beltran et al³³ tested the validity of visual screening by a dental hygienist and a nurse against an examination by a dentist. This was a prospective observational study that had a crossover element involving 632 children. Validity was high for screening for caries and treatment needs, but less valid for fluorosis, injuries and the presence of sealants. Beltran et al concluded that a visual screening protocol was suitable as a surveillance tool for collecting data on oral health status.

4.2.11 Hawley et al³⁴ compared the effectiveness of screening by a single dentist and a dental hygienist. She found that 62% of children were referred by the standard examiner and the dentist, but only 27% by the dental hygienist.

4.2.12 Petersson & Bratthal³⁵ compared the ability of dentists and dental hygienists to assess the risk of caries against a computer programme. Rather than real patients, detailed descriptions of 5 patients were used. Dentists and dental hygienists showed a fairly high degree of agreement, with 73.5% of dental hygienists and 78.5% of dentists ranking the caries risk identical to the programme.

4.3 Periodontal Conditions

4.3.1 In a complex study, Mann et al³⁶ used dentists and dental hygienists to score 24 adults for plaque using the Turesky modification of the Quigley-Hein index. They found no systematic tendency for dentists to score at a different mean level from

³¹ Kwan S Y L, Prendergast M J. *The use of clinical dental auxiliaries as examiners in caries prevalence surveys in the United Kingdom: A feasibility study.* Community Dent Oral Epidemiol 1998; 26: 194-200.

³² Ohrn K, Crossner C-G, Borgesson I, Taube A. *Accuracy of dental hygienists in diagnosing dental decay.* Community Dent Oral Epidemiol 1996; 24: 182-186.

³³ Beltran E D, Malvitz D M, Eklund S A. *Validity of two methods for assessing oral health status of populations.* J Public Health Dent 1997; 57 (4): 206-214.

³⁴ Hawley G M, Wainwright-Stringer Y, Craven R, Blinkhorn A S. *An investigation into the use of a dental hygienist in school screening.* Community Dent Health 1999;16(4) :232-5.

³⁵ Petersson G H, Bratthal D. *Caries risk assessment: a comparison between the computer program 'Cariogram', dental hygienists and dentists.* Swed Dent J 2000;24(4):129-37.

³⁶ Mann J, Greene J J, Stoller N H, Byrne J, Chilton N W. *Inter- and intra-examiner variability in scoring supragingival plaque: 1. The clinical study.* Pharmacology and Therapeutics in Dentistry 1980; 5: 1-4.

dental hygienists. Thus there was no reason to prefer one group of professionals to the other.

- 4.3.2 Markkanen et al³⁷ used the Periodontal Treatment Need System (PTNS) to evaluate periodontal need in the Finnish adult population. Using kappa statistics, they found good intra-examiner agreement between dentists and expanded-duty dental nurses. In a later prospective observational study, Markkanen et al³⁸ provided a more systematic comparison of the performance of dentists and expanded-duty dental nurses. In this study of 7,190 patients the results again showed that the kappa values for intra- and inter-examiner reliability reflected high reproducibility.

4.3 Soft Tissue Diagnosis

- 4.3.1 Two American studies compared the ability of members of the dental team to recognise HIV- and AIDS-associated oral lesions. Tilliss & Stach³⁹ found from a convenience sample that the overall scores of dentists and dental hygienists in identifying different types of intra-oral lesions from colour photographs were not significantly different. Dentists correctly recognised 60% of the AIDS-associated lesions, dental hygienists 58%, and dental nurses 38%. In a subsequent convenience sample study, Tilliss & Vojir⁴⁰ assessed the degree to which different types of operator could recognise HIV- and AIDS-related oral lesions. They found that the performance of dentists, dental hygienists and dental nurses was not significantly different being 56% for dentists, 52% for dental hygienists and 44% for dental nurses. They concluded that there was no significant difference in recognition across the 3 groups, but that the level of recognition was low for all groups.
- 4.3.2 This can be compared with the study by Jullien et al⁴¹. Four groups of dental personnel were shown a total of 80 photographic slides of oral cancer and pre-cancer. The study found that the sensitivity for student dental hygienists and dental nurses was 0.73 (range 0.45-1.00) and for dentists 0.83 (0.5-1.00). The specificity for student dental hygienists and dental nurses was 0.65 (0.42-0.90) and for dentists 0.79 (0.47-1.00).
- 4.3.3 Nederfors et al⁴² compared the ability of one dentist with one dental hygienist to diagnose a range of mucosal changes as well as plaque index and treatment need. Only lingual mucosal changes, plaque scores and treatment need index were statistically different between the 2 examiners. The authors concluded that examinations performed independently by dentist and hygienist show acceptable inter-examiner agreement.

³⁷ Markkanen H, Rajala M, Paunio K. *Periodontal treatment need of the Finnish population aged 30 years and over*. Community Dent Oral Epidemiol 1983; 11: 25-32.

³⁸ Markkanen H, Paunio K, Paunio I, Rajala M. *Reproducibility of a clinical screening method for assessing gingival inflammation, pockets and plaque retentions*. Community Dent Oral Epidemiol 1985; 13: 33-6.

³⁹ Tilliss T S I, Stach D J. *Recognition of HIV/AIDS-associated oral lesions by the dental team*. Clin Prevent Dent 1991; 13 (6): 5-11.

⁴⁰ Tilliss T S I, Vojir C P. *Identification of HIV/AIDS-associated oral lesions*. J Dent Hygiene 1993; 67 (1): 30-36.

⁴¹ Jullien J A, Downer M C, Speight P M, Zakrzewska J M. *Evaluation of health care workers' accuracy in recognising oral cancer and pre-cancer*. Internat Dent J 1996; 46: 334-339.

⁴² Nederfors T, Paulsson G, Isaksson R, Fridlund B. *Ability to estimate oral health status and treatment need in elderly receiving home nursing--a comparison between a dental hygienist and a dentist*. Swed Dent J 2000;24(3):105-16.

4.4 Slide Tests

- 4.4.1 Adair et al⁴³ assessed intra-examiner reliability in slide tests for *salivary S. mutans* and *lactobacilli*. Following a single calibration session, 2 dentists and 1 dental hygienist independently read 717 slides. The results indicated “moderately strong” agreement between the 3 examiners, but also suggested that multiple examiners should be calibrated at the outset and at regular intervals.

4.5 Temporo-Mandibular Disorders

- 4.5.1 Dworkin et al⁴⁴ examined the inter-examiner reliability of the measurement of temporo-mandibular disorders (TMD). They compared specifically trained dental hygienists with dentists. They found that the mean values for 3 measures of mandibular movement and 2 measures of inter-arch tooth relationship were comparable for dental hygienists and dentists. Dental hygienists were significantly more reliable than dentists in obtaining measurements of vertical jaw opening. However pain and joint sounds were very difficult to assess reliably. Dworkin et al concluded that the training of examiners was a crucial consideration in TMD. A subsequent study⁴⁵ compared the performance of dentists and dental hygienists in assessing the clinical signs of TMD. They used a randomised sequence using an incomplete Latin square design and assessed reliability for clinical variables using kappa statistics. The study found that without calibration experienced examiners showed poor reliability with other clinicians, demonstrating the importance of establishing reliable clinical standards.

4.6 Orthodontics

- 4.6.1 Few studies of orthodontic PCDs met the inclusion criteria. However a pilot study by Burden & Stratford⁴⁶ assessed the feasibility of training dental nurses in the use of the PAR index. The study conducted in Northern Ireland found that using similar contact time to that used in training orthodontists, only one in 4 dental nurses was successfully calibrated with a ‘gold standard’ examiner in the use of the PAR index.

4.7 Discussion

4.7.1 Quality of Studies

- 4.7.2 The diagnosis of and screening for caries and other dental and oral diseases are perceptual tests where human perception is used to distinguish between positive and negative. Any test that involves perception and judgement is bedevilled by variability of reporting results. It is important to remember that diagnostic variation exists within the same professional groups when considering the differences between different groups^{47,48,49,50,51,52,53}.

⁴³ Adair S M, Leverett D H, Shaffer C L. *Interexaminer agreement for readings of dip slide tests for salivary mutans streptococci and lactobacilli*. Caries Res 1994; 28: 123-126.

⁴⁴ Dworkin S F, LeResche L, DeRouen T. *Reliability of clinical measurement in temporomandibular disorders*. Clin J Pain 1988; 4: 89-99.

⁴⁵ Dworkin S F, LeResche L, DeRouen T, Von Korff M. *Assessing clinical signs of temporomandibular disorders: Reliability of clinical examiners*. J Prosthetic Dent 1990; 63 (5): 574-579.

⁴⁶ Burden D J, Stratford N. *Training dental nurses in the use of the PAR index: A pilot study*. Brit J Orthodontics 1996; 23: 153-155.

⁴⁷ Elderton-R J; Nuttall-N M. *Variation among dentists in planning treatment*. Br-Dent-J. 1983; 154(7): 201-6.

- 4.7.3 When assessing the validity of diagnostic tests a number of important questions arise⁵⁴. The first of these questions, “was there an independent, blind comparison with a reference standard or benchmark” was rarely addressed. However although often it could not be ascertained who was the standard examiner, in many cases it could be assumed that the dentist in the study was the reference standard.
- 4.7.4 The second of these questions relates to the use of an appropriate spectrum of patients. In many of the studies there was not sufficient information to establish the nature of the patient sample used. Larger sample sizes may alleviate this. However, use of an inappropriate sampling frame or recruitment method could produce a large skewed sample rather than a small one. While in the simulation studies of diagnosing oral cancer and pre-cancer⁴¹ and HIV and AIDS related conditions^{39,40} a far higher proportion of the slides used showed disease than would be seen in clinical practice and all the slides in the HIV and AIDS studies exhibited pathology. These studies may be a useful guide, but the predictive value of a test is only established when a study matches clinical practice.
- 4.7.5 When determining whether PCDs can screen and diagnose at a similar level to dentists, it is also important that studies should include an appropriate spectrum of skills-mix. Only the questionnaire studies^{27,35} and the slide studies of oral cancer/pre-cancer⁴¹ and HIV/AIDS related conditions^{39,40} involved a wide variety of dental operators.

4.8 Training PCDs

- 4.8.1 In those countries noted in 4.1.1, PCDs are taught diagnosis. In studies in countries where this is not the case, there was a great deal of variation in the length of time and training undertaken prior to taking part in the studies. In many studies, the nature and duration of the training was not described.
- 4.8.2 Results from the studies indicated that PCDs could be trained to diagnose. However from the literature it is difficult to give any indication of what this training should involve. It also has to be borne in mind that dentists also exhibit a great deal of intra-professional diagnostic variability as discussed in paragraph 4.8.2.

⁴⁸ Mileman-P A, van-der-Weele-L T. *Accuracy in radiographic diagnosis: Dutch practitioners and dental caries*. J-Dent. 1990 Jun; 18(3): 130-6.

⁴⁹ Lussi-A. *Validity of diagnostic and treatment decisions of fissure caries*. Caries-Res. 1991; 25(4): 296-303.

⁵⁰ Kay-E J, Nuttall-N M, Knill-Jones-R. *Restorative treatment thresholds and agreement in treatment decision-making*. Community-Dent-Oral-Epidemiol. 1992 Oct; 20(5): 265-8.

⁵¹ Bader-J D, Shugars-D A. *Variation in dentists' clinical decisions*. J-Public-Health-Dent. 1995 Summer; 55(3): 181-8

⁵² Mojon-P, Favre-P, Chung-J P, Budtz-Jorgensen-E. *Examiner agreement on caries detection and plaque accumulation during dental surveys of elders*. Gerodontology. 1995 Jul; 12(1): 49-55.

⁵³ Downer-M C, Kay-E J. *Restorative treatment decisions from bitewing radiographs--performance of dental epidemiologists and general dental practitioners*. Community-Dent-Oral-Epidemiol. 1996 Apr; 24(2): 101-5.

⁵⁴ Sackett D L, Strauss S E, Richardson W S, Rosenberg W, Haynes R B. *Evidence-based medicine: How to practice and teach*. 2nd Ed. Churchill Livingstone 2000.

4.9 Study Design

- 4.9.1 Large, well-designed randomised controlled trials (RCTs) can and should provide the most valid estimates of individual health care interventions, including diagnostic interventions undertaken by PCDs. However RCTs of diagnostic and screening technologies are comparatively rare as they raise ethical and practical concerns as well as being expensive to conduct.
- 4.9.2 The majority of the studies in this section were carried out in the 1990s. However the overall study design was poor. For example, while several studies assessed inter- and intra-examiner reliability in terms of sensitivity, specificity, or kappa statistics, there was not enough detailed information provided to perform meta-analysis of this data.

4.10 Conclusions

- 4.10.1 The general quality of research in this area is poor. A number of basic aspects of experimental design ought to be incorporated in future studies by researchers in this field.
- 4.10.2 Ideally large scale randomised controlled trials should be undertaken to provide an authoritative assessment of the abilities of different members of the dental team in recognising disease.
- 4.10.3 Alternatively, well-conducted controlled trials using non-random treatment allocation or prospective observational studies can provide valid information for clinical and policy decisions.
- 4.10.4 Whatever study design is chosen, the method of treatment allocation should be described together with details of the selection and recruitment of patients.
- 4.10.5 Comparisons should be made using outcome measures that can be validated ideally by using “gold standard” examiners.
- 4.10.6 Studies should combine clinical examinations of patients with radiographs of teeth to be extracted where the number and extent of carious lesions can be readily identified.
- 4.10.7 Consideration should be given to studies of appropriate design assessing caries diagnosis at a range of levels from incipient caries to frank lesions
- 4.10.8 Studies should be carried out with sufficiently large numbers of operators and patients for their results to be more readily generalisable.
- 4.10.9 The variation in nomenclature associated with different types of PCDs has made the task of comparing these studies particularly difficult. While standardisation of the terminology associated with this field is likely to be difficult clear descriptions of the training, accreditation and normal duties of PCDs should be provided in studies in this area.
- 4.10.10 There is a consensus among the studies that PCDs with the appropriate training can perform screening and diagnosis to a level similar to that of a dentist. Only 2 papers disagreed with this assessment. One study by Hawley et al³⁴ compared the effectiveness of screening by only one single dentist and one dental hygienist. They found that 62% of children were referred by the standard examiner and the dentist

but only 27% by the dental hygienist. The other paper by Kwan & Prendergast³¹ showed there was good agreement on caries diagnosis for 5-year-olds, but not for 12-year-olds. Further well-designed larger scale studies are required to confirm this view and also to determine the level of training needed for them to carry out the various tasks.

5. TECHNICAL COMPETENCE

5.1 Introduction

5.1.1 The technical or clinical competence of PCDs was the subject of 41 studies that fitted the criteria. Many were not concerned solely with technical competence and were also included as part of studies of productivity. In the studies conducted in the 1960s and early 1970s, the focus was mainly on how far expanded-duty dental nurses could place restorations and carry out other reversible procedures to a level that was deemed to be satisfactory. In the mid-1970s, there was more interest in whether expanded-duty dental hygienists could carry out reversible procedures that included cutting tissues. More recently, concerns have been in areas such as sealant placement and retention, periodontal treatment, and skills in using certain types of instruments. The great majority (31) were conducted in the USA. (See Table 3). Studies where operators placed the material, carved and polished the restoration were separated from those where the operator cut the tooth, prepared the cavity and finished the restoration.

COUNTRY	NUMBER OF STUDIES
USA	30
Australia	3
Canada	3
Zimbabwe	2
Netherlands	1
Singapore	1

*One study from Spain and not included in the table is a meta-analysis combining the findings of several international studies.

Table 3

5.1.2 The earliest studies were carried out in the US Navy, the Canadian Air Force, the US Indian Health Service and individual American states. Later studies were conducted in Canada and the Netherlands.

5.1.3 Ludwick et al⁵⁵ designed a special 7-week training programme for expanded-duty dental nurses in the American Navy and then evaluated the quality of their restorations (silicates and single and multiple surface amalgams). A small random sample of restorations found 2 (9.5%) restorations by the research teams unsatisfactory and all the restorations by the control group satisfactory and recommended that the training was sufficient to justify the second part of the study. In the full study, Ludwick et al⁵⁶ found that 2% to 5% of restorations were unsatisfactory, 9% to 24% fair, 50% to 60% good, and 11% to 33% excellent. They argued that these results demonstrated that quality was not affected by increased delegation to expanded-duty dental nurses.

⁵⁵ Ludwick W E, Schnoebelen E O, Knoedler D J. *Greater utilisation of dental technicians. I. Report of training.* Dental Research Facility. Naval Training Centre. Great Lakes. Illinois, 1963.

⁵⁶ Ludwick W E, Schnoebelen E O, Knoedler D J. *Greater utilisation of dental technicians. II. Report of clinical tests.* Dental Research Facility. U.S. Navy Training Centre. Great Lakes. Illinois, 1964.

- 5.1.4 These results were replicated in a large number of trials from the mid-1960s onwards in the United States. Several were inspired by problems of oral health care service delivery. Abramowitz⁵⁷ attempted to determine the effectiveness of dental teams trained to provide additional duties in the US Indian Health Service. He found that 45% of Class II restorations completed by dentists and expanded-duty dental nurses were satisfactory and 28% of those carried out by dentists and 31% of those by expanded-duty dental nurses were unsatisfactory. In a later study Abramowitz & Berg⁵⁸ again claimed that there was no significant difference between dentists and expanded-duty dental nurses in the acceptability rating for alloy and silicate restorations. From these studies they concluded that restorations by the expanded-duty dental nurses were of a comparable quality to those of dentists.
- 5.1.5 A similar study by Hammons & Jamison⁵⁹ at the University of Alabama attempted to determine the potential of expanded-duty dental nurses. It concluded that expanded-duty dental nurses could be trained to perform a range of procedures to the same standard as dental students. In a subsequent study of unfinished, finished, and temporary restorations and matrix bands Hammons et al⁶⁰ suggested that dental students and expanded-duty dental nurses performed equally well with few differences being statistically significant.
- 5.1.6 A large scale study conducted by Rosenblum⁶¹ at the University of Minnesota compared the quality of procedures carried out by 20 experimental teams that included expanded-duty dental nurses with 10 control teams. Six out of 333 restorations (1.8%) carried out by the control teams and 30 out of 851 restorations (3.5%) completed by the experimental teams were judged to be unacceptable. Rosenblum concluded that there was no significant difference in quality between expanded-duty dental nurses and dental students and that a 3-month course provided adequate training.
- 5.1.7 One of the most comprehensive studies was reported by Lotzkar et al in 2 separate articles^{62,63}. It considered whether expanded-duty dental nurses could perform delegated procedures safely and efficiently over a 5-year period. In the second phase when dental nurses were trained to perform additional functions, 73% of chairside procedures were acceptable and 79% met the required standards. The study concluded that dental nurses could be trained successfully in expanded functions. These results were confirmed by findings in the third phase when 82% procedures “met quality standards”. Independent evaluation found that 72% were “acceptable”. Lotzkar et al concluded that expanded-duty dental nurses could perform delegated duties as well as dentists in a reasonable period of time.

⁵⁷ Abramowitz J. *Expanded functions for dental assistants: a preliminary study*. JADA 1966; 72: 386-391.

⁵⁸ Abramowitz J, Berg L E. *A four-year study of the utilisation of dental assistants with expanded functions*. JADA 1973; 87: 623-635.

⁵⁹ Hammons P E, Jamison H C. *Expanded functions for dental auxiliaries*. JADA 1967; 75: 658-672.

⁶⁰ Hammons P E, Jamison H C, Wilson L L. *Quality of service provided by dental therapists in an experimental program at the University of Alabama*. JADA 1971; 82: 1060-1066.

⁶¹ Rosenblum F N. *Experimental pedodontic auxiliary training programme*. JADA 1971; 82: 1082-1089.

⁶² Lotzkar S, Johnson D W, Thompson M B. *Experimental program in expanded functions for dental assistants: Phase 1 baseline and phase 2 training*. JADA 1971; 82: 101-122.

⁶³ Lotzkar S, Johnson D W, Thompson M B. *Experimental program in expanded functions for dental assistants: Phase 3 experiment with dental teams*. JADA 1971; 82: 1067-1081.

- 5.1.8 Soricelli⁶⁴ reported that expanded-duty dental nurses in Philadelphia with 2 months clinical experience placed restorations of which 40% were superior or outstanding. After 5 months the equivalent figure was 75%. This study also reports another comparative study by Eiser⁶⁵ of the Philadelphia data giving an average quality point score for expanded-duty dental nurses at 3.5 with dentists achieving 2.9, from which they draw the conclusion that the expanded-duty dental nurses' quality is better than the average dentist.
- 5.1.9 A complex experiment by Brearley & Rosenblum⁶⁶ reported that experimental teams comprising expanded-duty dental nurses with one year's experience performed more effectively in terms of "quality" of process and output than dental students and those with no experience.
- 5.1.10 Similar studies were conducted in Canada using expanded-duty dental hygienists rather than expanded-duty dental nurses. Romcke & Lewis⁶⁷ claimed that restorations completed by expanded-duty dental hygienists were at least as good as if not better than those completed by dentists.
- 5.1.11 Heid and Barr⁶⁸ examined the potential of using expanded-duty dental nurses in the US Army Dental Corps. Two independent dentists assessed the quality of restorations placed by dental nurses and dentists. 979 restorations were assessed for quality but the distribution of those completed by dentists and dental nurses are not given. Both groups had a 98% satisfactory score for the restorations, with a slightly higher proportion of the dentists' restorations meeting all the standards (68% compared with 61%).
- 5.1.12 Hord et al⁶⁹ evaluated the quality of 237 amalgam and resin restorations placed by dentists and expanded-duty hygienists. They rated as excellent 28% of resin restorations carried out by dentists and expanded-duty hygienists. 17% dentists' amalgam restorations and 37% expanded-duty dental hygienists were also rated as excellent. Hord et al concluded that using expanded-duty dental hygienists and expanded-duty dental nurses did not compromise quality.
- 5.1.13 By the mid-1970s, different training programmes for PCDs were established and some studies attempted to measure their effectiveness. Robinson & Bradley⁷⁰

⁶⁴ Soricelli D A. *Implementation of the delivery of dental services by auxiliaries - The Philadelphia experience*. American J Public Health 1972; 62 (8): 1077-1087.

⁶⁵ Eiser H M A. *A comparative study of the evaluation of quality of dental care delivered by dentists and dentist-technotherapist teams in a closed panel dental health program*. Division of Dental Health, Philadelphia, Department of Public Health.

⁶⁶ Brearley L J, Rosenblum F N. *Two-year evaluation of auxiliaries trained in expanded duties*. JADA 1972; 84: 600-610.

⁶⁷ Romcke R G, Lewis D W. *Use of expanded function dental hygienists in the Prince Edward Island dental manpower study*. J Canad Dent Assn 1973; 4: 247-262.

⁶⁸ Heid T H, Barr J H. *Dental Therapy Assistant: Quality of Restorations Placed and Finished*. 1973. Fort Sam Houston, Texas. Health Care Research Division, Academy of Health Sciences, US Army. AD-759 140.

⁶⁹ Hord A B, Thompson G W, Ellis R L. *The Ontario Dental Association Demonstration Project on dental auxiliaries with expanded duties*. Ontario Dent 1974; 51 (6): 14-18.S

⁷⁰ Robinson G E, Bradley E L. *TEAM vs. DAU: a study of clinical productivity*. Med Care 1974; 12 (8): 693-708

compared training in a Training in Expanded Auxiliary Management (TEAM) which used expanded-duty dental nurses with a Dental Auxiliary Utilisation (DAU) employing conventional dental nurses. Restorations for the TEAM patients were placed by expanded-duty dental nurses. Restorations were evaluated as acceptable or unacceptable, with 88% of DAU and 94% of TEAM restorations being found acceptable.

- 5.1.14 Douglass et al⁷¹ attempted to determine the effect of introducing expanded-duty dental nurses into a single-handed private practice. They found that 87% of restorations placed by dentists and 88% of those placed by expanded-duty dental nurses were satisfactory.
- 5.1.15 In the late 1970s and early 1980s, a number of studies were instigated by individual American states. Kaplan⁷² reports the quality effects of a large scale survey in Kentucky where general dentists co-operated to assess the use of expanded-duty dental nurses and dental hygienists (also reported in Mullins et al⁷³). The overall assessment of 5 common tasks (placing rubber dam, overlays for crowns, temporary crown and bridge construction, placing and finishing restorations) was found to be 94% acceptable or excellent. Independent evaluation of restoration quality found 74% acceptable and 23% excellent with 3% unacceptable. Later Mullins et al⁷⁴ summarised the whole study in a paper that also reported on productivity. Again he reported no significant difference in the technical ability of dentists, expanded-duty dental nurses and expanded-duty dental hygienists to carry out restorations.
- 5.1.16 In the Netherlands Tan et al⁷⁵ compared the quality of restorations by dentists and expanded-duty dental hygienists and found no differences in the quality of restorations completed by the 2 professional groups.
- 5.1.17 Bader et al⁷⁶ compared the technical performance of dentists and expanded-duty dental nurses in placing and carving amalgam restorations. A sample of 30 restorations performed by expanded-duty dental nurses and dentists over a 6-month period was evaluated blind by 2 dentists. Only 5% of dentists' restorations and 3% expanded-duty dental nurses were judged unacceptable. Bader et al concluded that there was no difference in the percentage of unacceptable restorations completed by dentists and expanded-duty dental nurses.

⁷¹ Douglass C W, Moore S, Lindahl R L, Gillings D B. *Expanded duty dental assistants in solo private practice*. J Amer Coll Dent 1976; 43: 144-163

⁷² Kaplan A L. *Clinical quality and delegation in a private dental office utilising expanded-function dental auxiliaries*. J Public Health Dent 1980; 40 (2): 118-125.

⁷³ Mullins M R, Kaplan A L, Mitry D J, Armstrong S R, Lange K W, Steuer R E, Johnson K H. *Production-economic effects of delegation and practice size in a private dental office*. JADA 1979; 98: 572-577.

⁷⁴ Mullins M R, Kaplan A L, Bader J D, Lange K W, Murray B P, Armstrong S R, Haney C A. *Summary results of the Kentucky dental practice demonstration: A co-operative project with practising general dentists*. JADA 1983; 106: 817-825.

⁷⁵ Tan H H, Theunissen B A H M, Crielaers P J A. *De kwaliteit van restauraties vervaardigd door tandartsen en mondhygienisten met uitgebreid takenpakket*. Ned Tijdschr Tandheelkd 1979; 86: 121-127.

⁷⁶ Bader J D, Mullins R, Lange K. *Technical performance on amalgam restorations by dentists and auxiliaries in private practice*. JADA 1983; 106: 338-341.

- 5.1.18 In a summary of the Washington State Dental Auxiliary Project, Milgrom et al⁷⁷ reported some of the aspects of the quality care provided in practices employing high and low levels of delegation to PCDs. A more detailed analysis of the quality of care reported by Bergner et al⁷⁸ looked at the structure, process and outcomes of care in 33 practices. Sixteen were regarded as high delegation and 17 as low delegation. However the criteria for separating the levels of delegation were not clear. They reported 82% restorations carried out by expanded-duty dental hygienists and 87% by dentists were satisfactory, with 18% and 13% being correspondingly unsatisfactory.
- 5.1.19 In a retrospective study of restorations in Dutch children aged 7 to 13, Carpay et al⁷⁹ found 10% were rated excellent for school dentists, 14% for dentists and 44% for dental nurses. The percentage of restorations rated as very poor was 9% for school dentists, 16% for dentists and 1% for dental nurses. The authors claimed that dental nurses performed better than school dentists and dentists

5.2 Technical Competence in Carrying Out Complete Restorations

- 5.2.1 In the 1970s, there was more interest in irreversible procedures that could be carried out by dental hygienists. Powell et al⁸⁰ compared the clinical performance of expanded-duty student dental hygienists and dental students in Class I and Class II cavity preparations and Class I amalgam restorations. There were no differences between dental students and student dental hygienists in carrying out Class I amalgam preparations on patients and Class I and II cavity preparations on dentoforms.
- 5.2.2 Sisty et al⁸¹ used a stratified randomised sample of operators to compare operative procedures in 123 patients and periodontal procedures in 63 patients. She found ratings were the same for dental students and student dental hygienists in Class II and Class III restorations and concluded that student dental hygienists were able to perform selected operative procedures at a comparable level to that of dental students.
- 5.2.3 In the *The Forsyth Experiment*⁸² Lobene reports in detail Project Rotunda conducted at The Forsyth Institute in Boston. In 3 blind evaluations of the quality of all stages of restoration preparation conducted in 1973 and 1974 expanded-duty dental hygienists performed to the same level as dentists. In the initial "pilot" assessment in March 1973 only 5 out of 26 of the expanded-duty dental hygienists' restorations suffered from minor correctable defects. Later that year dental hygienists achieved a group mean quality score of 10.2 compared with 10.6 for dentists (9.0 being acceptable).

⁷⁷ Milgrom P, Bergner M, Chapko M K, Conrad D, Skalabrin N. *The Washington State dental auxiliary project: Delegating expanded functions in general practice*. JADA 1983; 107: 776-781.

⁷⁸ Bergner M, Milgrom P, Chapko M K, Beach B, Skalabrin N. *The Washington State dental auxiliary project: Quality of care in private practice*. JADA 1983; 107: 781-786.

⁷⁹ Carpay J J, Nieman F H M, Konig K G, Felling A J A, Lammers J G M. *Quality of dental restorations and dental treatment in Dutch schoolchildren*. Community Dent Health 1990; 7: 43-51.

⁸⁰ Powell W O, Sinkford J C, Henry J L, Chen M S. *Comparison of clinical performance of dental therapist trainees and dental students*. J Dent Education 1974; 38 (5): 268-272.

⁸¹ Sisty N L, Henderson W G, Paule C L, Martin J F. *Evaluation of student performance in the four-year study of expanded functions for dental hygienists at the University of Iowa*. JADA 1978; 97: 613-627.

⁸² Lobene R R. *The Forsyth Experiment: An Alternative System for Dental Care*. 1979. Cambridge, Massachusetts. Harvard University Press.

The differences were not statistically different. The final blind examination conducted by 6 professors of restorative dentistry in 1974 resulted in a group mean quality score of 10.2 for expanded-duty dental hygienists and 10.0 for dentists. A sub-group analysis of multi-surface restorations showed that expanded-duty dental hygienists achieved a significantly higher mean score than dentists. However the sample of multi-surface restorations was small. In addition to the blind assessment regular daily quality assessments were undertaken. Throughout the project of over 17,023 restorations placed by expanded-duty dental hygienists only 4% required adjustment and 2% immediate replacement. None were totally unacceptable. During this period expanded-duty dental hygienists carried out 19,849 administrations of local anaesthetic with no serious consequences from infiltration or mandibular block injections.

- 5.2.4 Nixon⁸³ trained expanded-duty dental nurses as dental therapists, and compared baseline and experimental phases in 4 practices over 4 months. Out of 200 procedures, he claimed that there was a significant difference for 2 out of 12 and both favoured the expanded-duty dental nurses.

5.3 Technical Competence in Periodontics

- 5.3.1 A study by Pelton et al⁸⁴ compared the quality of prophylaxis on 210 patients by expanded-duty dental nurses and dental students. Evaluated after 2 days, they found that 64% patients treated by expanded-duty dental nurses and 58% treated by dental students were free of calculus. 79% patients treated by expanded-duty dental nurses and 69% treated by dental students were free of stains. 51% treated by expanded-duty dental nurses and 44% treated by dental students were free of calculus and stains.
- 5.3.2 Sisty et al⁸¹ compared the performance and competence of student dental hygienists and dental students in periodontal examination, treatment planning and root planing and curettage. There were no statistical differences in any of the assessment criteria between the 2 student groups. They concluded that student dental hygienists were able to perform selected periodontal procedures at a comparable level to that of dental students.
- 5.3.3 A more recent study by Wilson et al⁸⁵ compared the performance of dental students and student dental hygienists in scaling and root planing procedures before and after 2 pre-clinical courses. 23 dental students and 29 student dental hygienists were tested and compared before and after a 13-week pre-clinical periodontal instrumentation course. The relative performance of dental students and student dental hygienists did not differ significantly before or after training. Wilson et al concluded that there were no significant overall differences between dental students and student dental hygienists in learning periodontal instrumentation.

⁸³ Nixon J R. *The Indian Health Service Study of the Expanded-Duty Dental Auxiliary II (EDDA II)*. J Public Health Dent 1980; 40 (2): 99-117.

⁸⁴ Pelton W J, Bethart H, Goller K S. *The ability of dental therapists to perform dental prophylaxes*. JADA 1972; 84: 611-615.

⁸⁵ Wilson S G, Tsutsui P T, Farnoush A. *An assessment of the relationship of time to fine motor skill acquisition in scaling and root planing procedures*. Quintessence International 1985; 6: 407-413.

- 5.3.4 Zappa et al⁸⁶ compared scaling and root canal forces exerted by dentists and dental hygienists. They found significant difference in the forces between the 2 groups for one particular instrument while scaling or root planing with the dentists using greater forces, 7.56 Newtons (N) compared with 6.59N for hygienists for scaling, and 6.34N and 4.24N for root planing. All other parameters showed no significant differences.

5.4 Technical Competence in the Clinical Aspects of Denture Provision

- 5.4.1 Only a small number of studies address whether PCDs can substitute for dentists in carrying out the clinical aspects of providing dentures. Of these only one study provides any comparison between dentists and PCDs. Benson⁸⁷ trained 4 expanded-duty dental nurses to carry out all the intra-oral procedures involved in making complete dentures. He found that there was no statistical difference between the scores for expanded-duty dental nurses and dental students and that the performance of expanded-duty dental nurses was comparable to that of dental students. However they received more didactic and clinical instruction than dental students leading Benson to suggest a one or 2-year training would be required for expanded-duty dental nurses.

5.5 Technical Competence in Orthodontics

- 5.5.1 Few of the included studies considered the technical competence of orthodontic PCDs although this is a part of orthodontic treatment in many countries, particularly North America. Oliver & Griffiths⁸⁸ examined 4 different methods of in vitro residual composite removal following debonding performed by 2 types of clinical operators, an orthodontist and a dental hygienist, and assessed these for enamel surface damage. There was no difference in the quality of the enamel surface appearance between the 2 operators regardless of the method used for composite removal.
- 5.5.2 More recently, Mandall & Read⁸⁹ compared the ability and efficiency of dental hygienists with postgraduate orthodontists. They found that there was no statistically significant difference between dental hygienists' and orthodontists' ability to perform potential orthodontic "auxiliary" procedures. However fully trained orthodontists were more efficient.

5.6 Technical Competence in the Preventive Therapies, Fissure Sealants, Atraumatic Restorative Treatment

- 5.6.1 As the emphasis in dentistry has moved towards prevention, there have been a number of studies dealing with sealants and the effect of using different types of operator. More recently, studies have looked at new techniques, including atraumatic restorative treatment (ART) and glass ionomer cements.

⁸⁶ Zappa U, Rothlisberger J,P, Simona C, Case D. *In vivo scaling and root planing forces in molars*. J. Periodontol 1993; 64: 349-354.

⁸⁷ Benson D. *Experimental utilisation of auxiliaries in removable prosthodontics*. J Dent Educ 1973; 37 (10): 27-30

⁸⁸ Oliver R G, Griffiths J. *Different techniques of residual composite removal following debonding - time taken and surface enamel appearance*. Brit J Orthodont 1992; 19: 131-137.

⁸⁹ Mandall N A, Read M J F. *The effectiveness and efficiency of hygienists in carrying out orthodontic auxiliary procedures*. Brit J Orthodont 1999;26(3) 229-32.

- 5.6.2 Tappan & Fitch⁹⁰ reported that after a 9-week training programme, expanded-duty dental nurses in Denver could apply fluoride with cyanoacrylate with comparable quality to dentists and dental hygienists.
- 5.6.3 A few studies compared the performances of PCDs with dentists. An early Canadian study by Leake & Martinello⁹¹ compared dentists and dental hygienists in all aspects of the application and evaluation of sealant programmes. They found that 29% of sealants placed by dentists and 9% placed by dental hygienists were retained after 4 years. Leake & Martinello concluded that dentists had a better clinical success rate after 4 years than dental hygienists.
- 5.6.4 Stiles et al⁹² examined differences in the retention of sealants placed by a dentist, dental hygienist and expanded-duty dental nurse. They reported highly significant differences between the expanded-duty dental nurse and the dentist and the dental hygienist, but no differences between the dentist and the dental hygienist. Retention rates were 55% for the dentist, 54% for the dental hygienist and 39% for the expanded-duty dental nurse.
- 5.6.5 Ooi & Tan⁹³ evaluated the retention of sealants placed by dentists and an expanded-duty dental nurse over 2 years. They conducted tests with 2 types of sealant (Concise & Delton) on 196 children aged 6 to 7, who were recalled for examination at 6, 12, 18, and 24 months. Although Ooi & Tan found significant differences in the retention rates of the 2 different types of sealants, they showed that there were no significant differences in the success rates of the 2 types of operator.
- 5.6.6 Other studies provided data about the differences between different types of operator in their self-evaluation of technical competence. Scruggs et al⁹⁴ investigated the use of specific criteria and examiner calibration on the reliability of inexperienced examiners on sealant evaluation. They found no significant difference in reliability between dental students and student dental hygienists ($t = 0.77$, $p = 0.46$). Intra-examiner reliability for dental students was 0.73 (mean r) and for student dental hygienists, 0.64. However this study was more concerned with evaluating calibration sessions than with assessing the differences between the 2 types of dental professionals.
- 5.6.7 In a later study, Daniel et al⁹⁵ assessed the accuracy of students' self-evaluation of sealants by comparing self-evaluation by dental students and student dental hygienists with the scores of faculty members. Students' scores were consistently higher than the faculty scores with student dental hygienists higher than dental students. Daniel et al concluded that dental students and student dental hygienists scored themselves higher than the faculty members.

⁹⁰ Tappan W, Fitch M A. *The training and utilisation of paraprofessional personnel in a public health dental program of prevention*. J of Public Health Dentistry 1975; 35 (1): 35-39.

⁹¹ Leake J L, Martinello B P. *A four year evaluation of a fissure sealant in a public health setting*. J Canad Dent Assn 1976; 8: 409-415.

⁹² Stiles H M, Ward G T, Woolridge E D, Meyers R. *Adhesive sealant clinical trial: Comparative results of application by a dentist or dental auxiliaries*. J of Prevent Dent 1976; 3 (3): 8-11.

⁹³ Ooi C L, Tan G C. *A two-year study on the retention of pit and fissure sealants applied by different dental operators*. Sing Dent J 1986; 11 (1): 15-17.

⁹⁴ Scruggs R R, Daniel S J, Larkin A, Stoltz R F. *Effects of specific criteria and calibration on examiner reliability*. J Dent Hygiene 1989; 125-129.

⁹⁵ Daniel S J, Scruggs R R, Grady J J. *The accuracy of student self-evaluations of dental sealants*. J Dent Hygiene 1990; 339-342.

- 5.6.8 Wood et al⁹⁶ compared the retention rates of fissure sealants carried out by dentists, dental hygienists or dental students at an average of 9 months. They found no difference in retention rates between the various types of operator.
- 5.6.9 A recent meta-analysis considered the effectiveness of fissure sealants and the factors that influenced this. The results were inconclusive in relation to operator effect. 24 studies identified by Llodra et al⁹⁷ found that the overall effectiveness of auto-polymerized sealants was 71%. Results ranged between 73% for dentists working with dental nurses, 73% for dentists alone, 65% dental students working with dental nurses and 63% for dental hygienists alone. This appeared to indicate that dental hygienists working alone were less effective than dentists working in tandem with dental nurses.
- 5.6.10 Several studies examined the effectiveness of new materials and techniques. Phantumvanit et al⁹⁸ reported the results of a 3-year trial in Thailand, which compared survival rates of amalgam, and ART restorations placed by a dentist and 2 extended-duty dental nurses. There were no statistical differences in survival between those restorations placed by the dentist and those placed by the extended-duty dental nurses.
- 5.6.11 Frencken et al⁹⁹ reported the results of a similar 3-year study of ART restorations and glass ionomer sealants placed by 2 dentists and 2 newly qualified dental therapists in Zimbabwe. With 85% of ART restorations and 50% of sealants surviving at 3 years, they found a statistically significant difference in the survival of ART restorations between dentists and dental therapists. However one dental therapist was performing significantly below the other 3 operators.

5.7 Discussion

- 5.7.1 In the discussion of technical competence, it is important to distinguish between the different types of studies. Traditionally there has been a differentiation between reversible procedures such as prophylaxis and placing and carving of amalgams, and irreversible procedures such as cavity preparation. The majority of the included studies are concerned with reversible procedures, but a wide range of procedures was investigated. For example:

- Placing rubber dam
- Overlays for crowns
- Temporary crown/bridge construction
- Impression taking
- Placing and finishing restorations
- Cavity preparation

⁹⁶ Wood A J, Saravia M E, Farrington F H. *Cotton roll isolation versus Vac-Ejector isolation*. J Dent Children 1989; 56: 438-441.

⁹⁷ Llodra J C, Bravo M, Delgado-Rodriguez M, Baca P, Galvez R. *Factors influencing the effectiveness of sealants - A meta-analysis*. Community Dent Oral Epidemiol 1993; 21: 261-8.

⁹⁸ Phantumvanit P, Songpaisan Y, Pilot T, Frencken J E. *Atraumatic restorative treatment (ART): A three-year community field trial in Thailand – Survival of one-surface restorations in the permanent dentition*. J Public Health Dent 1996; 56 (3): 141-145.

⁹⁹ Frencken J E, Makoni F, Sithole W D, Hackenitz E. *Three-year survival of one-surface ART restorations and glass-ionomer sealants in a school oral health programme in Zimbabwe*. Caries Res 1998; 32: 119-126.

- Scaling and polishing/root planing
- Fissure sealants
- Intra-oral stages of denture construction
- Orthodontic procedures

5.7.2 The vast majority of studies were conducted in the USA. However the overall standard of the studies and reporting is rarely better than mediocre. This in addition to the great variability in the procedures undertaken and the methods used for assessment means that it is only possible to undertake a qualitative synthesis. In relation to quality, dentists who trained PCDs were often also responsible for assessing the quality of the final outcome.

5.7.3 Although a large number of procedures undertaken by PCDs have been assessed, 2 areas have received little attention, orthodontics and the clinical stages of denture construction. For orthodontics, it is surprising that there have been so few studies published, as orthodontic PCDs are widely used in North America. In relation to the clinical stages of denture construction, one study was identified that showed PCDs were as competent as dentists.

5.7.4 While excluded from our main study as there was no comparison with dentists, Foreman examined in 2 separate studies the sealant retention rates of dental hygienists and extended-duty dental nurses following the same training programme^{100,101}. Extended-duty dental nurses had a significantly higher retention rate than dental hygienists, 91% against 81%. The comparison group was a historical control and it was unclear whether the patient groups were similar.

5.7.5 Another issue to consider is the effect of operator performance. This is known to vary and could have a significant impact on the overall difference in performance between the various grades of operator. This can be seen clearly in the study by Frencken et al⁹⁹ where one dental therapist performed to the same level as the dentist, but the other did not.

5.7.6 As with the section on diagnosis and screening little information is provided on the length and the type of training provided before PCDs undertook these additional tasks.

5.7.7 While PCDs were able to operate to the same level as dentists, the level and time spent in supervision of individual PCDs has an impact on the time that dentists spend with patients. Foreman¹⁰⁰ suggests that the amount of time spent on supervision can be as high as 40%. However issues of overall productivity and cost-effectiveness of PCDs in individual practices are addressed in Section 8.

5.8 Conclusions

5.8.1 The overall standard of the research was poor. The majority of the work was old, being conducted during the 1970s. Only one small study, which was in a non-clinical environment, was undertaken in the UK. There is therefore a clear need for high quality research in this area to be undertaken in the UK.

¹⁰⁰ Foreman F J. *Retention of sealants placed by dental technicians without assistance*. Paediatric Dent 1991; 13 (1): 59-61.

¹⁰¹ Foreman F J, Matis B A. *Sealant retention rates of dental hygienists and dental technicians using differing training protocols*. Pediatric Dent 1992; 14 (3): 189-190.

- 5.8.2 With the exception of one study comparing the retention of fissure sealants placed by dentists and by dental hygienists⁹¹, PCDs performed a wide range of technical procedures to the same quality as dentists.
- 5.8.3 The level of training required to attain these standards ranged from weeks to years, but only rarely was there any indication of what training comprised detailed in the studies. Consequently there is a need for research into the training requirements required for PCDs.

6. ORAL HEALTH PROMOTION

6.1 Introduction

- 6.1.1 There have been a large number of studies of oral health promotion including at least 2 systematic reviews. However these are usually concerned with the impact of oral health education and oral health promotion rather than the members of the dental team involved^{102,103}. Studies often do not specify who was responsible for the oral health education provided.
- 6.1.2 Many studies that do indicate that PCDs were involved make no valid comparison with the work of dentists. Ten studies met the inclusion criteria. (See Table 4)

COUNTRY	NUMBER OF STUDIES
USA	5
Netherlands	2
Sweden	2
Scotland	1

Table 4

6.2 Oral Health Education

- 6.2.1 Many early studies were concerned with evaluating the effectiveness of different treatment modes rather than assessing the relative performance of PCDs and dentists. However some later studies were concerned with oral health education. Axelsson & Lindhe¹⁰⁴ carried out a prospective interrupted time series to see whether oral hygiene instruction and prophylaxis could prevent caries and the progression of periodontitis over 3 years. Patients were allocated to test and control groups. The test groups received oral hygiene instruction and oral prophylaxis from dental hygienists once a month for 2 years and every 3 months in the third year. Control groups received traditional care. After 3 years, it was found that the test groups had reduced plaque scores, decreased frequency of inflamed gingival units, no changes in attachment levels, and decreases in the mean pocket depths. Test groups did not develop new carious lesions or recurrent caries. The control groups did. Axelsson & Lindhe concluded that regular oral hygiene instruction and prophylaxis was effective. Six years later in a subsequent follow-up¹⁰⁵, the test groups again had improved oral hygiene and plaque scores, whereas the control groups showed no improvement. Axelsson concluded that a preventive programme could prevent the progression of periodontal disease and caries in adults.

¹⁰² Sprod A J, Anderson R, Treasure E T. *Effective oral health promotion: Literature review*. 1996. Cardiff. Health Promotion Wales. Technical Report 20.

¹⁰³ Kay E J, Locker D. *Effectiveness of oral health promotion: A review*. 1997. London. Health Education Authority.

¹⁰⁴ Axelsson P, Lindhe J. *Effect of controlled oral hygiene procedures on caries and periodontal disease in adults*. J Clin Periodont 1978; 5: 133-151.

¹⁰⁵ Axelsson P, Lindhe J. *Effect of controlled oral hygiene procedures on caries and periodontal disease in adults*. J Clin Periodont 1981; 8: 239-248.

- 6.2.2 In the Netherlands, Tan¹⁰⁶ assessed the effect of repeated oral health education on gingival health, knowledge, attitude, behaviour and perceptions. Patients were allocated to experimental and control groups. The experimental groups received oral health care instruction and a single prophylaxis from dental hygienists for one year. Post-test differences between the experimental and control groups were significant for knowledge, attitudes, sweet consumption, and toothbrushing, perception of the condition of the gingiva, home care behaviour and dental care indices. Experimental groups used dental floss and toothpicks more frequently, thought more often of diagnosing gingivitis, and used fluoride toothpaste more. Tan concluded that there were significant improvements in the experimental groups in knowledge, attitudes, behaviour, perceptions of gingival status and the ability to diagnose gingivitis and the condition of the tissues.
- 6.2.3 An experiment in oral health education in Scotland in the mid-1980s was reported in 2 separate articles^{107,108}. The study measured the benefits of mobile surgery-based and school-based prevention programmes. In the study, 1,060 children received either oral health education advice from a dental hygienist, from teachers, or were in a control group that had no advice. The mean DMFT increment over 2 years was 1.45, 1.88, and 1.82. Gingival health at the final examination was assessed as inflammation at 5 or more sites. The incidence was 13%, 12%, and 19%. More subjects in the intervention groups had good dental knowledge than in the control group. The authors concluded that the clinical benefits of the 2 programmes were marginal and were not effective enough in preventing caries to be generally recommended. The study also showed how preventive programmes could generate extra costs in terms of treatment.
- 6.2.4 Uitenbroek et al¹⁰⁹ used a questionnaire-based study to assess the success of dental hygienists in giving oral health education advice. 26% (159) of patients, who attended practices that employed dental hygienists, and 39% (302) patients who attended practices that did not employ them, completed the questionnaires. The results indicated that patients who visited dental hygienists received more advice, dental instruction and preventive care than patients who did not. The authors concluded that on all scales, patients cared for by dental hygienists scored higher than patients not cared for by them, and that dental hygienists were successful in the behavioural aspects of their work.

6.3 Smoking Cessation Advice

- 6.3.1 Secker-Walker et al¹¹⁰ surveyed health promotion by dentists and dental hygienists in relation to smoking. The study was based on a questionnaire to 37 dentists and 27 dental hygienists and on a survey of 256 patients' smoking habits. 84% of dentists took a smoking history, 76% advised patients about smoking, 41% advised patients to cut down and 68% were willing to learn brief methods to counsel patients about

¹⁰⁶ Tan H H, Ruiter E, Verhey H. *Effect of repeated dental health care education on gingival health, knowledge, attitude, behaviour and perception*. Community Dent Oral Epidemiol 1981; 9: 15-21.

¹⁰⁷ Blinkhorn A S, Wight C, Yardley A. *Report of two dental health programmes for adolescents in the Lothian Region of Scotland*. J Dent 1987; 15: 213-217.

¹⁰⁸ Wight C, Blinkhorn A S. *An assessment of two dental health education programmes for school children in the Lothian region of Scotland*. J Paediatric Dent. 1988; 4: 1-7.

¹⁰⁹ Uitenbroek D G, Schaub R M H, Tromp J A H, Kant J H. *Dental hygienists' influence on the patients' knowledge, motivation, self-care, and perception of change*. Community Dent Oral Epidemiol 1989; 17: 87-90.

¹¹⁰ Secker-Walker R H, Hill H C, Solomon L J, Flynn B S. *Smoking Cessation Practices in Dental Offices*. J Public Health Dent 1987; 47 (1): 10-15.

tobacco use. Equivalent figures for dental hygienists were 86%, 81%, 53%, and 89%. Secker-Walker et al concluded that there was no correlation between the behaviour of dentists and dental hygienists in terms of taking a smoking history, the percentage of smokers advised against, the content or nature of the advice and patients' subsequent behaviour.

- 6.3.2 Little et al¹¹¹ used a randomised-controlled trial to test the effectiveness of a smokeless tobacco intervention in a dental environment. 518 users of smokeless tobacco were randomly assigned to routine care and intervention groups. Those assigned to the intervention group were examined and received advice from dental hygienists. All were followed up at 3 months. 32% of the intervention group and 21% of the routine care group had given up smoking. The prevalence of no tobacco use was 19% in the intervention group and 12% in the routine care group.
- 6.3.3 In a subsequent study, Secker-Walker et al¹¹² again used a questionnaire to compare the smoking cessation activities of dentists and dental hygienists. Of the 80% dentists and 78% dental hygienists who responded, 55% dentists and 66% dental hygienists asked new patients about smoking. 33% dentists and 47% dental hygienists asked returning patients about smoking. The median time spent counselling patients was 3 minutes. Dental hygienists provided more advice than dentists.
- 6.3.4 A questionnaire survey by Hastreiter et al¹¹³ to 630 dentists, 610 dental hygienists and 700 dental nurses with response rates of 73%, 79% and 62% found that a slightly higher proportion of dental hygienists (61%) than dentists (55%) asked about tobacco use, while only 20% of dental nurses did. However a higher proportion of dentists advised patients to quit 58% compared with 54% for dental hygienists and 27% for dental nurses. Hastreiter et al concluded that by acquiring tobacco intervention skills the dental team could take a leading role in reducing disease and mortality.
- 6.3.5 Using a questionnaire-based study, Halling et al¹¹⁴ described the work of dentists, dental hygienists and dental nurses in smoking prevention. The study was based on 2,628 dental professionals using random sampling and had a high response rate (90%). Results indicated that 53% of dentists, 72% of dental hygienists and 54% of dental nurses thought that participation in smoking prevention was important. 32% dentists, 68% dental hygienists and 10% of dental nurses routinely asked for a history of smoking habits. 15% dentists, 15% dental hygienists and 2% dental nurses offered routine counselling.

¹¹¹ Little S J, Stevens V J, Severson H H, Lichtenstein E. *An effective smokeless tobacco intervention for dental hygiene patients*. J Dent Hygiene 1992; 185-190.

¹¹² Secker-Walker R H, Solomon L J, Flynn B S, Dana G S. *Comparisons of the smoking cessation counselling activities of six types of health professionals*. Preventive Medicine 1994; 23: 800-808.

¹¹³ Hastreiter R J, Bakdash B, Roesch M H, Walseth J. *Use of Tobacco prevention and Cessation strategies and techniques in the dental office*. JADA 1994; 125: 1475-1484.

¹¹⁴ Halling A, Uhrbom E, Bjerner B, Solen G. *Tobacco habits, attitudes and participating behaviour in tobacco prevention among dental personnel in Sweden*. Comm Dent Oral Epidemiol 1995; 23: 254-5.

6.3.6 Dolan et al¹¹⁵ also conducted a questionnaire and telephone survey of 1,746 dentists and 723 dental hygienists with questions on advice on giving up smoking. The results indicated that 33% of dentists and 25% of dental hygienists had asked virtually all the patients seen in the previous 3 months whether they smoked. 66% of dentists and 60% of dental hygienists had given advice to smokers to stop. Dentists who employed dental hygienists were more likely to provide smoking cessation advice (34%). Dolan et al however concluded that tobacco cessation activities were not a routine aspect of dental practice.

6.4 Discussion of Studies on Oral Health Education

6.4.1 There have been a number of reviews of the effectiveness of oral health promotion^{102,103} that also included oral health promotion delivered by PCDs. However the number which included a comparison between PCDs and dentists were limited as can be seen by the small number of studies included in the review.

6.4.2 Direct comparison of delivery of an intervention by dentist to that delivered by a PCD was unusual. More usual was the comparison of interventions delivered by a PCD to routine care. This was the problem in many studies as routine care is rarely adequately described. The overall quality of the studies was poor with only one randomised controlled-trial. As a result only a limited summary of the general direction of the evidence can be given.

6.4.3 PCDs are regularly used to deliver oral health education and promotional advice and activities. A systematic review by Kay & Locker¹⁰³ found that:

- Oral health promotion involving the use of therapeutic agents containing fluoride
- Clinical chairside interventions
- Simple approaches aimed at improving oral hygiene

were all effective in improving oral health; that oral health promotion is effective in increasing knowledge, but there was no evidence that this resulted in changes in behaviour.

6.4.4 Many of these studies used PCDs to deliver these programmes. The direct costs for PCDs are low, which is probably the reason why they are often chosen to deliver oral health programmes. However, because of the limited number of direct comparisons between PCDs and dentists no firm conclusions can be made as to whether one is more effective than the other in delivering effective oral health promotion.

6.4.5 The studies on smoking cessation suggest that dental hygienists take greater interest than dentists do in patients' smoking behaviour and modification of these behaviours. These studies are mainly questionnaires. Despite good responses in some studies, all were self-reported and as a result subject to responder bias.

¹¹⁵ Dolan T A, McGorray S P, Grinstead-Skigen C L, Mecklenburg R. *Tobacco control activities in US dental practices*. JADA 1997; 128: 1669-1679.

6.4.6 Overall the quality of studies in this area is of poor quality.

6.5 Conclusions

6.5.1 Only 10 studies compared delivery of oral health promotion by PCD and dentists. The quality of the available evidence is poor but it suggests that PCDs can deliver oral health promotion at least as well as dentists.

7. ACCEPTABILITY

7.1. Introduction

- 7.1.1. There are few studies about the acceptability of PCDs to patients. Of the 13 included studies the majority were conducted in the USA (Table 5). The majority dealt with patients' satisfaction with expanded-duty dental nurses and dental hygienists. However some studies provided a comparison between patients who were treated by clinical dental technicians and by dentists. In many early studies some assessment of acceptability was included although this did not appear a core element.

COUNTRY	NUMBER OF STUDIES
USA	11
Finland	2

Table 5

7.2. Acceptability of Expanded-Duty Dental Nurses to Patients

- 7.2.1. Lotzkar et al^{62,63} assessed patient satisfaction in 2 phases of their extensive project and reported that 95% of procedures carried out by expanded-duty dental nurses were satisfactory in each phase .
- 7.2.2. Soricelli⁶⁴ also found that acceptability to patients of services given by expanded-duty dental nurses was overwhelmingly favourable.
- 7.2.3. Gilmore¹¹⁶ reported a questionnaire survey that assessed the attitudes of consumers to PCDs. However this only had a response rate of only 5 per cent.

7.3. Acceptability of Expanded-Duty Dental Hygienists to Patients

- 7.3.1. Sisty & Henderson¹¹⁷ assessed whether patients were satisfied with operative and periodontal procedures performed by expanded-duty student dental hygienists and dental students. The response rates to the questionnaire were high. 667 patients were treated by dental students (67%) and 494 patients treated by student expanded-duty dental hygienist (46%). For advanced periodontal procedures patients rated dental hygienists as "slightly better" in 5 out of 6 categories and for other periodontal procedures, patients rated them as "better" in all 6 categories. The 2 groups were rated similarly, 5 out of 6 for operative procedures and the remaining category favoured expanded-duty student dental hygienists.
- 7.3.2. During the Project Rotunda at Forsyth reported by Lobene⁸² data were initially collected for patients for each individual visit. After assessing 2,000 questionnaires and finding out only 2% of patients were dissatisfied with the explanation of the treatment to be carried out, no further collection was carried out. In a detailed final questionnaire completed by 45% of the 2,668 treated patients, 99% of patients were satisfied with treatment quality and operator competence, and 96% with comfort during treatment and duration of the visit. 38.9% of patients did not know what type

¹¹⁶ Gilmore N D, Stevens C, Pierce V, Giddon D B. *Consumer and provider attitudes toward dentist and expanded auxiliary functions*. JADA 1976; 93: 614-621.

¹¹⁷ Sisty N L, Henderson W G. *A comparative study of patient evaluations of dental treatment performed by dental and expanded-function dental hygiene students*. JADA 1974; 88: 985-996.

of therapist had provided the treatment and only 1.5% were uncomfortable with being treated by a female (at this time a male operator was virtually always a dentist). However 98.9% said they would chose the same team for dental work in the future.

7.4. Acceptability of Expanded-Duty Dental Nurses and Expanded-Duty Dental Hygienists

- 7.4.1. Some studies sought to compare the experience of patients in different settings. Martens et al¹¹⁸ tried to discover whether patients who had been treated by PCDs were more positive towards them than those who had not. Responses from patients at a TEAM clinic, a dental school and a private group practice were compared. Delegation of duties to PCDs occurred in all 3 locations, but a wider range of procedures was provided in the TEAM clinic. TEAM patients, who had received more delegated treatment, responded more favourably towards delegation than the other group. However all patient groups were favourable to delegation. Out of 13 procedures tested, those least favoured for delegation were cavity preparation, diagnosis and treatment planning, and extractions.
- 7.4.2. Milgrom et al⁷⁷, reporting from the Washington State Project, which looked at delegation in a general practice, found that patients were satisfied with the care that they had received. However satisfaction with dentist-patient relations, patient waiting time and continuity of care was less when there was more delegation. This could be related to dentists spending less time with patients and more time scheduling. However, in a similar study in Kentucky Mullins et al⁷³ found that patient satisfaction scores did not change with increasing delegation.

7.5. Acceptability of Clinical Dental Technicians and Dentists

- 7.5.1. A small number of studies have looked at the acceptability of members of the dental team making and fitting complete dentures.
- 7.5.2. Benson⁸⁷ reported from a randomised controlled trial that patients' evaluation scores for dentures made by expanded-duty dental nurses and dental students were similar.
- 7.5.3. In a Finnish study, Rantanen & Kononen¹¹⁹ assessed the number of complete dentures made by dentists and clinical dental technicians, and patients' future intentions for their care and the reasons for their choice. 56% of patients said that in future they would go to a clinical dental technician and 33% to a dentist. 11% did not know. Dentists' patients indicated good results and the treatment relationships as their reasons for returning. Clinical dental technicians' patients said lower costs. However they also thought that their dentures were better than or as good as those made by dentists.
- 7.5.4. In another Finnish study Tuominen¹²⁰ surveyed 98 dentists' patients and 46 patients of clinical dental technicians. 62% of dentists' patients and 60% of clinical dental technicians' patients responded. Interestingly while 94% of dentists' patients and 95% of clinical dental technicians' patients were satisfied with their current dentures, fewer of the dentists' patients, 74%, were satisfied with their teeth and gums

¹¹⁸ Martens L V, Loupe M J, Modlin L D, Diangelis A J. *Patient views on team dentistry and expanded duties*. Dent Hyg 1975; 49: 305-310.

¹¹⁹ Rantanen T, Kononen M. *Dentists and dental technicians as competing suppliers of complete dentures in Southwest Finland*. Community Dent Oral Epidemiol 1979; 7: 270-273.

¹²⁰ Tuominen R. *A comparison of dentists' and denturists' complete denture patients*. Proc Finn Dent Soc 1987; 84 (1): 53-59.

compared to clinical dental technicians' patients, 87%. Prices charged by clinical dental technicians were around half that of dentists and this may have influenced patient evaluation.

- 7.5.5. Friedrichsen et al¹²¹ compared the socio-economic status and patterns of choice of 135 patients of clinical dental technicians and dentists. He reported that 52% of dentists' patients and 68% of clinical dental technicians' patients were highly satisfied with the treatment they received.

7.6. Discussion of Studies on Acceptability

- 7.6.1. Of the included studies, few addressed the issue of the acceptability to patients of being treated by PCDs. This is perhaps surprising. Perhaps more surprising is that no included studies looked in detail at the attitude of the dentists to PCDs. Dental professional opinion worldwide has ranged from widespread acceptance to outright hostility to their acceptability.
- 7.6.2. The majority of studies assessed acceptability using questionnaires. However there is little indication in many of the studies about the length of questionnaires, number of questions related to acceptability or whether the questions had been validated in any way.
- 7.6.3. Response rates also varied wildly, with 67.5% being achieved by Sisty & Henderson¹¹⁷, but only 5% by Gilmore¹¹⁶. The delegation projects in Kentucky and Washington State included assessments of patient satisfaction; these comprised 14 practices in the former and 120 in the latter. In the Washington State project, questionnaires were distributed to 50 patients in each practice over 3 years. However response rates were low, 34 per cent in 1979, 45 per cent in 1980, and 40 per cent in 1981. DeFriese et al¹²² reported from a large scale survey of Kentucky and Washington State. This paper provides an overview of the studies' conclusions but no data. They found no differences in patient satisfaction with care between practices that did and did not use expanded-duty dental nurses and expanded-duty dental hygienists. They concluded that there was a clear relationship between delegation and patient satisfaction.
- 7.6.4. In a number of cases questionnaires were administered in the waiting room. This may result in more favourable responses from the patients anxious about their environment or awaiting treatment.
- 7.6.5. The Tuominen study¹²⁰ suggested that patients' responses to the acceptability of PCDs might also be affected by their financial circumstances. Clinical dental technicians were seen to offer a cheaper service, which may make them more acceptable to patients on a lower income. Dentists may charge additional fees for treatment provided by a dental hygienist and consequently this could also affect acceptability to the patients.
- 7.6.6. The latest of these studies was conducted in 1987. Since then there has been an increasing degree of delegation in medicine in many countries. This has included the introduction of nurse practitioners the increasing role of the paramedic and the

¹²¹ Friedrichsen S W, Herzog A E, Christie C A. *A socio-economic comparison of patients receiving prostheses in a two-tier delivery system.* J Prosthet Dent 1992; 67 (3): 348-357.

¹²² DeFriese G H, O'Shea R M, Meskin L, Pfister J, Barker B D. *The Kentucky and Washington State demonstrations: Expanded-function dental auxiliary personnel in private general practice.* JADA 1983; 107: 773-776.

introduction of the phlebotomist. This generally increasing trend to delegation may have had an effect upon the satisfaction with dentist-patient relations, and continuity of care issues raised by Milgrom⁷⁷.

- 7.6.7. Douglass et al⁷¹ suggested that the results of surveys about patients' attitudes showed that patients reacted favourably to expanded-duty dental nurses. All responded positively to questions about assessment of personal attention received, quality of care, and willingness to go to a dentist employing expanded-duty dental nurses.

7.7. Conclusions

- 7.7.1. The overall quality of the studies addressing acceptability is poor with many being merely a part of larger studies assessing other aspects of PCDs work.
- 7.7.2. Overall the studies suggest that patients find having work conducted by PCDs is acceptable. However none of the included studies addresses the attitude of the dentist to working with or employing of PCDs.

8. PRODUCTIVITY

8.1 Introduction

8.1.1 During the First World War high levels of dental disease and shortages in the dental workforce led to early attempts to improve productivity. Dental hygienists were trained from 1906 in the USA starting in Connecticut¹. The UK created “dental dressers” during the First World War, but the 1921 Dentists Act led to their training and employment ending¹. New Zealand created dental nurses in 1921¹. Both dental dressers and New Zealand Dental Nurses were early types of dental therapist. Workforce shortages became an issue again during the Second World War. As a result many studies of productivity focus on military personnel. The current concern with the productivity of dental services stems from the increasing cost of health care. There is increasing recognition in many branches of health care that inter-disciplinary teamwork has potential to achieve gains in productivity.

8.2 Methods

8.2.1 This section aims to review all the papers identified by the searches reported in the Methodology, which provide information relevant to the productivity of PCDs. (See Section 3). The Concise Oxford Dictionary defines “productivity” as “production per unit of effort”. However few identified papers address both production and effort or cost. Initially, therefore, all 53 identified papers were included that seek to estimate the output or cost of PCDs.

8.2.2 This section excludes papers that focus on the cost-effectiveness of training. For example McClellan & Cox¹²³ evaluated the effect of a one-week training programme in teamwork on the productivity of dentists already working with PCDs. Immediately afterwards participants increased the mean number of treatments by 14% without increasing working hours. After 18 months the accumulated value of additional treatments was 6 times the cost of training. However this paper does not address the basic cost-effectiveness of employing PCDs.

8.2.3 The quality of the 53 included papers is variable. Not surprisingly few show evidence of input from an economist. Of more concern is that few include all the basic information needed to undertake a rigorous synthesis. In particular most give no information on inter-practice variability. Thus the application of quality criteria, common in systematic reviews, would have much reduced the number of eligible papers. Rather than discard potentially useful if less than rigorous material, however, details of all 53 papers are included in Appendix 6, and summarise them in Sections 8.3 to 8.6.

8.2.4 The 53 selected papers come from 8 countries. (See Table 6). Despite the dominance of American studies, however, the last of them dates from 1989: recent papers have come exclusively from Australia and Scandinavia.

¹²³ McClellan T E, Cox J L. *Description and evaluation of dentist-dental assistant team training in efficient dental practice management.* J Am Dent Assoc 1968; 76: 548-53.

COUNTRY	NUMBER OF STUDIES
USA	32
Canada	4
Norway	4
Sweden	4
Australia	3
United Kingdom	3
Finland	2
Netherlands	1

Table 6

- 8.2.5 Whilst some studies are cross sectional, comparing different dental teams at a single point in time, many studies adopt an incremental approach. They expand dental teams with no or few PCDs by adding more PCDs, and measure changes in output. Though many of these studies are well planned quasi-experiments, only 2 tried to randomise patients and neither was entirely successful. Bentley et al¹²⁴ allowed patients scope to change treatment after randomisation. Brown et al¹²⁵ randomised practices without dental hygienists between receiving those periodontic education or not. Their comparison between practices with and without dental hygienists, more relevant to this review, was less rigorous.
- 8.2.6 Other studies are longitudinal, in the sense that they measure the output of growing teams over time. Unfortunately both quasi-experiments and longitudinal studies are open to the criticism that teams with few or many PCDs may differ in many other respects that affect productivity. Sections 8.3 and 8.4 summarise incremental studies and cross sectional studies of general PCDs and dental hygienists respectively. Interpretation of these needs to take account of potential biases.
- 8.2.7 Section 8.5 summarises studies that use computer simulation to try and overcome the potential biases of incremental studies. Whether or not they are successful in reducing bias, they are open to a second criticism – that they evaluate theoretical models of dental practice rather than practice in the real world. Section 6.6 summarises studies that use economic modelling to try and overcome bias. While this approach can overcome some of the potential biases of cross-sectional and longitudinal studies, it is still open to biases due to multi co-linearity, that is complex relationships between the many variables that affect productivity.
- 8.2.8 Only by evaluating marginal PCDs within randomised controlled trials (RCTs) can one be confident of drawing unbiased conclusions about their cost-effectiveness. The use of RCTs to evaluate medical practice has grown enormously since the founding of both the NHS R&D Programme and the Cochrane Collaboration over the past decade. Unfortunately the use of RCTs to evaluate dental practice is still rare.

¹²⁴ Bentley J M, Green P, Ship I I. *Achieving health outcomes through professional dental care: comparing the cost of dental treatment for children in three practice modes*. Health Services Research 1984; 19: 181-96.

¹²⁵ Brown L F, Keily P A, Spencer A J. *Evaluation of a continuing education intervention: periodontics in general practice*. Comm Dent Oral Epidemiol 1994b; 22: 441-7.

Indeed we found only one relevant to this chapter (See 8.2.5). Thus the conclusions of this chapter are susceptible to bias, and need careful interpretation.

- 8.2.9 Reported measures of output include gross income, numbers of patient visits and procedures, and indices like Relative Time Units (RTUs) and Relative Value Units (RVUs) – designed to adjust for the differing resource demands of different procedures. Thus many of the 53 included papers permit the (potentially biased) estimation of the marginal output of a PCD relative to the average output of a single-handed dental practice.
- 8.2.10 This review is generally too heterogeneous to permit meta-analysis (See 3.1.2). However the homogeneous measures of relative output used by many studies reviewed in this chapter encourage us to try and synthesise them through meta-analysis. If the findings show homogeneity or, failing that, consistent heterogeneity, the potential biases to which we have referred may be less marked than we feared.

8.3 Incremental and Cross Sectional Studies of General PCDs

- 8.3.1 In the prototype study in this field, Klein¹²⁶ surveyed 3,000 American dentists. From their responses he estimated that one dentist working alone could increase the patients treated by 24% by adding a second chair; by 63% by adding only a dental nurse; by 63% by adding a dental nurse as well as a chair; and by 75% by adding a dental nurse and 2 chairs. He concluded that additional dental nurses and chairs would lead to significant increases in productivity.
- 8.3.2 Baird et al showed that the addition of PCDs to an existing Canadian airforce dental team of one dentist and one dental nurse much increased productivity. The pilot study showed that the addition of a single expanded-duty dental nurse and half a dental nurse increased output¹²⁷. The main study showed that the addition of one expanded-duty dental nurse increased output by 46%, and that of one expanded-duty dental nurse, one dental nurse, one dental hygienist and 3 dental chairs increased output by 169%¹²⁸.
- 8.3.3 At the US Navy Great Lakes Training Centre, Ludwick et al⁵⁵ conducted an experiment with 3 dentists in 3 phases of 12 weeks. They showed that the average dentist with an extra expanded-duty dental nurse and an extra chair eventually treated 89% more patients than when working in a traditional team. They also showed that the average dentist with 2 extra expanded-duty dental nurses and 2 extra chairs eventually treated 112% more patients than in a traditional team.
- 8.3.4 In 2 studies of the US Indian Health Service, Abramowitz compared the marginal output of expanded-duty dental nurses with that of dental nurses. Abramowitz⁵⁷ found that 2 teams each including 2 recently trained expanded-duty dental nurses provided about 25% more topical fluorides compared with 2 teams including traditional dental nurses, but at the cost of fewer other procedures. Abramowitz & Berg⁵⁸ compared different dental teams over 4 phases of 100 days. A team comprising one dentist and 3 expanded-duty dental nurses achieved a 58% increase in Relative Time Units (RTUs) over a team comprising one dentist and 1.5 traditional

¹²⁶ Klein H. *Civilian dentistry in war-time*. J Am Dent Assoc 1944; 31: 648-61.

¹²⁷ Baird K M, Purdy C E, Protheroe D H. *Pilot study on the advanced training and employment of auxiliary dental personnel in the Royal Canadian Dental Corps: final report*. J Canad Dent Assoc 1963; 29: 778-89.

¹²⁸ Baird K M, Covey G R, Protheroe D H. *Employment of auxiliary clinical personnel in the Royal Canadian Dental Corps*. J Canad Dent Assoc 1967; 33: 184-91.

dental nurses. The cost per RTU continued to decline as the number of expanded-duty dental nurses in the team increased to 4 and 5. The authors concluded that expanded-duty dental nurses increased the number of patients that dentists could treat and decreased the cost of each.

- 8.3.5 In England Sutcliffe¹²⁹ used routine data to estimate the increased output of a School Dental Clinic when a dental therapist joined a single-handed dentist. The number of patients increased by 64%, and the number of procedures by 51%, including 79% in restorations and 29% in extractions.
- 8.3.6 Back in the USA Kilpatrick¹³⁰ reported a cross-sectional study showing that dentists saved 16% of working time by delegating to one dental nurse and 29% by delegating to 2. He concluded that dental nurses could save dentists up to 50% of working time and increase efficiency by 70%.
- 8.3.7 Lotzkar et al⁶² described the training of expanded-duty dental nurses and compared their output during training with that of dentists. In the final phase of this study Lotzkar et al⁶³ found that expanding traditional teams by 3 expanded-duty dental nurses increased output by 84%. Expansion by 4 expanded-duty dental nurses increased output by 123%. However expanded-duty dental nurses took about 40% longer than dentists to complete procedures.
- 8.3.8 Rosenblum⁶¹ estimated over 9 months that 20 experimental teams comprising one dental student, one expanded-duty dental nurse and one dental nurse completed 40% more procedures on average than 10 control teams comprising one dental student and one dental nurse. Time taken for procedures did not differ significantly between dental students and expanded-duty dental nurses. Reporting on a replica study lasting 12 months Brearley & Rosenblum⁶⁶ estimated that experimental teams saw 33% more patients on average than control practices. Analysis suggested that further gains were possible with another dental nurse.
- 8.3.9 Soricelli⁶⁴ reported that 7 months training had enabled expanded-duty dental nurses to match public dentists earning twice as much, and private dentists earning 4 times as much in output per session. By trying different skills-mixes they estimated that a team comprising one dentist, 3 expanded-duty dental nurses and 2 dental nurses could increase the numbers of surfaces restored and patient visits per session by 400% compared with a single dentist.
- 8.3.10 Heid¹³¹ reported an uncontrolled before-and-after study conducted in the US Army Dental Corps. When 12 traditional teams comprising one dentist, one dental nurse and one chair received an expanded-duty dental nurse and an additional chair they increased patient visits by 50% on average. When 3 traditional teams received 2 expanded-duty dental nurses and 2 additional chairs they increased patient visits by an average of 142%.

¹²⁹ Sutcliffe P. *Dental auxiliaries: a method of measuring their clinical usefulness*. Br Dent J 1969; 126: 418-20.

¹³⁰ Kilpatrick H C. *Production increases due to chairside assistance*. J Am Dent Assoc 1971; 82: 1367-72.

¹³¹ Heid T H. *Dental therapy assistant: effect on team productivity*. Fort Sam Houston, TX: Health Care Research Division, Academy of Health Sciences, US Army; 1973: Publication (AD) 759-139.

- 8.3.11 Pelton et al¹³² reported that the addition of one expanded-duty dental nurse and one dental nurse to a single-handed dentist with 2 existing dental nurses had increased the number of patients treated by 21%, procedures carried out by 26%, and gross income by 37%. Furthermore the dentist had spent 11% less time at the chairside. Pelton et al¹³³ then added one more expanded-duty dental nurse, making 2, and one more dental nurse, making 4 in all. They reported that this increased patients treated by a further 41% and gross income by a further 27%.
- 8.3.12 In Canada Romcke & Lewis⁶⁷ reported on the King Edward Island Dental Manpower Study. This was a prospective study in a children's clinic comprising 7 phases over 2.5 years. The addition of one dental nurse to a basic team of one dentist and one dental nurse with 2 chairs increased output measured in 'time units' by 23%. The addition of one expanded-duty dental nurse, one dental nurse and one chair to the basic team increased output by 113%. Finally the addition of 2 expanded-duty dental nurses, 2 dental nurses and 2 chairs increased output by an average of 177% compared with the basic team.
- 8.3.13 Still in Canada Curry et al¹³⁴ used a team of one dentist, 2 expanded-duty dental nurses and 3 dental nurses to treat children under 12 years in the Oxbow region of Saskatchewan. They compared team results with those in 4 other areas using traditional systems of delivering dental care, 2 with a preventative service and 2 without. Oxbow children had significantly better oral health at the end of the study. Furthermore the cost of care was much less.
- 8.3.14 Back in the USA Douglass¹³⁵ introduced expanded-duty dental nurses under laboratory conditions into 4 single-handed private teams, each with 2 existing dental nurses. He assessed their marginal output both before and after extra training. Gross income increased by 13% in each of the experimental phases. The author concluded that an extra expanded-duty dental nurse would increase productivity in private practice if dentists were willing to delegate. Douglass et al⁷¹ reported on a replica study in which each team later acquired a second expanded-duty dental nurse and a third dental nurse. Gross income increased by 12% before training, 30% after training, and 41% with the extra staff.
- 8.3.15 Redig et al¹³⁶ used a before-and-after study controlled by non-participating partners to study the effect of training dental nurses in 3 private practices to act as expanded-duty dental nurses. Gross income increased by 24% in each of 2 sub-practices that trained one dental nurse as an expanded-duty dental nurse, 33% in a sub-practice who trained 2 dental nurses, but an average of only 4% in control sub-practices. Net income increased by an average of 32% in the first 2 sub-practices and 44% in the

¹³² Pelton W J, Overstreet G A, Embry O H, Dilworth J B. *Economic implications of adding one therapist to a practice*. J Am Dent Assoc 1973a; 86: 1301-9.

¹³³ Pelton W J, Embry O H, Overstreet G A, Dilworth J B. *Economic implications of adding two expanded-duty dental assistants to a practice*. J Am Dent Assoc 1973b; 87: 604-9.

¹³⁴ Curry T M, McPhail CW B, Peacock G H, Robinson J A, Paynter K J, Thompson G W. *Saskatchewan studies with the British dental auxiliary model*. In Lucaccini LF, Handley J, eds. *Research in the use of expanded function dental auxiliaries: report of a symposium*. Bethesda, MD: US Department of Health, Education & Welfare; 1974: Publication (HRA) 75-14.

¹³⁵ Douglass C W. *Utilisation of expanded-duty dental assistants in a solo private practice*. In Lucaccini LF, Handley J, eds. *Research in the use of expanded function dental auxiliaries: report of a symposium*. Bethesda, MD: US Department of Health, Education & Welfare; 1974: Publication (HRA) 75-14.

¹³⁶ Redig D, Snyder M, Nevitt G, Tocchini J. *Expanded-duty dental auxiliaries in four private dental offices: the first year's experience*. J Am Dent Assoc 1974; 88: 969-84.

third, but an average of only 2% in the control sub-practices. The authors concluded that using expanded-duty dental nurses was economically feasible.

- 8.3.16 In another study set in a dental school (see 8.3.8), Robinson & Bradley⁷⁰ compared expanded-duty dental nurses working with dentists who had received Training in Expanded Auxiliary Management (TEAM) with dental nurses working with dentists trained in Dental Auxiliary Utilisation (DAU). TEAM patients received more procedures more quickly. The authors estimated that TEAM had resulted in a 38% increase in fee income (95% CI 15% to 60%).
- 8.3.17 In an MSc dissertation submitted to the University of London, Seal¹³⁷ analysed data from the Hampshire School Dental Service between 1967 and 1972 on the aggregated output of dentists, dental hygienists, and dental therapists. The enhanced data from 1972 showed that dental hygienists undertook 88% as many consultations as dentists, though almost all were for prevention rather than restoration. They also showed that dental therapists undertook 71% as many consultations as dentists, even though paid only 43% as much. Unfortunately none of these data relate to dental teams. This limits their value to this review.
- 8.3.18 Back in the USA Tappan & Fitch⁹⁰ reported an observational study from the Denver Neighbourhood Health Program. Expanded-duty dental nurses with 9 weeks training performed fluoride applications of the same quality as dentists and dental hygienists. The average cost per application was \$1.79 for expanded-duty dental nurses, \$2.79 for dental hygienists and \$8.13 for dentists.
- 8.3.19 Parker¹³⁸ looked at the cost-effectiveness of expanded-duty dental nurses following their wider use in the US Army following the work of Heid.¹³¹ He found more than 20 different configurations of dental teams in the 30 sites he investigated. The 17 teams with one expanded-duty dental nurse were significantly more productive on all indicators than the 89 teams without. The lowest cost per patient and per relative value unit (RVU) occurred in the team comprising one dentist, 3 expanded-duty dental nurses, one dental nurse and 3 dental chairs.
- 8.3.20 In the Netherlands, Tan and van Gemert¹³⁹ studied a traditional practice that recruited 2 expanded-duty dental nurses and added one chair for one of the 2 dentists. The quality of restorations was as good. The dentist working with expanded-duty dental nurses and a dental nurse produced 50% more restorations than the one working with only a dental nurse, but at 50% greater cost.
- 8.3.21 Davis et al¹⁴⁰ compared 8 dental students working closely with a dental nurse with 13 working alone. They found no gain in production from the addition of a dental nurse. They concluded that this failure was due to the inexperience of the dental students. They predicted that experienced dentists would gain from 4-handed dentistry.

¹³⁷ Seal E. *New Cross dental auxiliary utilisation*. London: University of London; 1974: MSc dissertation.

¹³⁸ Parker W A. *Dental therapy assistant: cost performance analysis*. Fort Sam Houston, TX: Health Care Research Division, Academy of Health Sciences, US Army; 1976: Publication (HSCD) 76-006R.

¹³⁹ Tan H H, van Gemert H G. *Time utilisation, productivity and costs of solo and extended duty auxiliary dental practice*. *Comm Dent Oral Epidemiol* 1977; 5: 151-5.

¹⁴⁰ Davis T E, Rakow B, Ponce M L, Holmes L W, Eleczko R S, Littman H. *Study of sophomores shows their use of dental auxiliaries does not increase productivity*. *Dent Stud* 1978; 56: 45-8.

- 8.3.22 Nixon⁸³ trained 4 dental nurses from 4 practices in the US Indian Health Service as expanded-duty dental nurses. All procedures except stainless steel crowns increased in number by at least 55%. Even so total production dropped in one practice.
- 8.3.23 Mullins et al⁷³ reported the results of a project to encourage 14 practices to make more use of expanded-duty dental nurses. Three out of 5 practices increased output by between 14% and 18% and net income by between 20% and 39%. They concluded that delegation could improve productivity.
- 8.3.24 Incremental studies of general PCDs in the USA were typical of the 1970s. Thereafter Sintonen¹⁴¹ used questionnaire data to study productivity across a sample of 150 Finnish public and private practices. The use of trained expanded-duty dental nurses increased output per dentist hour by 60%. The use of trained dental nurses increased output per dentist hour by 39%. Despite the danger of comparing like with unlike Sintonen concluded that the higher, though not significantly higher clinical productivity of public dentists resulted from their greater use of PCDs.

8.4 Incremental and Cross Sectional Studies in Periodontics

- 8.4.1 After Sintonen¹⁴¹ incremental studies focused on periodontics. In the only American study in this section Spencer & Webster¹⁴² collected questionnaire data from 137 (56%) of a stratified random sample of 245 general dental practices across North Carolina. Even after adjusting for confounding variables they found that the employment of dental hygienists by 101 practices was statistically associated with increased provision, not only of periodontal services, but also of restorative services and services as a whole.
- 8.4.2 In the first of 3 Australian studies Brown et al¹⁴³ used routine data to compare a random sample of practices without dental hygienists with a complete sample of practices with dental hygienists. Both samples achieved response rates close to 75%. Practices who employed dental hygienists recorded 13 of 23 periodontal procedures significantly more often than other practices. Brown et al¹²⁵ used the same practices in a partially randomised study to evaluate an educational programme in periodontics. This increased the provision of periodontal care, especially in practices with dental hygienists. More relevant to this review they found at both ends of the study that practices employing dental hygienists had more periodontal records than the rest. In an observational study Brown et al¹⁴⁴ collected data from 55% of practices approached with dental hygienists and from 40% of practices approached without dental hygienists. They reported that practices employing dental hygienists treated 46% more patients per dentist than the rest.

¹⁴¹ Sintonen H. *Comparing the productivity of public and private dentistry*. In Culyer A J, Jonsson B, eds. *Public and private health services: complementarities & conflicts*. Oxford: Blackwell: 1986: 219-34.

¹⁴² Spencer A J, Webster D. *Employment of hygienists and provision of periodontal services*. *J Dent Res* 1989; 68: 540.

¹⁴³ Brown L F, Keily P A, Spencer A J. *Hygienist employment and the presence of periodontal notations in general dental practice patient records*. *Austral Dent J* 1994a; 39: 45-9.

¹⁴⁴ Brown L F, Spencer A J, Keily P A. *Service mix in general dental practices employing and not employing dental hygienists*. *J Clin Periodontol* 1994c; 21: 684-9.

- 8.4.3 In Sweden Holst & Braune¹⁴⁵ used a small prospective cohort study to evaluate the use of 2 specially trained expanded-duty dental nurses to screen 100 children for caries. The proportion of children with no caries at 4 years was not significantly different from the county mean of 77%. Within the test team, however, dentists spent an average of 27 minutes over 3 years with each child, compared with a county mean of 60 minutes. The expanded-duty dental nurses spent an average of 71 minutes, compared with a county mean of 90 minutes. Disappointed that they had not improved performance, Holst et al¹⁴⁶ evaluated a more intensive programme to screen another cohort of 100 children. The proportion of children with no caries at 4 years rose to 93% – significantly more than the county mean of 76%. Although the test expanded-duty dental nurses were now spending 50 minutes more on average with each child than the county mean, the test dentists were still spending 28 minutes less.
- 8.4.4 In Norway Wang & Riordan²⁹ used an uncontrolled before-and-after study to evaluate the use of dental hygienists to conduct recall examinations and tailor recall intervals to individual patients. They reported that recall intervals increased from the previous norm of 12 months to an average of 17 months. They also reported an improvement in the process of dental care as measured by radiographic quality, but deterioration in health outcome as measured by the number of sound tooth surfaces recorded.

8.5 Computer Simulations and Modelling

- 8.5.1 In the 1970s computer simulations began to estimate the effect of PCDs on productivity. First Kilpatrick et al^{147,148} developed a model of private dental practice in the USA and projected the effect of introducing expanded-duty dental nurses on patient throughput and waiting time, staff utilisation, and gross and net revenue. They claimed that by employing 3 extra expanded-duty dental nurses single-handed practices could increase patient throughput by 169% and net revenue by 233%. Kilpatrick et al¹⁴⁹ later described the model in more detail.
- 8.5.2 In Britain Hobdell et al¹⁵⁰ simulated the delivery of treatment to patients in a long stay hospital for the mentally disabled, as part of the Experimental Dental Care Project (EDCAP)¹⁵¹. They calculated that the most efficient team, comprising one dentist, one dental nurse and 3 dental therapists would cost 33% less than the conventional team of one dentist and one dental nurse.

¹⁴⁵ Holst A, Braune K. *Dental assistants' ability to select caries-risk children and to prevent caries.* Swed Dent J 1994; 18: 243-9.

¹⁴⁶ Holst A, Martensson I, Laurin M. *Identification of caries-risk children & prevention of caries in pre-school children.* Swed Dent J 1997; 21: 185-91.

¹⁴⁷ Kilpatrick K E, Mackenzie R S, Delaney A G. *Expanded-function auxiliaries in general dentistry: a computer simulation.* Health Services Research 1972; 7: 288-300.

¹⁴⁸ Kilpatrick K E, Mackenzie R S. *Computer simulation model for manpower research.* In Lucaccini LF, Handley J, eds. *Research in the use of expanded function dental auxiliaries: report of a symposium.* Bethesda, MD: US Department of Health, Education & Welfare; 1974: Publication (HRA) 75-14.

¹⁴⁹ Kilpatrick K E, Mackenzie R S, Kisko T H. *Dental practice analysis using computer simulation.* J Dent Educ 1976; 40: 745-9.

¹⁵⁰ Hobdell M H, Burt B A, Longhurst P. *A method of planning a dental treatment program for an institutionalised population.* Comm Dent Oral Epidemiol 1975a; 3: 166-73.

¹⁵¹ Allred H, Hobdell M. *Current experiments in delivery of dental services.* Int Dent J 1974; 24: 457-66.

- 8.5.3 Back in the USA Lipscomb & Scheffler¹⁵² used a data-based model to estimate that adding an expanded-duty dental nurse increased net revenue by between 71% and 169% depending on the number of dentists in the practice. They concluded that a dentist working single-handed in private practice could double revenue by employing an expanded-duty dental nurse. However a second expanded-duty dental nurse would not increase productivity. In a validation based on one practice with 4 dentists who added one expanded-duty dental nurse, the actual increase was only half what the model predicted.
- 8.5.4 Marcus et al¹⁵³ used simulation to extrapolate data from patient records in 3 practices over 4 weeks. By comparing actual output across practices they estimated that delegation to expanded-duty dental nurses and dental hygienists reduced costs. However they recognised that this conclusion was sensitive to variability in times taken by different workers to perform the same procedure. So they recommended a more rigorous analysis of productivity.
- 8.5.5 Mityr et al¹⁵⁴ showed that a complex form of production function fitted data from the Louisville expanded-duty dental nurse experiment (Lotzkar et al^{62,63}). They deduced that one extra expanded-duty dental nurse would increase relative productivity units (RPU) per day by 36% and another expanded-duty dental nurse would add another 28%. They concluded that the return on investment was nearly constant.
- 8.5.6 Overstreet et al¹⁵⁵ used a controlled before-and-after study supported by computer simulation to estimate the optimum skills-mix for expanded-duty dental nurses. They measured productivity over 11 months in 4 teams who acquired expanded-duty dental nurses in different configurations. Adding one expanded-duty dental nurse to a control team of one dentist and 2 dental nurses increased net income by 62% and the number of and patients seen and procedures by about 50%. Extra expanded-duty dental nurses or dental nurses did not improve net income.
- 8.5.7 Mullins et al⁷³ used simulation to extrapolate the findings of a before-and-after study in which 2 expanded-duty dental nurses joined separate single-handed dentists already supported by dental nurses. They calculated that the most efficient team was one dentist, one dental nurse and 2 expanded-duty dental nurses together using 3 chairs. However the estimated increase was only 36% in gross income and 19% in net income.

8.6 Economic Modelling

- 8.6.1 Several studies have studied productivity through complex economic models based on routine data. Feldstein¹⁵⁶ based his analysis of dental care on routine surveys from 1950 until 1970. As baseline he took the gross income of dentists without PCDs in 1970. He estimated that one PCD would increase this by 33%, 2 by 92%, 3 by

¹⁵² Lipscomb J, Scheffler R M. *Impact of expanded-duty assistants on cost and productivity in dental care delivery*. Health Services Research 1975; 10: 14-35.

¹⁵³ Marcus M, Van Baelen A, Forsythe A, Bleich D. *Dental productivity: a perspective*. Inquiry 1975; 12: 204-15.

¹⁵⁴ Mityr D J, Johnson K, Mityr N W. *Specification of the production function for dentistry: measurement and paraprofessional input*. Inquiry 1976; 13: 152-7.

¹⁵⁵ Overstreet G A, Dilworth J B, Legler D W. *Productivity and economic implication of a simulated practice using expanded-duty dental assistants*. Comm Dent Oral Epidemiol 1978; 6: 233-9.

¹⁵⁶ Feldstein P.J. *Financing dental care: an economic analysis*. Lexington, MA: Lexington Books; 1973.

161%, and 4 by 218%. Though he did not discuss types and functions of PCDs, he concluded that they could achieve substantial increases in output.

- 8.6.2 Using data from a US national survey in 1967-70 Scheffler & Kushman¹⁵⁷ estimated the Cobb-Douglas production function of single-handed dentists. Cobb-Douglas production functions are econometric equations that regress the logarithm of the output variable on a linear function of the input variables. They estimated the net marginal revenue products for dentists, dental nurses, dental hygienists and dental technicians in terms of wage rates. Subsequently Kushman et al¹⁵⁸ used the rest of the same data set to estimate the production function in practices of more than one dentist. They explored whether there were increasing returns to size, and what effect revenue-sharing had on productivity. Both studies concluded that PCDs increased productivity.
- 8.6.3 In Sweden Klock¹⁵⁹ compared the costs and benefits of a trial programme in which expanded-duty dental nurses provided preventive measures for children for 2 years. The average cost per child per year was 280K (Swedish Krona) in the trial clinic, and 340K in regular clinics. However traditional therapeutic care was less expensive than either form of preventive care.
- 8.6.4 Back in the USA Bentley et al¹²⁴ randomised children across an entire county between private dentists in the community and public dentists supported either by one dental nurse or by one dental nurse and 2 expanded-duty dental nurses. Over 2 years they found that using expanded-duty dental nurses supported public practice was 9% less expensive per patient than regular public practice but delivered 4% fewer Relative Value Units (RVUs). Although private practice was cheaper still, less treatment was given, and analysis of covariance could not draw useful conclusions about cost-effectiveness for lack of data about skills-mix in private practice.
- 8.6.5 Nordengen et al¹⁶⁰ considered extending the duties of dental hygienists. They estimated that, if dental hygienists undertook examinations and sealing fissures as effectively as dentists, Norway would need 98 to 175 fewer dentists and correspondingly more dental hygienists. If dental hygienists also undertook local anaesthesia and restorations as effectively as dentists, Norway would need 138 to 225 extra dental hygienists with a corresponding reduction in dentists. This would save some 40 million K (Norwegian Krona) per year – 6% of the cost of the Public Dental Health Service.
- 8.6.6 In Finland Utriainen & Widstrom¹⁶¹ assessed the effectiveness, output and costs of dental care in 34 health centres across Finland from 1982 until 1985. They used regression analysis to model the relationship between these factors. They found a statistically significant positive correlation between cost per visit and the ratio of dental nurses to dentists. In other words productivity fell as the number of PCDs

¹⁵⁷ Scheffler R M, Kushman J E. *A production function for dental services: estimation and economic implications*. *Southern Economic Journal* 1977; 44: 25-35.

¹⁵⁸ Kushman J E, Scheffler R M, Miners L, Mueller C. *Nonsolo dental practice: incentives and returns to size*. *J Economics and Business* 1978; 31: 29-39.

¹⁵⁹ Klock B. *Economic aspects of a caries preventive program*. *Comm Dent Oral Epidemiol* 1980; 8: 97-102.

¹⁶⁰ Nordengen R E, Fylkesnes K, Sogaard A J. *Increasing effectiveness of dental health care services: could funds be saved by increased delegation to dental hygienists?* *Norske Tannlegeforenings Tidende* 1990; 100: 152-8.

¹⁶¹ Utriainen P, Widstrom E. *Economic aspects of dental care in Finnish health centres*. *Comm Dent Oral Epidemiol* 1990; 18: 235-8.

rose. However the authors had to analyse by health centres rather than patients. So this unexpected finding could be a statistical artefact of complex relationships between economic variables at health centre level. Alternatively it could reflect over provision if the typical difference was between one dental nurse to 2 rather between none and one.

- 8.6.7 Wang¹⁶² collected data from 137 (71%) of the 194 child dental clinics in Norway. She used these data to look at PCD inputs and outputs. She reported that the total treatment time per child was longer in clinics with dental hygienists, because the increase in dental hygienist time exceeded the saving in dentist time. The average time spent by dentists per child was also less in clinics with more dental nurses. Wang¹⁶³ used the same data to estimate a Cobb-Douglas production function linking dental inputs to outputs. The marginal productivity of dentist time was 0.61 in clinics with dental hygienists, but 0.58 in clinics without. The average time spent by dentists per child was 1.26 in clinics with dental hygienists, but 1.48 in clinics without. Wang concluded that the greater use of dental hygienists would save dentist time, and could also reduce costs given more delegation.
- 8.6.8 Hannerz & Westerberg¹⁶⁴ used a cohort study to compare the conventional model of service in the Swedish public health service of 2 dentists and 4 dental nurses with a trial team of one dentist and 5 dental hygienists. The trial team achieved an average 5-year caries incidence of 1.13 decayed, missing or filled teeth compared with 3.29 in the control team. The authors estimated that the benefits of the trial team were worth 546K per patient but cost only 369K, thus yielding a benefit-cost ratio of 1.48.

8.7 Quantitative Synthesis of Findings

8.7.1 The 53 papers reviewed in 8.3 to 8.6 vary enormously in design and scope. Unfortunately their quality varies less as it rarely exceeds mediocre. For example neither of the 2 randomised trials rigorously allocated patients to different combinations of PCDs (8.2.5). Intervention and control are not comparable in many studies; many of the “incremental and cross sectional” designs are uncontrolled before-and-after studies or non randomised cross sectional studies; few studies report variability adequately; and models and simulations are rarely tested adequately on real data. In qualitative terms studies consistently report that PCDs improve the output of dentists. However this conclusion is too vague to be of value in dental health policy. Fortunately the statistical technique of meta-analysis can provide quantitative syntheses when applied to subsets that are homogeneous or consistently heterogeneous.

8.7.2 In seeking homogeneous studies we focus on 3 subsets:

- Studies that compare dental practices with no expanded-duty dental nurse and similar practices with one expanded-duty dental nurse, for example practices with one dentist and one dental nurse versus practices with one dentist, one dental nurse and one expanded-duty dental nurse. (Subset A)

¹⁶² Wang N J. *Productivity in dental care for children: factors influencing the time spent delivering dental care*. *Comm Dent Health* 1994a; 11: 227-32.

¹⁶³ Wang N J. *Use of dental hygienists & returns to scale in child dental care in Norway*. *Comm Dent Oral Epidemiol* 1994b; 22: 409-14.

¹⁶⁴ Hannerz H, Westerberg I. *Economic assessment of a six-year project with extensive use of dental hygienists in the dental care of children: a pilot study*. *Comm Dent Health* 1996; 13: 40-3.

- Studies comparing practices with no dental nurse and similar practices with a dental nurse. (Subset B)
 - Studies comparing practices with no dental hygienist and similar practices with a dental hygienist. (Subset C)
- 8.7.3 Sections 8.3 and 8.4 include many such studies. However economic theory suggests that in a given practice the marginal productivity of the second PCD will be less than that of the first such PCD. To avoid underestimating the marginal productivity of the first PCD, we therefore begin with studies that focus on single-handed practices and compare one PCD per dentist with none. In particular we eschew studies that estimate the extra output of more than one expanded-duty dental nurse. We also discard studies that directly compare expanded-duty dental nurses with dentists. Fortunately several studies in Sections 8.5 and 8.6 generate unified models of the extra output of a single PCD per dentist. We therefore add these to the relevant subsets.
- 8.7.4 Of the 53 initial studies only 17 fall into these subsets. Twelve fall into A alone, Kilpatrick¹³⁰ and Wang¹⁶³ into B alone, Sintonen¹⁴¹ into both A and B, and Scheffler & Kushman¹⁵⁷ and Kushman et al¹⁵⁸ into both B and C. Of these Sutcliffe¹²⁹ and Romcke & Lewis⁶⁷ in subset A used only one (main) practice, and thus could not estimate inter-practice variation. Another 3 papers – Baird et al¹²⁸, Feldstein¹⁵⁶ and Mitry et al¹⁵⁴ – did not report how many practices they studied, thus hindering us from using them in meta-analysis. So, although we can use 17 studies to estimate unweighted marginal output, we can use only 12 for weighted estimates or meta-analyses.
- 8.7.5 Even in these 12 analysable studies there is a choice of sample sizes – the number of practitioners (dentists or PCDs) or the number of observations (patient visits or procedures). Some studies used only a few dentists but collected data on many patient visits. Others collected only summary statistics for each dentist. Given this variation between studies we choose the ‘lowest common denominator’ and analyse by dentist rather than patient.
- 8.7.6 Having chosen to analyse by dentist we have 3 methods of weighting and summarising marginal output (each qualified by a confidence interval):
- Unweighted average (ignoring sample size) – though simple this gives too much weight to small, potentially very biased, studies (unavoidable when studies do not report the number of dentists – 8.7.3).
 - Average weighted by number of dentists – this gives too much weight to large studies. As 2 papers (Scheffler & Kushman¹⁵⁷, Kushman et al¹⁵⁸) report on 2 independent substudies of the same very large study, their findings dominate these analyses.
 - Average weighted by square root of the number of dentists – a potential compromise between the two previous methods.
- 8.7.7 In principle meta-analysis is more rigorous than weighted averages. We used the statistical package Stats Direct to fit both fixed effect and random effect models, and tested whether they provided a good fit to the eligible studies. If so we derived pooled estimates and confidence intervals for the marginal output of PCDs. However the available measures of output are quantitative rather than qualitative. Meta-analysis therefore requires an estimate of the standard deviation of marginal output between dentists within each study. Unfortunately only one of the 15 studies (Heid¹³¹) provides dentist-specific means from which one can estimate these

standard deviations. In these circumstances we can undertake meta-analysis only by assuming equal variation within all studies. So the resulting estimates are only approximate. Indeed they are not necessarily better than weighted estimates.

8.7.8 The 17 studies in subsets A, B and C all measure output per unit of time, typically one week, by one or more of 5 measures – gross income, Relative Value Units (RVUs), and numbers of patient visits, procedures, or completed courses of treatment. Where papers report on many of these, we analyse RVUs or, failing those, patient visits. To derive a single dimensionless variable applicable to all types of output, we convert these to percentage increases over the baseline output before the addition of the relevant PCD.

8.7.9 Table 7 summarises the meta-analysis of subset A, which estimates the percentage increase in output from adding a single expanded-duty dental nurse to a single-handed dental practice previously without an expanded-duty dental nurse. The associated tests of homogeneity show that the 8 studies are very heterogeneous. So the fixed effects model is not valid. We therefore consider the random effects model.

**Percentage Increase in Output from Marginal Expanded-Duty Dental Nurse:
Meta-Analysis**

First Author, (Date, Country)	Number of Dentists		Percentage Increase	Approximate 95% Confidence Interval for %Increase	
	Experim'l	Control			
Rosenblum (1971, USA) ⁶¹	20	10	39.9	35.2	44.6
Brearley (1972, USA) ⁶⁶	20	10	33.3	28.6	38.0
Heid (1973, USA) ¹³¹	12	12	50.2	45.2	55.2
Douglass (1974, USA) ¹³⁵	4	4	27.1	18.5	35.7
Douglass (1976, USA) ⁷¹	4	4	29.8	21.2	38.4
Parker (1976, USA) ¹³⁸	17	89	65.5	62.3	68.7
Overstreet (1978, USA) ¹⁵⁵	4	4	59.4	50.8	68.0
Sintonen (1986, Finland) ¹⁴¹	10	81	60.0	55.9	64.1
Dersimonian-Laird Pooled Weighted Mean Difference			45.8	35.4	56.2

Test of Homogeneity: Q (chi-squared distribution with 7 degrees of freedom) = 227 (P < 0.0001)

Significance test: DerSimonian-Laird (chi-squared with 1 degree of freedom) = 75 (P < 0.0001)

Table 7

8.7.10 Figure 2 is a 'Cochrane plot' often called a forest plot displaying the random effects model with a confidence interval for each study. It confirms that variation between studies is larger than variation within studies, though not disastrously so.

Marginal EDDN: Cochrane Plot of Effect Sizes – Random Effects Model

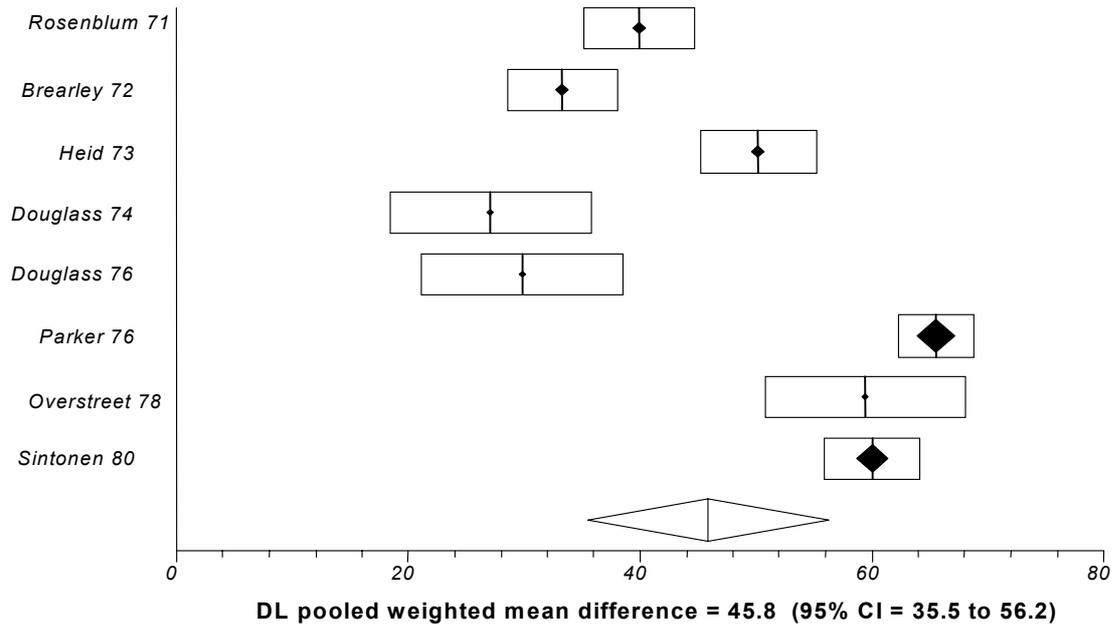


Figure 2

8.7.11 Figure 3 plots the effect sizes of the 8 studies against the reciprocals of the numbers of dentists they included. If the random effects model were a very good fit to these studies, this plot would take the form of an inverted funnel. Although Figure 3 is hardly that, it shows enough consistency to support this model. In particular the estimated effect sizes in the 3 smaller studies are slightly less than those in the 5 larger studies. Thus publication bias is unlikely to be a major problem. So we have some confidence in the estimated pooled weighted mean difference (WMD) of Table 7.

Marginal EDDN: Funnel Plot for Detecting Bias in Meta-Analysis

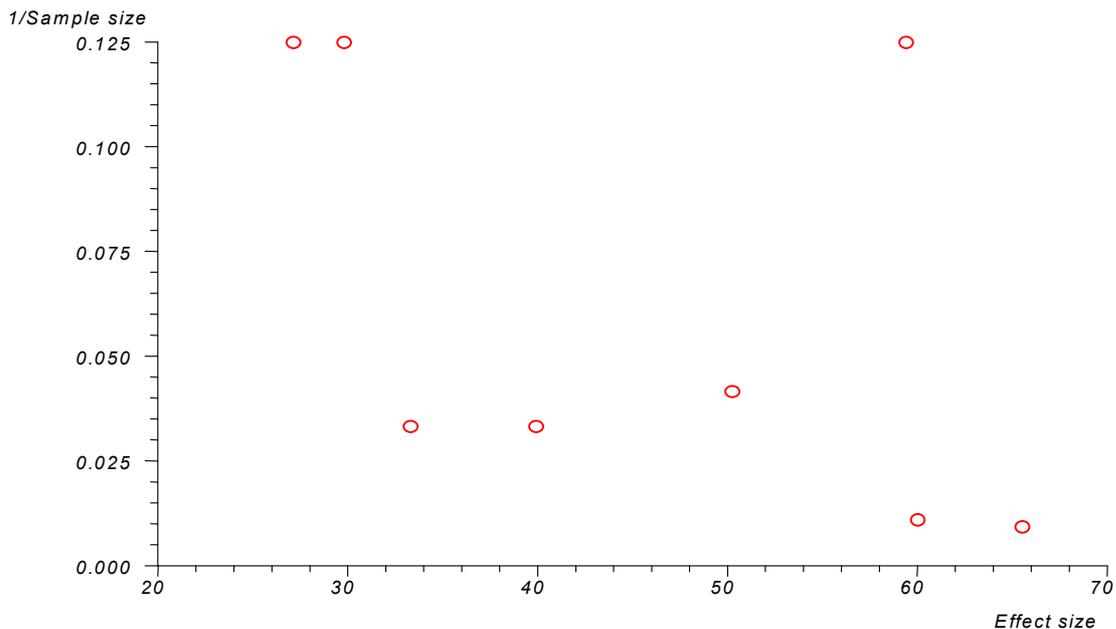


Figure 3

8.7.12 Table 8 summarises the meta-analysis of subset B, which estimates the percentage increase in output from adding a single dental nurse to a single-handed dental practice previously without a dental nurse. The tests of homogeneity both show that 5 studies are very heterogeneous. So the fixed effects model is not valid, and we consider the random effects model.

Percentage Increase In Output From Marginal Dental Nurse: Meta-Analysis

First ^t Author, (Date, Country)	Number of Dentists		Percentage increase	Approximate 95% Confidence Interval for % Increase	
	Experim'l	Control			
Kilpatrick (1971, USA) ¹³⁰	6	6	16.0	8.9	23.1
Scheffler (1977, USA) ¹⁵⁷	14,658	14,658	13.1	13.0	13.2
Kushman (1978, USA) ¹⁵⁸	2,595	1,385	10.8	10.4	11.2
Sintonen (1986, Finland) ¹⁴¹	52	39	30.9	28.3	33.5
Wang (1994b, Norway) ¹⁶³	68	69	19.3	17.2	21.4
Dersimonian-Laird Pooled Weighted Mean Difference			17.7	15.0	20.4

Test of Homogeneity: Q (chi-squared distribution with 4 degrees of freedom) = 332 (P < 0.0001)
 Significance test: DerSimonian-Laird (chi-squared with 1 degree of freedom) = 170 (P < 0.0001)

Table 8

8.7.13 Figure 4 is a 'Cochrane plot' displaying the random effects model with a confidence interval for each study. It confirms that variation between studies is larger than variation within studies, though not disastrously so. Of more concern is that 2 enormous linked studies with similar estimates dominate the WMD. If these are not representative, the WMD may suffer from bias and its confidence interval may be too narrow.

Marginal DN: Cochrane plot of effect sizes – random effects model

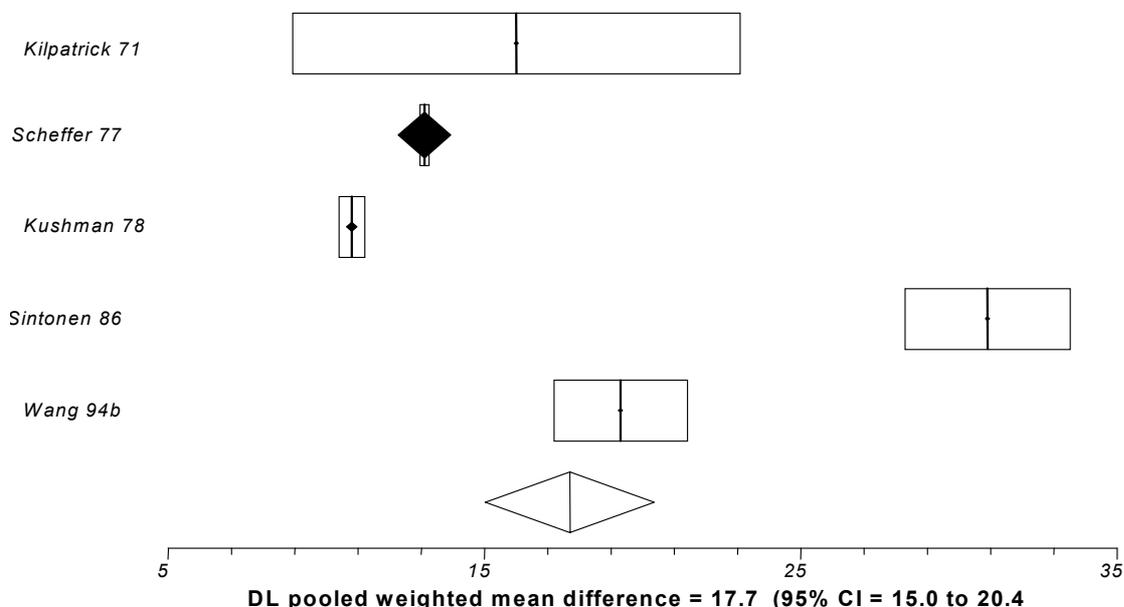


Figure 4

8.7.14 Figure 5 plots the effect size against the reciprocal of the number of dentists included in each study. If the random effects model were a very good fit, this plot would take

the form of an inverted funnel. Figure 5 is not that. Furthermore the estimated effect sizes are larger in the 3 smaller studies than in the 2 larger studies. Thus publication bias is a danger and we must treat the estimated WMD in Table 8 with caution.

Marginal DN: Funnel Plot for Detecting Bias in Meta-Analysis

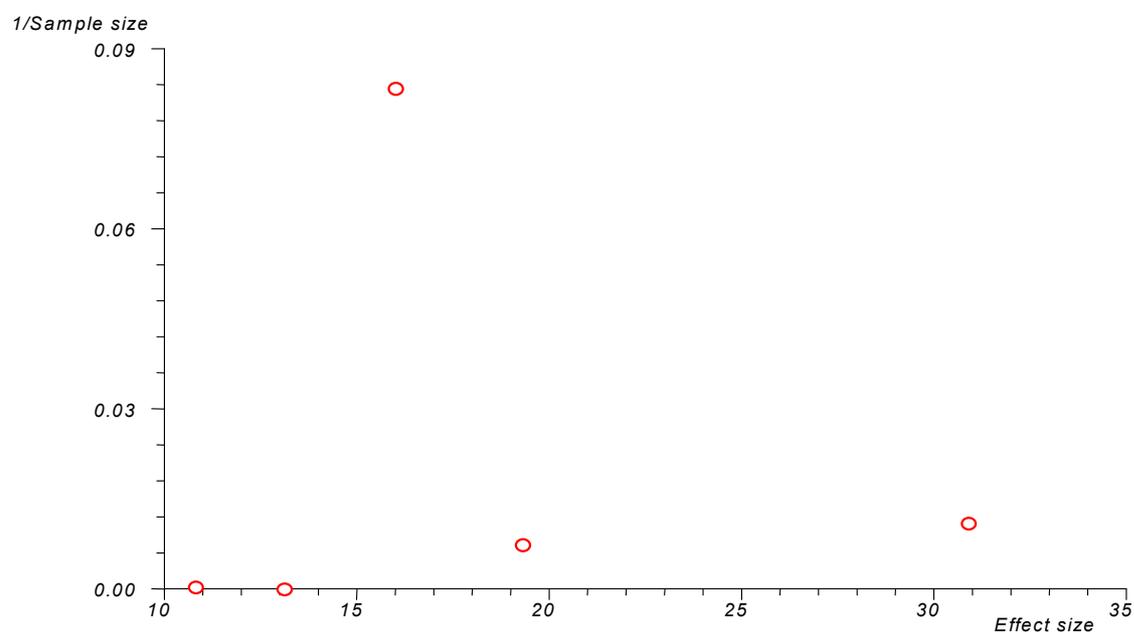


Figure 5

8.7.15 Table 9 summarises the meta-analysis of subset C, which estimates the percentage increase in output from adding a single dental hygienist to a single-handed dental practice previously without an dental hygienist. Of major concern is that the 2 enormous linked studies that dominated Table 8 now have no other studies to ameliorate them. Furthermore they now have very dissimilar estimates, even though they stem from complementary subsets of the same national data set. So the estimated WMD of Table 9 has a very wide confidence interval. Thus it gives little confidence.

Percentage Increase In Output From Marginal Dental Hygienist: Meta-Analysis

Author (Date, Country)	Number of Dentists		Percentage increase	Approximate 95% Confidence Interval for % Increase	
	Experim'l	Control			
Scheffler (1977, USA) ¹⁵⁷	7,330	21,986	25.1	24.9	25.3
Kushman (1978, USA) ¹⁵⁸	617	3,363	47.9	47.4	48.4
Dersimonian-Laird Pooled Weighted Mean Difference			36.5	14.2	58.8

Table 9

8.7.16 Table 10 summarises the findings of the 3 meta-analyses and 4 studies not eligible for meta-analysis. The first row shows that the random effects estimate of the mean increase in output from a marginal expanded-duty dental nurse (45.8%) is close to the unweighted estimate (48.9%). Furthermore the corresponding confidence intervals (35.4% to 56.2% and 38.0% to 59.9% respectively) are also very similar.

Since the unweighted analysis includes 3 studies not eligible for the random effects analysis, this provides further support for the model displayed in Figure 2.

Percentage Increase in Output from Marginal PCD: Estimates from Meta-Analysis, Weighted and Unweighted Analyses

Source of Estimate	Random Effects Model	Unweighted	Weighted (\sqrt{N} Dentists)	Weighted (Dentists)	Comment
PCD Type	Mean % Increase in Output (# of Studies) [Confidence Interval]				
EDDN	45.8% (8) [35.4, 56.2]	48.9% (11) [38.0, 59.9]	51.1% (8) [46.9, 55.3]	54.9% (8) [53.5, 56.3]	Random effects model supported by funnel plot and unweighted estimate
DN	17.7% (5) [15.0, 20.4]	18.0% (6) [10.6, 25.4]	13.5% (5) [13.0, 13.9]	12.86% (5) [12.85, 12.88]	Unweighted estimate best of 4 poor estimates, because 2 very large studies yield similar estimates
DH	36.5% (2) [14.2, 58.8]	35.7% (3) [7.2, 64.2]	31.6% (2) [30.3, 32.9]	28.2 % (2) [28.1, 28.3]	Unweighted estimate best of 4 poor estimates, because 2 very large studies yield different estimates

Table 10

8.7.17 We conclude that the addition of an expanded-duty dental nurse to a practice without an expanded-duty dental nurse increases output by 46% with a 95% confidence interval extending from 35% to 56%. Although this conclusion comes from a meta-analysis showing evidence of consistency across 8 studies, the main caveat is that 7 of them report on the USA in the 1970s.

8.7.18 The smaller subsets B and C estimate the percentage increase in output from adding a single dental nurse or a single dental hygienist respectively to a dental practice previously without one or the other. The first includes 2 complementary sub-studies of the same national data set (Scheffler & Kushman¹⁵⁷, Kushman et al¹⁵⁸) and the second comprises those 2 sub-studies. As a result meta-analysis is much less conclusive for subset B than for subset A, and meaningless for subset C.

8.7.19 In particular the last 2 rows of Table 10 show very different confidence intervals for the marginal output of dental nurses and dental hygienists. The reason is that Scheffler & Kushman¹⁵⁷ and Kushman et al¹⁵⁸ yield very similar estimates for the marginal output of a dental nurse, but very different estimates for that of a dental hygienist. In these circumstances the unweighted estimate seems prudent for dental nurses and dental hygienists because it has wider confidence intervals than the random effects estimate, but similar means. Thus we estimate very tentatively that the addition of a dental nurse to a practice without a dental nurse increases output by 18% with a 95% confidence interval extending from 11% to 35%. Equally tentatively the addition of a dental hygienist to a practice without a dental hygienist increases output by 36% with a 95% confidence interval extending from 7% to 64%.

8.8 Discussion

8.8.1 Our meta-analyses have yielded estimates of the marginal output of 3 types of PCD. Our confidence in the expanded-duty dental nurse estimate (See 8.7.16) is much

higher than in the dental nurse and dental hygienist estimate (See 8.7.18). It seems that the job description of an expanded-duty dental nurse may have intrinsic qualities that remain consistent, though not homogeneous, over times and places.

- 8.8.2 In contrast we could not derive coherent estimates of the marginal cost, still less the marginal productivity, of these PCDs from the 53 studies. The likely explanation is that the financing of health care in general, and dental health care in particular, varies even more widely by time and place. So it may be worth illustrating how to use our estimate of the generic marginal outputs of expanded-duty dental nurses to explore their marginal cost-effectiveness in the UK. Suppose a typical single-handed practice earns £100,000 a year. Table 7 estimates that the addition of one expanded-duty dental nurse would increase this to £146,000, with 95% confidence interval from £135,000 to £156,000. We believe that the marginal cost of employing an expanded-duty dental nurse in an existing practice is probably less than £35,000 and certainly less than £46,000. If so then the employment of an expanded-duty dental nurse would be cost-effective. To confirm this calculation, however, needs valid and reliable data on the operation of dental health care in the UK.
- 8.8.3 The conclusions of this section stem from 3 analyses of 17 studies. None of these is a randomised trial. None is British. Though the studies relating to expanded-duty dental nurses show some consistency, we have much less confidence in those relating to dental nurses and dental hygienists. Hence there is a need for rigorous studies of the marginal productivity of PCDs, especially in the UK.

9. SUMMARY OF FINDINGS

- 9.1 The studies included in the review were not only poor, but also old. They start in the 1960s. More come from the 1970s than from other decades. (See Figure 11). Studies about diagnosis and health promotion include more from the 1990s. Few of these studies come from the UK. There is a need for rigorous British studies to improve the evidence about effectiveness and cost-effectiveness of PCDs. Over the past forty years dental practice, equipment and materials, and the roles of PCDs, and attitudes to them, have all changed. Fortunately, despite the poor quality and the age of these studies, the evidence is remarkably consistent in time and space.

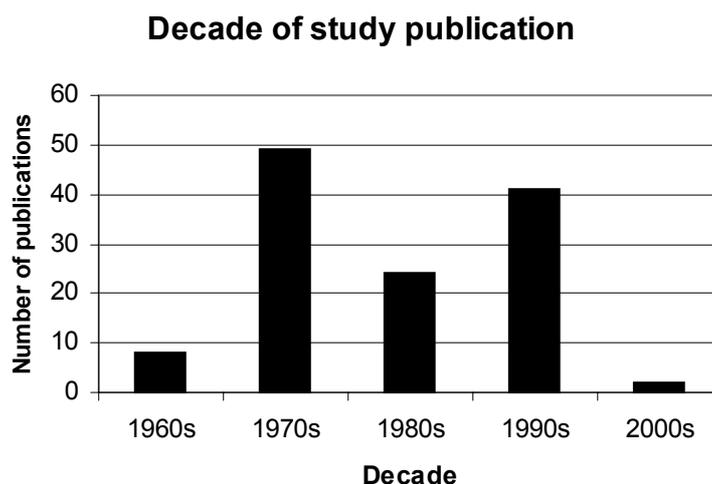


Figure 6

- 9.2 The variation in nomenclature associated with different types of PCDs has made the task of comparing these studies particularly difficult. While standardisation of the terminology associated with this field is likely to be difficult clear descriptions of their training, accreditation and normal duties of PCDs should be provided in studies in this area.
- 9.3 Considering each of the 5 main themes
- 9.3.1 **Diagnosis** (26-studies)

There is a consensus that PCDs with appropriate training can perform screening and diagnosis to a level similar to that of a dentist. Only 2 papers disagreed with this assessment. One by Hawley et al³⁴ compared the effectiveness of screening by a single dentist and hygienist. They found that 62% of children were referred by the standard examiner and the dentist but only 27% by the dental hygienist. The other paper by Kwan & Prendergast³¹ showed there was good agreement on caries diagnosis for 5-year-olds, but not for 12-year-olds. Further well-designed larger scale studies are required to confirm this view and also to determine the level of training needed for them to carry out the various tasks.

- 9.3.2 **Technical Competence** (41-studies)

With the exception of one study⁹¹ comparing the retention of fissure sealants between dentists and dental hygienists PCDs performed a wide range of technical procedures to the same quality as dentists.

9.3.3 Oral Health Promotion (10-studies)

The level of training required to attain these standards ranged from weeks to years but rarely was any indication the content of the training detailed in the studies. Consequently there is a need for research into the training requirements required for PCDs.

9.3.4 Acceptability (13-studies)

Overall the studies suggest that patients find having work conducted by PCDs is acceptable. However none of the included studies addresses the attitude of the dentist to working with or employment of PCDs.

9.3.5 Productivity (53-studies)

The aim here was modified from the broad initial one to a more focussed one following a qualitative review of the included studies. The new objective being – to estimate the average increase in output achieved by introducing one expanded-duty dental nurse (EDDN), one regular dental nurse (DN) or one dental hygienist (DH) to a single-handed dental practice previously without the specified professional complementary to dentistry (PCD).

Expanded-Duty Dental Nurses: Meta-analysis showing evidence of consistency across 8 studies (7 of them from the USA in the 1970s!) estimates that the addition of an expanded-duty dental nurse to a single-handed dental practice previously without an expanded-duty dental nurse increases output by 46% with a 95% confidence interval (CI) from 35% to 58% (Paragraph 8.7.17).

Dental Nurses: Meta-analysis of 5 studies from 3 countries, dominated by 2 enormous American studies in the 1970s with similar findings, estimates very tentatively that the addition of a DN to a single-handed dental practice previously without a DN increases output by 18% with a 95% CI from 11% to 25%. (See 8.7.19).

Dental Hygienists: Meta-analysis of the same 2 enormous American studies, now with dissimilar findings, estimates very tentatively that the addition of a dental hygienist to a single-handed dental practice previously without a dental hygienist increases output by 36% with a 95% CI from 7% to 64% (See 8.7.19).

The evidence from 17 studies from 4 countries outwith the UK suggests that, added to a typical single-handed dental practice, a marginal expanded-duty dental nurse would increase output by at least 35%. We believe this exceeds the marginal cost of employing an expanded-duty dental nurse. To derive the marginal productivity of British expanded-duty dental nurses from this global estimate of marginal output would be relatively easy and useful to policy-makers (See 8.8.2).

9.3.6 Overall the evidence from each of the 5 main themes suggests that PCDs:

- can diagnose and screen as effectively as dentists
- carry out a range of dental procedures to the same level of technical competence as dentists

- can conduct oral health promotion activities
- are acceptable to patients
- evidence also suggests that they can increase the productivity of single-handed practice.

While the level and quality of the evidence is low it is remarkably consistent in time and space.

10. RECOMMENDATIONS

- 10.1 The NHS needs more and better research into the effectiveness of PCDs.
- 10.2 The NHS also needs research into the economics of PCDs, in particular the most cost-effective ratio of PCDs (excluding dental nurses) to dentists.
- 10.3 The NHS also needs research into the optimal type and length of training for PCDs.
- 10.4 Unless results of this new research contradict the conclusions of this review, the UK needs to give serious consideration to increasing the ratio of PCDs (excluding basic dental nurses) to dentists from its current level of one to 6, so that it is much closer to one to one.

Electronic Search Strategy: Medline (1966-1998):

Key to abbreviations and symbols used for searching

/	all subheadings are to be searched	33.	dental technicians.sh.
\$, #	is the truncation symbol	34.	dental trainee\$.tw.
adj4	within 4 words	35.	skill mix adj4 dent\$.tw.
exp	explode the search term (ie include all narrower terms in the search)	36.	allied health personnel.sh.
exp*	explode and restrict to focus	37.	dental therap\$.tw.
.tw	denotes words in any of the text	38.	dental nurs\$.tw.
.ti	denotes words in the title	39.	dental prof\$.tw.
sh	denotes MESH headings	40.	denturis\$.tw.
1.	randomised controlled trial. pt.	41.	dent\$ team.tw.
2.	randomised controlled trials.sh.	42.	dent\$ workforce.tw.
3.	random allocation.sh.	43.	expanded-function auxiliar\$.tw.
4.	double blind method.sh.	44.	expanded-function dental hygienist\$.tw.
5.	single blind method.sh.	45.	expanded-duty assistan\$.tw.
6.	1 or 2 or 3 or 4 or 5	46.	expanded-duty auxiliar\$.tw.
7.	animal.sh.	47.	advanced skills hygienist.tw.
8.	human.sh.	48.	allied dental personnel.tw.
9.	7 not (7 and 8)	49.	chairside personnel.tw.
10.	6 not 9	50.	chairside auxiliar\$.tw.
11.	clinical trial.pt.	51.	chairside assistan\$.tw.
12.	exp clinical trials/	52.	four handed dentistry.tw.
13.	(clin\$ adj3 trial\$.ti,ab.	53.	six handed dentistry.tw.
14.	((singl\$ or doubl\$ or treb\$ or tripl\$) adj3 (blind\$ or mask\$)).ti,ab.	54.	clinical dental technician.tw.
15.	placebos.sh.	55.	clinical maxillo-facial technician.tw.
16.	placebo\$.ti,ab.	56.	maxillo-facial technician.tw.
17.	random.ti,ab.	57.	orthodontic auxiliary.tw.
18.	research design.sh.	58.	30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57
19.	11 or 12 or 13 or 14 or 15 or 16 or 17 or 18	59.	New Zealand.tw.
20.	19 not 9	60.	South Africa.tw.
21.	20 not 10	61.	59 or 60
22.	comparative study.sh.	62.	dent\$.tw.
23.	exp evaluation studies/	63.	61 and 62
24.	follow-up studies.sh.	64.	63 or 58
25.	prospective studies.sh.	65.	64 and (10 or 21 or 29)
26.	(control\$ or prospectiv\$ or volunteer\$.ti,ab.	66.	64 not 65
27.	21 or 22 or 23 or 24 or 25 or 26		
28.	27 not 9		
29.	28 not (10 or 21)		
30.	dental auxiliaries.sh.		
31.	dental hygienists.sh.		
32.	dental assistants.sh.		

Anon (1967)	x							2
Anon (1971)			x					3
Anon (1985)		x						4
Abernathy (1987)		x						6
Abramowitz (1971)					x			8
Abramowitz (1972)			x					9
Abramowitz and Mecklenburg (1972)		x						11
Abrams (1997)					x			12
Aker (1972)						x		14
Allen (1986)				x				15
Allred (1977)					x			16
Allred (1977) WHO					x			17
Allred (1973)					x			19
Arnold (1969)			x					20
Axelsson (1974)				x				21
Axelsson (1975)				x				22
Axelsson (1977)				x				23
Axelsson (1978)						x		24
Axelsson (1976)				x				26
Axelsson (1993)					x			27
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Bader (1984)				x				29
Baderstein (1975)				x				32
Bailit (1982)			x					33
Baird (1962)					x			36
Baker (1995)	Baker (1995)	x						37
Baltutis (1998)			x					38
Balzer (1980)					x			39
Banks (1994)				x				40
Barata (1993)				x				41
Barker (1995)				x				42
Barnes (1975)						x		43
Barr (1980)					x			44
Barrett (1999)					x			45
Barwise (1922)					x			46
Bean (1969)	Bean (1969)	x						47
Beautrais (1982)		x						48
Beck (1967)				x				49

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Berger (1976)			x					55
Berman (1969)						x		57
Bethart (1972)						x		58
Binder (1967)			x					59
Birn (1990)						x		60
Birn (1989)				x				61
Blau (1973)			x					62
Blomgren (1991)		x						64
Bombert (1985)							x	65
Boyer (1990)				x				66
Boyer (1996)						x		67
Brown (1994)							x	69
Brown (1978)			x					70
Brown (1996)		x						71
Brown (1967)			x					75
Bryn (1971)				x				76
Burman (1987)						x		78
Burt, CDOE (1977)		x						79
Burt, JPHD (1977)		x						80
Burt (1998)		x						81
Calderone (1983)				x				82
Campbell (1993)				x				83
Carlsson Int.J.P (1998)							x	84
Carlsson CDOE (1988)				x				85
Cecchini (1986)							x	87
Chambers (1996)				x				88
Chapko (1991)				x				89
Chapko MC 1985							x	90
Chapko, (1986)				x				91
Chapko AJPH (1985)								92
Chaytor (1971)	x							93
Christensen (1995)			x					94
Chu (1996)		x						95
Clark (1997)		x						96
Cline (1979)		x						97
Cohen (1978)				x				98

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Cohen (1993)				x				99
Cohen (1977)				x				100
Cohen (1987)				x				101
Cohen (1976)				x				102
Collett (1980)		x						103
Cooper (1993)				x				104
Cooper (1974)						x		105
Corry (1972)						x		106
Crandell (1958)				x				107
Cressford (1984)						x		108
Croxson (1984)		x						109
Cunningham (1980)							x	110
Curtis (1997)						x		112
Davis (1964)							x	114
Davidson (1975)							x	116
DeFriese (1983)			x					117
De Jongh (1993)		x						118
Della Pelle (1973)						x		119
De Paola (1972)				x				120
Devlin (1994)							x	122
DeVore (1989)							x	123
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Dirks (1961)				x				126
Disney (1990)						x		128
Disney (1992)				x				129
Doherty (1975)		x						130
Dolan (1980)				x				131
Domer (1977)				x				133
Douglass and Cole (1979)		x						135
Douglass (1973)				x				136
Douglass and Lipscomb (1979)						x		137
Douglass (1972)			x					139
Dragoo (1996)				x				141
Duffy (1987)				x				142
Dunn (1975)						x		143
Dunning (1958)						x		144
Dunning (1972)						x		145
Dunning (1978)			x					146

Eaton (1998)					x			149
Eden (1976)		x						150
Eijkman (1980)						x		151
Eiser						x		152
Ellis (1974)			x					154
Fee (1974)					x			156
Feldman (1982)		x						157
Fernandez (1988)							x	159
Fishwick (1998)				x				160
Fleiss (1983)				x				161
Fleiss (1980)		x						162
Fleiss (1979)		x						163
Fletcher (1976)	x							164
Foreman (1993)		x						165
Foreman (1991)				x				166
Foreman (1992)				x				167
Frank (1964)		x						168
Freed (1997)				x				169
Frencken, CR (1996)						x		170
Frencken, JPHD (1996)				x				172
Frencken (1994)				x				173
Fried (1989)				x				174
Fried (1990)				x				175
Friedman (1972)					x			176
Fulton (1951)				x				178
Fylkesnes (1988)				x				179
Galli (1987)						x		180
Garfunkel (1980)		x						181
GAO (1980)					x			182
GDC (1966)				x				183
Gerbert (1988)						x		184
Gibson (1982)		x						186
Gibson (1999)						x		185
Gierl (1990)							x	187
Gift (1976)				x				188
Gift (1975)		x						189
Gilbert (1998)						x		190
Godin (1976)		x						192

Gonzalez (1991)		x						193
Gould (1998)				x				194
Gourley (1975)				X				195
Graves (1991)					x			196
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Gruebbel (1950)				x				198
Gruner (1981)						x		199
Gruthuysen (1994)				x				200
Hammons, <u>IDJ</u> (1968)						x		202
Hammons <u>DA</u> (1968)					x			203
Hammons, <u>AJPH</u> (1968)						x		205
Hammons, <u>JACD</u> (1968)						x		206
Hamp (1978)				x				208
Hankin (1977)					x			209
Hannah (1998)					x			210
Harris (1988)						x		213
Hartshorne (1994)				X				214
Hastreiter (1990)				X				216
Haugejorden (1975)		x						217
Hay (1993)				x				220
Heid <u>JADA</u> (1973)				x				223
Heine (1983)							x	224
Hetland (1981)				x				225
Hewat (1952)					x			226
Hobdell, <u>QI</u> (1975)					x			228
Holcomb (1985)				x				229
Holcomb (1986)				x				230
Hollis (1970)					x			231
Holloway (1983)				x				232
Holmgren (1996)					x			233
Holst (1993)				x				235
Holt (1979)				x				237
Holt, <u>JRSM</u> (1980)				x				238
Holt, <u>BDJ</u> (1980)				x				239
Holt (1983)				x				240
Hord (1972)					x			241
Horst (1993)				x				243
Hull (1989)						x		246

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Humphris (1992)						x		247
Ibikunle (1985)				x				248
Ingber (1975)					x			249
Ingersoll (1978)						x		250
Ismail (1989)				x				251
Jager (1990)					x			252
Jago (1991)					x			253
Janczuk (1985)				x				254
Janczuk (1987)				x				255
Jeboda (1983)				x				256
Jerman (1980)		x						257
Johnson (1925)					x			258
Johnson (1979)						x		259
Kaplan (1983)				x				262
Kaplis (1979)					x			263
Kay (1996)				x				265
Kay (1997)				x				266
Kay (1998)				x				267
Keenan (1975)				x				269
Kennedy (1971)					x			270
Kilpatrick (1976)					x			274
Kinnby (1994)			x					275

Kinsey (1977)						x		276
Kirkpatrick (1982)					x			277
Klein (1944)					x			278
Klock (1979)		x						280
Koerner (1971)			x					281
Koerner (1973)				x				282
Koot (1978)						x		283
Kudrle (1981)				x				284
Kwan (1999)				x				286
Kwasman (1975)				x				289
Laatsch (1986)				x				290
Lakies (1986)							x	291
Lathrop (1968)			x					292
Lautar (1996)			x					293
Law (1953)		x						294
Law (1955)		x						295
Le-Gallee-Byle (1989) Part 1 & 2				X				297
Leske, JDE (1976)				x				298
Leske, JPD (1976)				x				299
Leslie (1966)				x				300
Leverett (1976)			x					301
Leverett (1975)			x					302
Leverett (1977)			x					303
Lewis (1995)				x				304
Lewis (1996)				x				305
Liang (1987)				x				306
Lindahl (1973)				x				307
Lindhe CDOE(1973)				x				308
Lindhe, (1975)		x						309
Lindhe (1966)				x				310
Lindhe, JCP (1975)				x				311
Lipscomb (1986)						x		312
Little (1991)						x		314
Llewellyn-Saunders (1951)	x							316
Lobene (1975)							x	318
Lobene in Lucaccini and Handley (1974)				x				320
Lobene, JDE (1974)				x				321
Locker (1989)							x	322

Locker (1996)						x		323
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Lovdal (1961)				x				327
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Magne (1993)						x		332
Mallow (1998)				x				333
Manz (1994)						x		336
Martin (1996)				x				342
Masouredis (1997)				x				343
Maurizi (1969)		x						345
McClellan (1968)						x		346
McCloskey (1977)						x		347
McConaughy (1991)				x				348
McDermott (1991)						x		349
McIntyre (1982)						x		350
McIntyre (1984)						x		351
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McKendrick (1970)				x				353
McKenna (1987)				x				354
McKenzie (1973)				x				355
Mertz-Fairhurst (1984)		x						357
Mescher (1978)				x				358
Messer (1997)				x				359
Milgrom (1983)						x		361
Miller (1990)							x	362
Minervini. (1981)							x	363
Ministry of Health (1950)				x				365
Ministry of Health (1951)				x				364
Mitchell (1989)						x		366
Mitry (1976)				x				367
Molvar (1982)		x						371
Moosbruker (1967)						x		372
Morch (1976)				x				373
Morgan (1998)				x				374
Mourshed (1971)		x						375
Mourshed (1972)		x						376
Mullins (1974)				x				377
Mullins (1978)							x	378

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Mullins (1979)						x		380
Mullins (1983)						x		379
Murtomaa (1983)				x				381
Murtomaa, CDH (1987)				x				382
Murtomaa, SJDR (1987)		x						383
Myers (1968)							x	384
Nawrot (1987)				x				385
Needleman (1995)						x		387
NZ Misson rpt. (1950)					x			388
Nixon (1978)				x				389
Obuhoff (1977)				x				392
O'Donnell (1993)						x		393
Odrich (1985)					x			394
Olivier (1992)				x				397
Orschel (1997)		x						399
Oscarson (1998)				x				400
O'Shea (1968)						x		401
O'Shea (1970)						x		402
O'Shea (1987)				x				403
Pack (1991)				x				405
Pebley (1976)					x			407
Pelton (1973)		x						409
Peretz (1997)						x		412
Perry (1997)				x				413
Pipe (1972)					x			416
Pitiphat (1994)				x				417
Postlethwaite (1990)					x			418
Poulsen (1976)				x				419
Poulsen (1983)				x				420
Poulsen (1975)		x						421
Pugh (1969)				x				423
Ramanathan (1995)		x						424
Ramirez (1972)				x				425
Rantanen (1976)					x			426
Rasmussen (1979)							x	428
Razak (1994)				x				429
Rich (1984)				x				431
Richardson (1971)		x						432

Richardson (1978)				x				433
Richardson (1980)				x				434
Riordan (1995)				x				435
Riordan (1997)				x				436
Ripa (1983)		x						438
Ripa (1984)		x						439
Ripa (1985)			x					440
Ripa (1976)				x				441
Robinson (1968)						x		443
Rock (1981)		x						444
Rock (1978)		x						445
Rock (1990)		x						446
Roder (1968)						x		447
Roder (1972)				x				448
Roder (1973)				x				449
Roder (1974)				x				450
Roder (1976)				x				451
Roder (1978)						x		452
Rolla (1994)	x							453
Romcke (1990)				x				455
Rosen (1981)				x				456
Rosenstein JMP 1980)	x							458
Rosenstein AJPH(1980)							x	459
Rosenzweig (1971)						x		460
Rovin (1982)				x				461
Ryge (1973)		x						462
Saemundsson (1997)				x				464
Sanders (1976)				x				465
Sankaranarayanan (1997)				x				466
Saparamadu (1996)						x		467
Sarll (1996)				x				468
Saskatchewan Department of Health. (1962)						x		469
Saunders (1963)						x		470
Savage (1997)		x						471
Schwarz (1998)			x					473
Seal (1969)						x		475
Secker-Walker (1998)				x				479

Severson (1998)				x				480
Severson (1990)				x				481
Seward (1978)					x			482
Shaner (1971)					x			483
Shapiro (1974)						x		484
Siegal (1986)					x			485
Silversin (1974)				x				486
Simonsen (1989)		x						487
Simonsen (1991)		x						488
Sisty-LePeau (1990)						xx		490
Sisty-LePeau (1992)						x		491
Sisty (1972)			x					492
Sisty (1979)					x			494
Skold (1994)				x				496
Smith (1979)		x						498
Smith (1919)		x						499
Smith (1970)		x						500
Snyder (1993)				x				501
Songpaisan (1985)				x				502
Spratley (1978)						x		505
Sprod (1996)		x						506
Stach (1992)				x				507
Stamm (1988)					x			508
Stephen (1978)				x				509
Stephens (1998)				x				510
Sterritt (1988)				x				511
Stewart (1984)					x			512
Stiefel (1985)				x				513
Stiefel, JDE (1979)				x				514
Stiefel, JPHD (1979)		x						515
Stokes (1992)						x		517
Strack (1980)				x				518
Stratford (1998)				x				519
Studstill (1991)					x			520
Suomi (1971)				x				521
Swallow (1978)		x						523
Swenson (1972)					x			524
Tan (1979)				x				525

Tan (1978)				x				527
Taniguchi (1985)							x	530
Taylor. (1976)							x	532
The Nuffield Foundation, 1993.					x			533
Thomson (1994)				x				535
Thylstrup (1976)				x				536
Thylstrup (1978)				x				537
Trainer (1973)						x		540
Tuominen (1984)						x		541
Turner (1993)						x		543
Uitenbroek (1989)				x				544
Utriainen. (1993)							x	548
Van Ostenbury (1983)							x	549
Vehkalahti. (1992)							x	550
Wadhwa (1978)							x	551
Wagner (1996)						x		552
Waldman (1987)							x	553
Wallace (1979)		x						554
Waller (1973)				x				555
Walsh (1970)						x		556
Walsh, JPHD (1987)						x		557
Walsh, DH (1987)			x					558
Wang (1991)							x	560
Wang, AOS (1998)						x		562
Wang (1995)		x						563
Wang, CDOE (1998)				x				564
Wang (1992)				x				565
Warnakulasuriya(1990)				x				567
Warnakulasuriya (1991)				x				568
Waterman (1952)						x		569
Waterman HR (1953)				x				570
Waterman (1956)		x						571
Waterman PHR 1953)							x	572
Waterman (1954)				x				573
Watt (1999)		x						574
Webster (1981)				x				575
Weintraub (1989)		x						576
Weintraub (1998)						x		577

Weintraub (1993)		x						578
Weissman (1971)		x						579
Whyte (1987)				x				580
Wiedenfield (1995)		x						581
Wilson (1985)						x		583
Winter (1981)					x			585
Wood (1997)				x				587
Wood (1995)				x				588
Woodward (1995)				x				589
Woolgrove (1984)			x					590
Woolley (1980)		x						591
WHO (1959)					x			592
WHO (1987)					x			593
Wright (1984)		x						594
Wyche (1994)		x						595
Yap (1993)					x			596
Yoneyama (1997)		x						597
Young (1998)		x						598

Skills Mix in Dentistry: Data Abstraction Form

Section 1: IDENTIFIERS

First author	
Journal	
Publication date	
Record number	
Reviewer	

Table 2: POPULATIONS, CONTEXT & INTERVENTION

Feature	Code	Description
Location & date		
Purpose of the study		
Setting (system for dental care and its finance)		
Professional groups examined		
Common features/facilities		
Description of intervention		
Duration of intervention		
Description of comparison		
Training of each professional group		
Extent of team working and division of responsibility		
Sampling (frame and method) of <i>professionals</i>		
Recruitment method and response rate to invitation (<i>professionals</i>)		
Characteristics of <i>professionals</i>		
Selection and recruitment of <i>patients</i>		
Recruitment method and response rate to invitation (<i>patients</i>)		
Number of patients		
Characteristics of <i>patients</i>		
Tasks examined		

Table 3: STUDY DESIGN

Feature	Code	Description
Study design		
Unit of allocation		
Method of allocation		
Relevant outcome measures		
Blinding of outcome assessment, where relevant		
Other properties of outcome measures described		

Table 4: ANALYSIS

Feature	Code	Description
Unit of analysis		
Main results		
Adjustments made and effects on main findings		
<i>Authors</i> conclusions		
<i>Reviewers</i> observations		

GLOSSARY OF TERMS FOR DENTISTS AND THE PROFESSIONALS COMPLEMENTARY TO DENTISTRY (Dental Auxiliaries)

CDT	Clinical dental technician (to include denturists)
D	Dentist
D (s)	Dental student (undergraduate)
DH	Dental hygienist
DH (s)	Dental hygienist student
DN	Dental nurse (to include dental assistant, dental surgery assistant, chairside assistant)
DT	Dental therapist (includes dental nurses/auxiliaries in Australia and New Zealand, New Cross dental auxiliaries in the United Kingdom)
DT (s)	Dental therapist student
DTech	Dental technician
E	Teacher
EDDN	Expanded duty dental nurse (to include all expanded duty dental nurses, dental assistants. Sometimes called dental therapists and technotherapists, especially in the USA)
EDH	Expanded duty dental hygienist
EDH(s)	Expanded duty dental hygienist (student)
L	Non-dental personnel
N	Nurse
O	Orthodontist
OA	Orthodontic auxiliary/orthodontic therapist

INCLUDED STUDIES – DIAGNOSIS (26)

APPENDIX 5

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS																								
Nederfors et al (42) (19) 2000 Sweden Controlled trial	To compare the ability of a dental hygienist & dentist to record oral health status & treatment need in an elderly population	D 1 DH 1 Convenience sample	<ul style="list-style-type: none"> • mucosal friction index • oral health status • oral hygiene status • treatment intention index • treatment need index <p>Assessed by D & DH</p> <p>Patients 188 - only 75 agreed to examination)</p>	Examiner agreement assessed by: • kappa scores	Kappa scores – only 3 showed significant differences • lingual mucosal changes • modified plaque index • treatment need index	Study demonstrates acceptable inter-examiner agreement	D & DH experienced in treatment of elderly. Only 2 operators																								
Petersson & Bratthall (35) (17) 2000 Sweden Questionnaire	To compare the outcome of a risk assessment with the "cariogram program" with dentists & dental hygienists	D 64 DH 313 298 DH completed questionnaire Convenience sample at local conference	To assess the caries risk in 5 virtual patients Patients - 5 virtual cases	Percentage agreement of D & DH with "cariogram" program	Percentage agreement with "cariogram" D 78.5 DH 73.5	Shows fairly high degree of agreement between D & DH in caries risk assessment	"Cariogram" used as benchmark Large number of operators but only 5 "virtual patients"																								
Hawley (34) (17) 1999 England Controlled trial	To measure the validity of using a dental hygienist to carry out school screening	D 1 DH 1 1 senior dentist as standard examiner	Examination of 7 & 8-year-old school children Patients - 98	Percentage agreement with standard examiner	<table border="0"> <tr> <td></td> <td>DH</td> <td>DT</td> </tr> <tr> <td>Sensitivity</td> <td>0.42</td> <td>0.97</td> </tr> <tr> <td>Specificity</td> <td>0.97</td> <td>0.78</td> </tr> <tr> <td>Kappa</td> <td>0.57</td> <td>0.62</td> </tr> </table>		DH	DT	Sensitivity	0.42	0.97	Specificity	0.97	0.78	Kappa	0.57	0.62	Standard training programme used to prepare dental officers to carry out school screening to an agreed standard was insufficient for this hygienist's needs	Only one of each type of operator used												
	DH	DT																													
Sensitivity	0.42	0.97																													
Specificity	0.97	0.78																													
Kappa	0.57	0.62																													
Kwan & Prendergast (31) (17) 1998 England Pragmatic controlled trial	To test the feasibility of using dental hygienists & dental therapists as examiners in epidemiological surveys for caries prevalence	D 1 DH 4 DT 4 DH & DT selected from 13 DH & 10 DT using computer-generated random numbers	5- & 12-year old children assessed for caries prevalence by DH, DT & D as standard examiner Patients - 32	Examiner agreement assessed by: • kappa scores • mean dmft • sensitivity • specificity	<table border="0"> <tr> <td></td> <td>DT</td> <td>DH</td> </tr> <tr> <td>Sensitivity</td> <td>0.88-.98</td> <td>0.84-.0.95</td> </tr> <tr> <td>Specificity</td> <td>0.95-.97</td> <td>0.93.0.97</td> </tr> <tr> <td>Kappa</td> <td>0.84-.87</td> <td>0.80.0.89</td> </tr> </table> <table border="0"> <tr> <td></td> <td>DT</td> <td>DH</td> </tr> <tr> <td>Sensitivity</td> <td>0.66-.95</td> <td>0.56.0.83</td> </tr> <tr> <td>Specificity</td> <td>0.93-.99</td> <td>0.97.0.99</td> </tr> <tr> <td>Kappa</td> <td>0.72-.83</td> <td>0.66.0.76</td> </tr> </table>		DT	DH	Sensitivity	0.88-.98	0.84-.0.95	Specificity	0.95-.97	0.93.0.97	Kappa	0.84-.87	0.80.0.89		DT	DH	Sensitivity	0.66-.95	0.56.0.83	Specificity	0.93-.99	0.97.0.99	Kappa	0.72-.83	0.66.0.76	DT & DH could be used as examiners in caries prevalence surveys of 5-year old children Examiner agreement was poor for 12-year olds: 4 did not meet national standards for agreement	Random selection of DH & DT D used as benchmark Small number of operators & patients See also: Kwan (1996)
	DT	DH																													
Sensitivity	0.88-.98	0.84-.0.95																													
Specificity	0.95-.97	0.93.0.97																													
Kappa	0.84-.87	0.80.0.89																													
	DT	DH																													
Sensitivity	0.66-.95	0.56.0.83																													
Specificity	0.93-.99	0.97.0.99																													
Kappa	0.72-.83	0.66.0.76																													

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS
Beltran et al (33) (17) 1997 USA Controlled trial with crossover element	To test the validity of visual screening for caries using dental hygienists & nurse	D 1 DH 1 N 1 D as standard examiner Not described	Results of visual screening of children by DH & N, compared with examination by D Patients - 632	Extent of dental caries Presence of sealants Validity & reliability assessed by D	Untreated disease DH N Sensitivity 0.94 0.92 Specificity 0.94 0.99 Sealants DH N Sensitivity 0.59 0.59 Specificity 0.99 0.99 Fluorosis DH N Sensitivity 0.88 0.72 Specificity 0.95 0.96 Kappa Caries Fluorosis D 0.97 0.92 DH 0.77 0.92 N 0.93 0.81	Visual screening suitable as surveillance tool for collecting data on oral health status No significant difference between DH & N	D used as benchmark Small numbers of operators Large number of patients
Burden & Stratford (46) (19) 1996 N Ireland Prospective before & after study	Pilot study to assess the feasibility of training dental nurses in the use of the Peer Assessment Rating (PAR) index	DN 8 D 1 D as standard examiner All available orthodontic DN in N Ireland	DN trained (seminars & 6 months experience) to use the PAR index Calibration exercise to assess effectiveness	PAR scores Intra-class correlation Co-efficient of reliability	Successfully calibrated only 2 DN 4 DN achieved lower 95% confidence limit for reliability, co-efficient above 0.75. 2 also showed significant bias (paired t-test) Reliability coefficient 0.74-0.91 95% lower confidence 84 limit 0.57-0.84	Using similar training time to orthodontists, 2/8 DN successfully calibrated	Small scale study External benchmark PAR index is an audit tool with limited clinical relevance
Jullien et al (41) (18) 1996 England Controlled trial	To test the use of photographic slides in assessing the performance of members of the dental team in cancer screening	D 83 DH(s) + DN 38 Not described Comparison part of a larger study that included hospital dentists	Clinical slides shown to the different operators Answers compared with diagnosis by consultant oral physician & pathologist Slides - 80	Mean sensitivity Mean specificity Proportion of negative slides scored correctly Mean total score	Sensitivity D 0.83 Range 0.50-1.00 DH(s)/DN 0.73 Range 0.45-1.00 Specificity D 0.79 Range 0.47-1.00 DH(s)/DN 0.65 Range 0.42-0.92	Slide test showed ability to discriminate between different clinical levels in diagnosis of oral cancer & pre-cancer	External benchmark 50% slides were positive for cancer or pre-cancer Useful for calibration but of limited relevance to clinical practice

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS
Kwan et al (30) (17) 1996 England Controlled trial	To investigate the diagnostic reliability of using dental hygienists & dental therapists in epidemiological surveys for caries prevalence	D 5 DT 1 DH 2 Compared to experienced epidemiologist Not described	After training, DH, DT & D compared to standard examiner (experienced epidemiologist) in assessing caries prevalence Patients - 24	Mean dmft Confidence intervals • kappa values • sensitivity • specificity	Mean group dmft values Standard 1.92 D 1.84 DH/DT 1.92 All within 95% confidence intervals of group mean Sensitivity D 0.54-1.00 DH/DT 0.80-0.94 Specificity D 0.97-0.99 DH/DT 0.97-0.99 Kappa values D 0.70-0.90 DH/DT 0.82-0.87	It is possible to train & calibrate DH & DT to acceptable diagnostic standards for caries prevalence surveys	External benchmark Recruitment of professionals was not randomised Small number of operators See also: Kwan & Prendergast (1998)
Wang & Riordan (29) (16) 1995 Norway Prospective observational study with historical control	To estimate whether the quality of care was affected by individual recall examinations being carried out by dental hygienists	D not stated DH not stated Not described	Patient recall intervals increased from 12 months to 16-18 months Compared quality of health outcome in 2 districts over 3 years 1989-91 Patients - 300/956	Dental health before & after changes Caries prevalence & % sound surfaces Restoration treatment threshold % uninterpretable surfaces on radiographs	Association length of interval & carious surfaces not statistically significant in one district: (F = 0.51 P = 0.48) Other longer intervals associated with fewer carious surfaces: (F = 4.17 P = 0.04) Very few surfaces that were sound, or had caries only in enamel were restored Radiographic quality showed statistically significant improvement in one district, no change in other	Changes in clinical & administrative routines were not associated with major changes in quality of care in the short term Changes made to the recall intervals were relatively modest	Historical control conducted in 2 districts No details of operators

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS
Ohrn et al (32) (17) 1996 Sweden Controlled trial with crossover element	To investigate whether dental hygienists could examine & record caries with the same accuracy as dentists working with patients & extracted teeth	D 14 DH 7 7 teams Not described	7 teams of 2 D & 1 DH recorded caries in radiographs of extracted teeth (5 ratings) & examined patients (3 categories) Patients - 213 Extracted teeth - 100	Ratings carious lesions from radiographs Standard deviation & ranges Accuracy of clinical diagnosis	Radiographs No statistically significant differences between DH & D Correct diagnosis Existing lesions Sound surfaces D1 76% 79% D2 79% 77% DH 71% 83% Clinical examination: 92% tooth surfaces recorded identically by DH & D Restoration needed: no statistically significant difference in 5 out of 7 teams, or between DH & D	Accuracy in diagnosing dental caries comparable for D & DH	Comparison against benchmark only used for radiographs Convenience sample of patients Evidence of decrease in accuracy with age of patients Small numbers of operators
Adair et al (43) (19) 1994 USA Controlled trial	To assess inter-examiner reliability of independent raters of dip-slide tests for salivary <i>mutans streptococci</i> & <i>lactobacilli</i>	D 2 DH 1 Not described	Examiners independently read each slide following <u>one</u> calibration session Slides - 717	Inter-examiner agreement • % agreement • kappa scores • Pearson's R	Cariescreen Pearson's R 0.84-0.90 Kappa 0.56-0.61 Agreement 72%-77% Bactotest Pearson's R 0.78-0.87 Kappa 0.70-0.74 Agreement 86%-88%	Moderately strong agreement between 3 examiners, but multiple examiners should be calibrated initially & periodically	No external benchmark Results do not distinguish between D & DH Only 3 operators
Espelid et al (28) (16) 1994 Norway & Australia Prospective observational study	To compare radiographic diagnoses of caries in extracted teeth & treatment decisions of dentists & dental therapists in Norway & W. Australia	D[N] 433 D[WA] 62 DT[WA]108 Not described	Compared radiographic diagnoses & treatment decisions of D & DT in 2 countries Surfaces - 68	Mean number of restorations suggested Diagnostic quality	Mean restorations suggested D [N] 14.3 D [WA] 13.0 DT [WA] 14.5 % of surfaces proposed filled D [N] 4% D [WA] 7% DT [WA] 11% D [N] showed best diagnostic quality, DT [WA] the worst	D & DT [WA] had more of a "watch & wait" philosophy Differences in treatment philosophy may be due to experience of caries & fluoridation	Large-scale study Cavity preparation as the benchmark Based on extracted teeth See also Riordan (1991)
Tilliss & Vojir (40) (18) 1993 USA Prospective observational study	To assess the recognition of HIV/AIDS-related oral lesions by members of dental team	D 486 DH 124 DN 25 Convenience sample	D, DH & DN assessed photographs of intra-oral lesions Results compared Photographs - 6	% answering correctly in each group Differences in selected variables assessed by ANOVA & t-tests	No significant difference in correct mean scores D 56% DH 52% DN 44% Differences related to year of qualification in all 3 groups	No significant differences in recognition in 3 groups General level of recognition low	Convenience sample Small number of photographs & all with pathology See also Tilliss & Stach (1991)

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS
Disney et al (25) (16) 1992 USA Prospective cohort study	To compare caries prediction based on examinations by dentists & screening by dental hygienists	D 4 DH 2 Not described	Children from Grade 1 & Grade 5 children (2 sites in Aiken, South Carolina, & Portland, Maine) examined by D & screened by DH for caries prevalence Patients - 5,233	Examiner agreement assessed by: • predictive values • sensitivity • specificity	Aiken Grade 1 Grade 5 Sensitivity D 0.58 0.59 DH 0.62 0.53 Specificity D 0.82 0.79 DH 0.82 0.79 Portland Grade 1 Grade 5 Sensitivity D 0.57 0.61 DH 0.57 0.61 Specificity D 0.83 0.84 DH 0.83 0.84	Clinical evaluation can be carried out for children at high risk of caries using screening by DH rather than examination by D with no loss of precision	D examined children using mirror & explorer. DH screened using tongue blade & dental light Small number of operators See also Mauriello (1990)
Katz et al (26) (16) 1992 USA Randomised controlled trial	To determine the prevalence of nursing caries in 3-year olds Assess reliability of clinical & lay examiners	D 1 DH 1 L 23 D as standard examiner Not described	D, DH & L examined random sample of children, aged 3-5 years for prevalence of nursing caries Comparison of results Patients - 71	Prevalence & severity of caries Diagnostic reliability % agreement • sensitivity • specificity • kappa scores	Prevalence of maxillary incisor caries D 41% DH 34% L 29% D & DH agreement 93% Sensitivity 82.8 Specificity 100.0 Kappa 0.850	"Strong-to-good" diagnostic agreement for D & DH Diagnosis by L was poor	Random sample Only 1 D & 1 DH
Riordan et al (27) (16) 1991 Australia Questionnaire	To compare radiograph-based treatment decisions of dentists & dental therapists	D 45 DT 207 Invitation Response rate D 92% DT 84%	Questionnaire to D & DT on opinions about diagnosis of approximal caries & use of radiographs Questions - 6	Self-reported attitudes & knowledge	Restore when lesion into dentine D 60% DT 53% Believe radiographs underestimate extent of lesions D 80% DT 59% Time for caries to progress from outer enamel to dentine D 57% > 12 months DT 51% < 12 months	53% all operators would intervene while caries still confined to outer enamel, but differences between D & DT not great	High response rate Self-reported attitudes & knowledge See also Espelid (1994)

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS
Tilliss & Stach (39) (18) 1991 USA Prospective observational study	To assess & compare the abilities of members of the dental team in recognising HIV/AIDS associated oral lesions	D 82 DH 96 DN 56 Convenience sample	D, DH & DN assessed photographs of intra-oral lesions Photographs - 6	Number of conditions identified correctly Mean total correct scores Number of correctly identified items % of groups	Mean total of correct scores D 3.1 DH 2.9 DN 1.9 Overall scores of D & DH not significantly different. Scores of DN significantly lower than both Correctly recognised AIDS-associated lesions D 60% DH 58% DN 38%	Members of the dental team may not be adequately recognising oral clinical manifestations of HIV/AIDS infection	Convenience sample Small number of photographs & all with pathology See also Tilliss & Vojir (1993)
Dworkin et al (45) (19) 1990 USA Controlled trial	To evaluate examiners in assessing clinical signs of temporomandibular disorders (TMD)	D 3 DH 4 Not described	After training DH, patients were assessed by D & DH for TMD to compare reliability & agreement Patients - 24	Assessed reliability for clinical variables by: • correlation co-efficient kappa • intra-class	Reliability Range of motion 0.38-0.98 Occlusal & tooth relationships 0.28-1.00 Detection of joint sounds 0.30-0.74 Assessment of pain 0.46-0.94 Representative sample of clinical signs D 0.09-0.92 DH 0.30-0.98	Without calibration, experienced examiners showed low reliability with other clinicians Study showed importance of establishing reliable clinical standards	No differences between D & DH 40% of the patients were asymptomatic Small numbers of operators & patients See also Dworkin (1988)
Mauriello et al (24) (15) 1990 USA Prospective cohort study	To assess the degree of agreement between dentists & dental hygienists in caries prediction	D 4 DH 2 Not described	D examined Grade 1 & 5 children (2 sites in Aiken, South Carolina, & Portland, Maine). DH screened for caries prevalence Patients - 5,233	Examiner agreement assessed by • % agreement • kappa	Caries indices DMFT Agreement 80% Kappa 0.61 dmft Agreement 72% Kappa 0.72 Non-caries indices Agreement 53%-84% Kappa 0.07-0.43	To determine caries prevalence at DMFT level, DH reasonable alternative to D	Large-scale study Small number of operators Random sample to assess inter-examiner reliability D examined children using mirror & explorer. DH screened using tongue blade & dental light See also Stamm (1988) Disney (1990)

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS
Dworkin et al (44) (19) 1988 USA Prospective observational study	To examine the inter-examiner reliability in the measurement of temporo-mandibular disorders (TMD)	D 4 DH 3 Not described	4 specifically trained examiners (DH) & 3 untrained examiners (D) each examined patients for TMD Analysis of results Patients - 48	Reliability of assessment Inter-examiner reliability	Mean values of 3 measures of mandibular movement & 2 measures of inter-arch tooth relationship comparable for DH & D For measurements of vertical jaw opening, DH significantly more reliable among themselves than D Pain & joint sounds were very difficult to assess reliably, DH generally more reliable than D	Training examiners is a crucial consideration in TMD & some signs & symptoms are more consistent than others	No external benchmark 40% of the patients were asymptomatic Small numbers of operators See also Dworkin (1990)
Markkanen et al (38) (18) 1985 Finland Epidemiological study	To evaluate the reproducibility of the Periodontal Treatment Need System (PTNS)	D 8 EDDN 1 Not described	EDDN examined 7,190 patients D re-examined 1,232 patients EDDN re-examined 207 patients Total patients - 7,190	Reproducibility through kappa Weighted kappa for inter-examiner & intra-examiner	Intra-examiner kappa PTNS 0.67±0.05 Plaque retention 0.48±0.15 Inter-examiner kappa between PTNS recordings Same day 0.77±0.05 Plaque retention 0.74±0.12 Inter-examiner agreement on day higher than intra-examiner agreement with 2-6 month interval between examinations	Kappa values for intra- & inter-examiner reliability reflected high reproducibility	No external benchmark Little detail on professionals See also Markkanen (1983)
Markkanen et al (37) (18) 1983 Finland Epidemiological study	To evaluate periodontal need in Finnish adult population using Periodontal Treatment Need System (PTNS)	D not stated EDDN 1	D & EDDN recorded periodontal disease status Re-examination of every 30th & 5th subject 1-6 months after primary registration Patients - 4,752	Validity of clinical data Periodontal treatment need Periodontal disease & tissue retention Mean treatment time	Intra-examiner reproducibility in clinical recordings kappa Clinical index 0.78±0.04 Plaque retention 0.90±0.03 Intra-examiner reproducibility in clinical data kappa Clinical index 0.68±0.02 Plaque retention 0.83±0.03	Clinical index reproducible & valid Kappa statistics were highly acceptable	No external benchmark Reproducibility data for same day was more useful than in later examinations See also Markkanen (1985)

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS
Hughes et al (14) (14) 1982 USA Controlled trial	To record the prevalence of dental caries, periodontal disease & oral hygiene status in N Carolina in 1976-77, & relate these to selected biological, ecological & social characteristics	D 28 DH 22 DN 1 Standard examiners From a pool of 72 operators	Pilot for a larger survey 7-day training course & calibration session for D, DH & DN 6/22 D standard examiners Other D, DH & DN randomly assigned to 3 groups Each patient examined independently & results compared Patients - 30	DMFT & dft indices Periodontal disease Oral hygiene status	DMFT scores against standard Identical 57% Within 1 DMFT 32% Periodontal scores Identical 32% Within 0.2 60% Oral hygiene status Agreed with standard 33% Within 0.2 54% Close agreement obtained between D & DH as groups & standard of appropriate group for all 3 conditions measured No systematic bias discernible for individual D or DH	It appears that a large number of both D & DH can be trained to collect epidemiological data in a reliable manner	Operators randomly assigned Standard examiners reached a consensus score for each patient Only 30 patients
Mann et al (36) (18) 1980 USA Randomised controlled trial	To examine the relationship between level of training & experience in scoring for plaque using inter- & intra-examiner reliability	D 2 DH 2 Not described	Patients examined by D & DH & scored for plaque using Turesky modification of Quigley-Hein index Patients - 24	Means & standard deviations for plaque scores	No systematic tendency for D to score at different mean level to DH More experienced examiners scored at same mean level to less experienced Reliability co-efficients show precision in excess of 0.90 % Examiner variation due to: Measurement error - 8% Inter-examiner variation - 7% Patient/examiner interaction-5%	No systematic difference between D & DH in scoring plaque No reason to prefer D over DH	No external benchmark Complicated statistical analysis Small number of operators & patients See also Fleiss (1980)
Howat & Cannell (23) (15) 1979 England Controlled trial with crossover element	To test whether a dental hygienist can obtain similar results to a dentist using clinical & radiographic examinations	D 1 DH 1 Not described	Clinical & radiographic examination of children by D & DH at beginning of study & at 3 subsequent yearly examinations Patients - 178	Mean DMFS Re-test reliability coefficients Mean caries prevalence Caries incremental score Confidence limits	Prevalence scores early lesions D 20.4 DH 17.9 Cavitation level/radiographic diagnosis D 20.6 DH 18.5 Incremental scores Early Cavitation lesion D 9.26 3.37 DH 6.12 2.73	Clinical diagnoses by D & DH similar at cavitation & gross lesion levels At early lesion level, inter-examiner variability was evident Dental epidemiologists should consider using dental auxiliaries for diagnosis, but careful calibration may need to be obtained	11% loss of subjects in follow-up Comparison between 1 D & 1 DH

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Haugejorden (22) (15) 1976 England Controlled trial	To describe the construction of standards for primary approximal caries radiographic diagnosis	D 3 D(s) 2 DH 2 D as standard examiners Not described	Radiographs examined for approximal caries diagnosis by D, D(s) & DH Patients - 40	Standard ranking of subjects Diagnostic standard for group Diagnostic standard for individual tooth surfaces	Ranking D(s) +0.81-+0.94 DH +0.86-+0.94 Group results D(s) mean primary caries score always higher than mean intermediate score per subject 1 DH had only 1 mean score higher - other DH had 2 mean scores higher	Acceptable level of agreement for ranking Less so for mean scores compared to intermediate score per subject & standard for individual surfaces	No real benchmark Complex analysis Small number of operators

INCLUDED STUDIES: TECHNICAL COMPETENCE (41)

APPENDIX 6

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN/	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS
Mandall & Read (89) (29) 1999 England Controlled trial	To assess dental hygienists' ability to carry out orthodontic procedures & to assess their effectiveness	DH 5 O 5	DH & O carried out range of orthodontic exercises on phantom head typodonts	DH assessed on performance of the following procedures: • archwire placement • canine • elastic separators • figure of 8 tie • molar bands • power chain • rotation wedge	No statistically significant differences between DH & O in terms of ability to carry out potential orthodontic PCD procedures. However O more efficient (P < 0.05).	Ability of DHs to carry out potential orthodontic tasks after appropriate training is supported	Orthodontists had far greater experience at carry out the procedures Gold standard was that of the average of the 5 orthodontists
Frencken et al (99) (31) 1998 Zimbabwe Prospective interrupted time series	To compare the survival rates of one-surface ART restorations & sealants placed by dentists & dental therapists after 3 years	D 2 DT 2 Not described	D & DT carried out ART restorations & placed glass-ionomer sealants in 14-year-olds Patients - 569	Sealant retention rate at 3 years Survival of ART restorations after 3 years	ART restorations Survived after 3 years 85% Per operator 96-69% Sealants Retained after 3 years 50% Per operator 69-30% Significant statistical difference between operators. 1 DT significantly worse	ART & glass-ionomer sealants have made preventive & restorative dental care available for student population in Zimbabwe	Evaluation by independent D High loss in follow-up: 36% restorations 39% sealants Small number of operators See also Frencken (1996)
Phantumvanit et al (98) (31) 1996 Thailand Controlled trial	To report on the longevity of one-surface ART restorations compared to amalgam restorations in permanent teeth	D 1 EDDN 2 Not described EDDN trained on 2-year programme	Community field trial in 3 rural villages Compared ART & amalgam restorations carried out by D & EDDN Evaluation at 1, 2 & 3 years Patients - 282	Restorations evaluated as acceptable & not acceptable at 1, 2 & 3 years using 10 criteria • Longevity of restorations • Presence of caries	Survival of ART restorations placed by D & EDDN did not differ significantly Cumulative survival rates 1 year 2 year 3 year D 92% 79% 66% EDDN 93% 85% 73% Logrank test not significant	ART is a feasible approach for the management of dental caries especially 1 surface lesions in the permanent dentition	Evaluation by 2 "independent operators" Loss in 3-year follow-up 28% ART restorations 34% amalgam restorations Small numbers of operators
Llodra et al (97) (31) 1993 Spain Meta-analysis	To determine the effectiveness of fissure sealants & factors that influence their effectiveness	D not stated D(s) not stated DH not stated DN not stated	Meta-analysis of studies on effectiveness of sealants 24 studies in 34 articles	Effectiveness defined as % of caries treatment avoided by placing sealants • Type of polymerisation • Length of follow-up • Fluoridation of water • Operator • Date of beginning study	Effectiveness Overall 71% D/DN 73% D 73% D(s)/DN 65% DH 63%	Need further research to assess operator effect more carefully	Meta-analysis Operators only one aspect Few studies clearly defined the types of operator

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Zappa et al (86) (29) 1993 Switzerland Randomised controlled trial	To assess in vivo scaling & planing forces applied by different operators	D 10 DH 10 Convenience sample from dental & dental hygiene schools	Scaling of molars in adult patients with periodontitis. Forces applied recorder with a piezo-electric receiver Patients - 20	Mean forces applied during scaling & root planing in Newtons	Forces D DH Scaling 7.56N 6.59N Root planing 6.34N 4.24N Differences statistically different with 11/12 curette (results above) but not with 13/14 curette	Extent of instrumentation given to molar root surfaces depends more on operator than clinical need	Compares D with DH Study not primarily designed to illustrate differences between them Small number of operators & patients
Oliver & Griffiths (88) (29) 1992 Wales Prospective observational study	To compare the competencies of one dental hygienist & one orthodontist in removing composite using 4 different methods	O 1 DH 1 Not described	DH & O removed composite from extracted teeth using 4 methods Timed & assessed in terms of Enamel Surface Index (ESI) scores Extracted teeth - 30	Time taken to clean the composite from enamel (seconds) Modified ESI scores	Only significant statistical difference in time taken by O & DH for method 4, tungsten carbide burr Little difference between modified ESI scores	No evidence that the DHs skills were inferior to those of O DH could be trained as expanded duties PCDs & become a safe & cost- effective member of the orthodontic team	Only 2 operators Based on extracted teeth Very minor procedures
Carpey (79) (27) 1990 Netherlands Retrospective observational study	To study the dental status of primary schoolchildren in relation to the dental treatment they had received	D (school) D (general practice) EDDN All not stated Not described	Retrospective study of quality of restorations in Dutch children (7-13) in 4 regions by type of dental operator used Patients - 713 EDDN cut & completed restorations	Quality of restorations (6 criteria) Co-variance with quality criteria Mean observed treatment need	Restorations rated excellent D (school) 10% D (general practice) 14% EDDN 44% Restorations rated very poor D (school) 9% D (general practice) 16% EDDN 1% Proportion of restorations needed in deciduous teeth that had been completed D school/general 59% EDDN 83	DN performed better than D in almost all quality criteria	Aspects of sampling & evaluation not described Unclear how data was collected No detail of operators
Daniel et al (95) (30) 1990 USA Prospective observational study	To assess the competence of dental & dental hygiene students' self-evaluation of sealant placement	D(s) 17 DH(s) 13 From North Carolina School of Dentistry	D(s) & DH(s) self-evaluated sealants that they had placed Evaluations checked against those of faculty members (n = 4) (D = 2) (DH = 2) Patients - 29	Average mean score Comparison of scores by students & examiners	Student scores consistently higher than those of faculty D(s) x 1 DH(s) x 3 D faculty mean 3.65-3.88 D(s) mean 3.72-3.97 DH faculty mean 3.46-3.84 DH(s) mean 3.64-3.98	D(s) & DH(s) gave themselves higher scores than D. DH(s) to a greater degree than D(s) DH(s) may have scored themselves higher because less experienced than D(s)	Implications for clinical care unclear Faculty members were calibrated See also Scruggs (1989)

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Scruggs et al (94) (30) 1989 USA Prospective interrupted time series	To investigate the use of specific criteria & examine calibration on the reliability of inexperienced examiners in dental sealant evaluation	D(s) 8 DH(s) 8 Volunteers from North Carolina School of Dentistry	DH(s) and D(s) examined all extracted teeth (16) Calibration session for 8 - 4 with an expert & 4 with non-expert All 16 conducted second evaluation Extracted teeth - 20	Intra- & inter-examiner reliability	No significant difference in reliability D(s) & DH(s) (t=0.77 (p=0.46) Intra-examiner reliability D(s) 0.73 DH(s) 0.64 Inter-examiner reliability pre-test D(s) 0.39 DH(s) 0.62 Inter-examiner reliability post-test D(s) 0.44 DH(s) 0.55)	No statistically significant differences in intra-examiner reliability No significant differences between D(s) & DH(s)	Concerned with evaluating the effect of the calibration sessions than with differences between the D(s) & DH(s) Based on extracted teeth Evaluation by 4 faculty members See also Daniel (1990)
Wood et al (96) (31) 1989 USA Prospective observational study	To compare the retention of sealants placed by different methods & using different operators	D 1 D(s) 1 DH 1 D(s) were selected from a pool of 20	Children screened by D & D(s) Sealants applied by 3 different teams using 2 different methods of moisture control A D, DN B D(s), DN C DH, DN Patients - 145	Number of sealants • completely retained • partially retained • not retained Evaluation by 2 independent D at 9.3 months (average)	Number of teeth sealed D 202 D(s) 280 DH 41 2 way analysis of variance showed no statistically significant differences among operators on any tooth sealed (p > 0.11)	Retention of sealant not affected by method of moisture control Either insulation method worked equally well in hands of D, D(s) & DH	Primarily concerned with evaluating different methods of moisture control Random allocation of operators & patients No real data on retention rates of different types of operator, or on drop-out rates Small numbers of operators
Ooi & Tan (93) (30) 1986 Singapore Prospective interrupted time series	To evaluate the retention of 2 types of sealants placed by a dentist & an expanded duty dental nurse over 2 years	D 1 EDDN 1 Not described	D & EDDN placed sealants in children aged 6-7 Recall at 6, 12, 18 & 24 months Examination of sealant retention Patients - 196	Number of teeth • fully sealed • partly sealed • sealant lost At 6, 12, 18 & 24 months	Concise fully sealed at 6 months 24 months D 96% 74% EDDN 95% 81% Delton fully sealed at 6 months 24 months D 98% 95% EDDN 96% 95%	Significant differences in retention rates of 2 sealants No significant differences in the success rates of operators	Compares sealant retention rates by D & EDDN Evaluation by same D & EDDN who had placed sealants Only 2 operators

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Wilson et al (85) (28) 1985 USA Controlled before & after study	To compare the performance of dental students & dental hygiene students in scaling & root planing procedures before & after 2 pre-clinical courses	D(s) 23 DH(s) 29 Random sampling D(s) 128 DH(s) 50	Tested D(s) & DH(s) Compared performance before & after 2 x 13 week pre-clinical periodontal instrumentation courses	Independent evaluation of 5 process skills Pre-test & post-test scores	Comparison between D(s) & DH(s) did not differ significantly before or after training P 0.590 - 0.063 Instrument skills for D(s) & DH(s) similar before & after training for all but 1 Mean scores (out of 25) Pre-test D(s) 4.71 DH(s) 5.48 Post-test D(s) 19.71 DH(s) 21.56	No significant overall differences in learning periodontal instrumentation between D(s) & DH(s)	Evaluation by 4 professors who were calibrated Large number of operators Training courses of 2 groups were different as were abilities at baseline
Bader et al (76) (26) 1983 USA Retrospective observational study	To evaluate & the performance of dentists & expanded duty dental nurses in placing & carving amalgam restorations	D 7 EDDN 16 7 practices chosen from 14	After training for EDDN, evaluated 596 restorations by EDDN & D in 6 month period EDDN placed & finished restorations Practices - 7	Surface Anatomic form Marginal integrity Complexity & number of surfaces Distribution of errors	No statistically significant difference in proportion of restorations rated unacceptable D 5% EDDN 3% Distribution of errors that resulted in unacceptable rating similar for D & EDDN Restorations completed within previous 6 months & tended to be of the simpler type	No difference in % of unacceptable restorations completed by D & EDDN No difference in frequency of distribution of errors by severity or type between D & EDDN	Study in 7 private practices with stratified sample of patients Blind evaluation by 2 D following standardisation session Examiner agreement 97% See also Mullins (1979) Mullins (1983)

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Bergner et al (78) (27) 1983 USA Prospective observational study	To compare the quality of care & differences in high & low delegation practices	D not stated EDH not stated 33 practices chosen from 120	Evaluation of restorations by D & EDH EDH placed & finished restorations Practices - 17 Patients - 457 Evaluation of structure, outcome & process of care from patient records & staff questionnaire Practices - 33 High delegation - 16 Low delegation - 17	Quality of restorations Evaluated by independent D Structure & process of care	Restorations rated unsatisfactory D 13% EDH 18% Amalgam restorations rated unsatisfactory D 12% EDH 14% Composite restorations rated unsatisfactory D 14% EDH 27% Higher proportion of high delegation practice records had treatment plans Take blood pressure routinely High delegation 67% Low delegation 29%	EDH had higher number of unsatisfactory composite restorations High delegation practices at least as likely & usually more likely to provide high quality care as low delegation	Study of restorations in 17 private practices Independent blind evaluation suggested EDH had higher number of unsatisfactory restorations than D See also Milgrom (1983)
Kaplan (72) (26) 1980 USA Controlled before & after study	To assess the effects on clinical quality of using expanded duty dental nurses in private practice	D 2 EDDN 6 DN 2 EDDN already in practice	Baseline period of 6 weeks was compared with expanded phase of 6 months A 2 D, 2 DN B 2 D, 2 EDDN, 1 DN Procedures • constructing overlays for crowns • constructing temporary crowns or bridges • placing & finishing restorations • placing rubber dams • taking preliminary impressions Practice - 1 Patients - 32	Daily quality of care: 5 functions rated in 5 categories Quality of restorations	Ratings 5 delegated functions Ranged 74-100% Acceptable/excellent 94% Number restorations judged satisfactory: A 32/33 B 30/33	In private practice, EDDN performed expanded functions at a satisfactory level of quality D still performed many functions themselves	Evaluation of quality of care by practice D & of restorations by 2 independent D (blind) Dentists did not delegate more complex restorations Only 1 practice & small numbers of operators Other procedures not evaluated blind See also Mullins (1979) Mullins (1983)

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Nixon (83) (28) 1980 USA Controlled before & after study	To determine the feasibility of increasing the role of expanded duty dental nurses to include all aspects of dentistry in the US Indian Dental Services	D not stated) EDDN 4 DN selected to be trained as EDDN	Trained 4 DN as EDDN in all aspects of dentistry Compared baseline & experimental phases in clinics over 15 months Procedures <ul style="list-style-type: none"> Class IV aesthetic restorations complete dentures pocket debridement pulpectomy removable prostheses stainless steel crowns Clinics - 4 Examinations - 8,342 Treatments completed 3,524	Number & type of procedures Time taken Quality of procedures	Examination of 6 procedures Significant difference in 2 Both favoured EDDN (Class IV) aesthetic restorations & stainless steel crowns)	Selected EDDN capable of providing large variety of reversible procedures at quality comparable to that of D Considered not practical to employ EDDN & did not propose to take project further	Not clear whether groups were comparable Evaluation by 2 independent D but unclear Small number of operators
Lobene (82) (27) 1979 USA Controlled trial	To test whether dentists could increase productivity, reduce costs, spend more time on challenging procedures, & increase net income by delegating procedures	D not stated EDH 10 EDH recruited from among DH graduating from 3 schools of dental hygiene	EDH trained for 47 weeks & evaluated over 14 months Assessed <ul style="list-style-type: none"> acceptability to patients costs increases in speed & efficiency productivity quality of work Clinics - 1 Patients - 2,668) EDH carried out cavity preparation & restoration	Quality of cavity preparations & restorations in quality points Acceptability to patients Time usage by D Hourly & annual income Local anaesthetic infiltration & ID block	First assessment Based on too few procedures to make valid statistical comparisons between EDH & D Second assessment Indicated no significant differences in quality in cavity preparations & restorations between operators Third assessment Indicated qualitative differences in performance of 2 groups statistically non-significant	Cavity preparations & restorations by EDH of high quality & equal to those of D	Study that deals with irreversible procedures Blind evaluation of cavity preparations & restorations Numbers of procedures small (34 in second assessment & 25 in the third assessment) Number of D is not stated Conducted in specially-designed experimental clinic
Tan et al (75) (26) 1979 Netherlands Simple transversal comparison	To compare the quality of restorations by dentists & expanded duty dental hygienists	D 5 EDH 4 Not described	Complete restorations by D compared with partial restorations by D & EDH Restorations - 487 Practices - 1 EDH placed restorations only	Quality of restorations on 6 characteristics: <ul style="list-style-type: none"> anatomical form contact point level marginal crest marginal adaptation relation antagonist smoothness 	No differences between D & EDH per type of filling Fillings of good quality on average per criterion Only one type of filling showed difference between private patients & insured patients	Despite small differences, quality of fillings by D & EDH was comparable	Small number of operators Summary of average scores per criterion is insensitive No information about blinding

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Sisty at al (81) (27) 1978 USA Randomised controlled trial	To compare the performance & competence of expanded duty dental hygiene & dental students	D(s) 48 EDH(s) 48 DN 96 Selected on academic performance (stratified samples)	Following experimental programme in expanded procedures, compares operative & periodontal procedures by D(s) & EDH(s) in 4 year follow-up EDH(s) did • Class II preparations & amalgam restorations • Class III preparations & composite restorations Patients - 186	Number of procedures rated • excellent • acceptable • unacceptable • time taken to complete procedures	Out of 154 evaluations only 16 criteria showed significant differences between 2 groups No consistency for procedures between groups No statistically significant differences found for D(s) & EDH(s) for • Class II restorations • Class III restorations • Periodontal procedures	EDH(s) able to perform selected operative & periodontal procedures at comparable level to D(s)	Randomisation of professionals & patients Deals with irreversible procedures Blind evaluation by 3 D Study based on patients & dentoforms
Douglass et al (71) (26) 1976 USA Prospective incremental design	To determine the effect of introducing expanded duty dental nurses in one private practice	D 4 EDDN 2 DN not stated EDDN selected from DN	Incremental design with 4 D adding: A 1 EDDN B 1 EDDN following training course C 2 EDDN Practices - 1 EDDN placed restorations	Productivity & income Quality of restorations Acceptability	Satisfactory restorations D 87% EDDN 88%	EDDN can increase productivity & revenue, & perform many procedures to a quality level equal to that of D	Study was conducted in 1 private practice Blind evaluation of restorations by 3 D Small numbers of operators See also Douglass (1973)
Leake & Martinello (91) (30) 1976 Canada Prospective interrupted time series	To compare dentists & dental hygienists in all aspects of application & evaluation of sealant programmes	D 1 D 1 Not described	Teams led by DH & D screened & placed sealants in children aged 5 & 7 Examinations at 6, 12, 18, 24, 36, & 48 months Patients - 518	Success rate of sealants Costs per patient Rates of acceptance Dental status at 48 months Accuracy of assessment	Radiographs success rate D 98% DH 97% Complete retention at 4 years D 29% DH 9% Effectiveness at 4 years D 5% DH 18% Success of treatment by D significantly better than by DH (P < 0.001)	DH & D similar for evaluations D had better clinical success rate at 4 years A single preventive approach does not appear worthwhile in light of the cost-benefit consideration	Children stratified & assigned randomly Blind evaluation by D suggests performance of DH was worse 81% patients remained in study at 48 months Small numbers of operators Not clear how DH & D led the teams

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Stiles et al (92) (30) 1976 USA Prospective interrupted time series	To determine the effectiveness of a pit & fissure sealant when applied by different members of the dental team	D 1 DH 2 EDDN 1 Operators & patients selected from the US Coast Guard Service	Children aged 5-21 had sealant applied by 1 of 4 operators Examinations to check retention at 6 & 12 months Patients - 166	Complete/partial sealant retention at 6 & 12 months Caries attack rate for treated sites	Partitioned chi square analysis revealed no difference between D & DH for retention Highly significant difference between EDDN & D & DH (P < 0.001) Retention at 12 months Permanent Deciduous D 55% 45% DH1 54% 57% DH2 55% 61% EDDN 39% 25%	Apart from EDDN no difference in retention of sealants between D & DH	Blind evaluation by independent D Patients allocated randomly Small number of operators EDDN had least training
Tappan & Fitch (90) (30) 1975 USA Prospective observational study	To compare the use of expanded duty dental nurses to supply preventive care with dentists & dental hygienists	D 2 DH 2 EDDN 7 Selected from Denver Neighbourhood Health Programme	After 9-weeks training, EDDN compared with D, DH in application of fluoride with cyanoacrylate on children	Incidence of plaque Costs	After 6 months, performance of EDDN judged to compare favourably with D & DH Performance of EDDN comparable to D & DH	EDDN can be trained in 9 weeks to work with quality comparable to that of D & DH Performed at reduced cost. Training also inexpensive	Study lacks detail in most aspects No data on evaluation & criteria for it Small numbers of operators
Hord et al (69) (25) 1974 Canada Prospective controlled observational study	To evaluate the effect of a team approach to dental care delivery in respect of efficiency, costs, effectiveness, & quality of service	D 8 EDH 8 EDDN 8	Evaluated quality of amalgam & resin restorations placed by D & EDH & quality of procedures by EDDN Amalgam restorations - 204 Resin restorations - 33 Total restorations - 237 Practices - 8 DH placed & finished restorations Procedures by EDDN <ul style="list-style-type: none"> • oral hygiene instruction • polishing of restorations • polishing of tooth surfaces • removal of calculus • rubber dam placement • topical fluoride application 	Restorations rated from excellent to unsatisfactory Services provided by EDDN also rated for quality	Proportion of restorations rated excellent Amalgam Resin D 18% 28% DH 37% 28% Procedures by EDDN rated excellent - 61%	Quality of service not compromised when EDH & EDDN assume restorative & preventive responsibilities	Independent evaluation by 2 D Blind only for old restorations No comparison for work of EDDN See also Hord (1972)

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Powell et al (80) (27) 1974 USA Controlled trial	To examine the clinical performance of expanded duty dental hygienist students & dental students	D(s) 12 EDH(s) 11 From Howard University School of Dentistry, Washington D(s) volunteers	Evaluation of EDH(s) & D(s) in carrying out Class I amalgam restorations & Class I & Class II cavity preparations Patients - 23 dentoforms	Rating system for restorations & cavity preparations Inter-evaluator reliability co-efficient Times taken to complete procedures	All mean scores (100 maximum) Cavity preparation on patients EDH(s) 84.5 D(s) 81.5 Condensation & contouring on patients EDH(s) 81.2 D(s) 85.2 Restorations on dentoforms Class I Class II EDH(s) 76.4 75.1 D(s) 77.6 76.5	No differences in performance of D(s) & EDH(s) in Class 1 amalgam preparations clinically & on Class I & Class II cavity preparations on dentoforms	Study that deals with EDH(s) doing irreversible procedures Blind evaluation by 7D Patients allocated at random Carried out on patients & dentoforms Small number of operators
Robinson & Bradley (70) (26) 1974 USA Pragmatic controlled trial with crossover element	To compare Training in Expanded Auxiliary Management (TEAM) & Dental Auxiliary Utilisation (DAU) in respect of productivity, time, quality & costs	D(s) 20 EDDN 1 DN 3 Not described	Treatment of patients in 2 different settings Evaluation of productivity, quality, costs A 1D(s), 1EDDN, 2DN B 1D(s), 1DN A 90 restorations B 61 restorations Patients - 151	Quality of treatment Time per patient Time per surface restored Costs	Quality of restorations Acceptable Unacceptable A 94% 6% B 88% 12%	TEAM performed sufficiently more services to pay for additional salaries Patients in chair longer, but received more treatment	Comparison of TEAM & DAU rather than D(s) & EDDN Patients assigned arbitrarily Study based on patients & dentoforms D(s) allocated randomly Crossover element
Abramowitz & Berg (58) (24) 1973 USA Prospective incremental design	To determine the feasibility of using expanded duty dental nurses & the effect on quality, productivity & costs in the US Indian Health Service	D 8 EDDN 20 DN 12 EDDN selected from DN	Comparison of different dental teams in 4 phases each of 100 days A 2D, 3DN B 1D, 3EDDN C 1D, 4EDDN D 1D, 5EDDN Clinics - 4 Procedures by EDDN: • packed & carved alloy • placed, compressed & finished silicate restorations	Number of procedures Time taken to complete procedures in Relative Time Units (RTUs) Quality	No significant differences in acceptable ratings for Class II alloy & Class III silicate restorations between D & EDDN (P<0.05) No significant differences in distribution of reasons for unsatisfactory ratings between D & EDDN	Restorations by EDDN of comparable quality to those by D Using EDDN led to an increase in number of patients that D could treat, & to decreased costs per service	Random sample of restorations Blind evaluation by 2 independent D High level of disagreement between evaluators See also Abramowitz (1966)

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Benson (87) (29) 1973 USA Controlled trial	To train 4 expanded duty dental nurses to carry out all the intra-oral procedures involved in making complete dentures	D(s) not stated EDDN 4 EDDN selected from 2-year training programme	Phase 1 Training course Phase 2 Clinical programme, written examination, evaluations of treatment & dentures & patient satisfaction Patients - 30	Ability of EDDNs in range of procedures Quality of dentures (7 criteria) Patient satisfaction	Statistical analysis using t-test indicated no statistical difference between scores for dentures made by EDDN & D(s) Average scores D(s) 69% EDDN 68%	Performance of EDDN was comparable to D(s) EDDN need a 1-2 year training programme to be completely proficient	Only study about skills mix in the clinical aspects of making complete dentures Double-blind evaluation of dentures by prosthodontists Different training for D(s) & EDDN Patients treated by D(s) randomly selected Small number of operators
Romcke & Lewis (67) (25) 1973 Canada Prospective incremental design	To determine whether employing expanded duty dental hygienists increases the productivity of dentist & whether it is economically feasible in private practice	D not stated EDH 6 DN not stated Not described	Compared productivity in children's clinic in 7 phases over 2.5 years A practice B 1D, 1DN, 2 chairs C 1D, 2DN, 2 chairs D 1D, 1EDH, 2DN, 3 chairs E 1D, 2EDH, 3DN, 4 chairs F 1D, 2EDH, 3DN, 4 chairs G 1D, 2EDH, 3DN, 4 chairs Assessed productivity in 6 private practices, 6 weeks baseline & 3 months study period Clinics - 1 Practices -6 EDH placed restorations D 98 old restorations EDH 115 new restorations 216 old restorations	Productivity in Relative Value Units (RVUs) Work distribution patterns Costs & benefits Quality Acceptability to patients	Quality Restorations placed by EDH as good as, if not better than those by D Satisfactory new restorations EDH 88% Average score EDH 19.6 Satisfactory old restorations D 81% EDH 92% Average scores D 17.1 EDH 17.6 Difference for scores not statistically significant (P > 0.05) but for percentages highly significant (P < 0.01)	Addition of EDH increased productivity of D in a public clinic & is economically feasible In private practices, benefits far exceed the costs	Comparison of public clinic & private practices Blind evaluation only of old restorations Small number of operators
Heid & Barr (68) (25) 1973 USA Prospective observational study	To determine the quality of procedures carried out by expanded-duty dental nurses	D 22 EDDN 19 D & EDDN selected	Comparison of 1, 2 & 3 or more surface amalgam & resin restorations placed & finished by EDDNs with those prepared by D Evaluation 2 independent D Patients - 310 Restorations - 979	Examiners assessed restorations as: <ul style="list-style-type: none"> • satisfactory • met all standards • not acceptable • replace for prevention • replace statim 	Number of restorations D EDDN Amalgam 154 606 Resin 31 168 % Satisfactory D EDDN 97.9 98.4 % meeting all standards D EDDN All 67.9 60.9 Amalgam 65.6 63.0 Resin 77.4 53.7	EDDNs can consistently place & finish restorations of satisfactory quality. However they have more difficulty with resin restorations & with more complex amalgam restorations.	Independent examiners had high level of inter & intra agreement. Military setting See also Heid (1973)

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN/	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS
Brerley & Rosenblum (66) (25) 1972 USA Controlled trial with contemporaneous comparison	To assess the effect on productivity quality & acceptability when a second dental nurse is added to a team of a dental student, dental nurse, & expanded duty dental nurse	D(s) 30 EDDNa 10 (no experience) EDDNa 10 (1 year's experience) DN 40 D(s) selected from 103	Compared 20 experimental & 10 control teams over 1 year A 1D(s), 1EDDNa, 1DN B 1D(s), 1EDDNa, 1DN C 1D(s), 1DN Extra DN added to A & B for first study period Patients - 571 Procedures • Class I, II, III & V amalgam restorations • EDDN placed, carved & finished amalgam restorations • prophylaxis & topical fluoride application • stainless steel crowns	Number of patients treated Numbers of specific procedures & time required to complete each Quality	1st study period B preferred to A in 2 out of 6 process measures & 3 out of 7 output 2nd study period No statistically significant differences	Productivity of dental teams can be increased by EDDN & further by an additional DN Additional training can improve performance	Patients randomly allocated Evaluation not blind See also Rosenblum (1971)
Pelton et al (84) (28) 1972 USA Controlled trial	To compare the quality of prophylaxis by expanded duty dental nurses & dental students	D(s) 13 EDDN 7 D(s) graduating class of senior dental students (stratified sample) EDDN selected in earlier studies	Dental prophylaxis by D(s) & EDDN evaluated 2 days after treatment Patients - 210	Number of surfaces free of: • calculus • stains • calculus & stains Tissue integrity	Proportion of patients free of calculus D(s) 58% EDDN 64% Proportion of patients free of stains D(s) 69% EDDN 79% Proportion of patients free of calculus or stains D(s) 44% EDDN 51% Evaluations of gingival tissues acceptable in all but 2 patients	EDDN carried out procedures as well as D(s)	Blind evaluation by 3 D Random allocation of patients See also Hammons (1967) Hammons (1971)
Soricelli (64) (25) 1972 USA Retrospective before & after study	To train & use expanded duty dental nurses & assess the feasibility & advisability of using them	D not stated EDDN 4 DN not stated EDDN selected from DN	7-month training programme for EDDN Various team mixes tried Evaluation of qualitative & quantitative results EDDN placed restorations	Number of surfaces treated Patient visits per session Quality of performance Quality of restorations Acceptability to patients	With 2 months experience 40% restorations by EDDN superior or outstanding After 5 months, 75%	EDDN trained for short period can deliver dental procedures effectively	Nature of the comparison was not clear Small numbers of operators See also Della Pelle (1973)

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN/	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS
Hammons et al (60) (24) 1971 USA Controlled trial	To evaluate the quality of care provided by expanded duty dental nurses	D 8 EDDN 4 EDDN had 2 years training in earlier study	Patients diagnosed & prepared for treatment by D Remainder of treatment completed by EDDN Evaluated over 8 months EDDN inserted, carved, & finished the restorations Patients - 471/447	6 procedures rated • excellent • acceptable • unacceptable • inapplicable	Unfinished restorations No statistically significant differences in excellent rating Finished restorations Only 2 of 13 statistically significant between D/EDDN Temporary restorations Excellent rating favoured EDDN Matrix bands No statistically significant difference but excellent rating favoured D in 8 out of 12	No clinical differences between D & EDDN Few differences were statistically significant	Patients assigned randomly Blind evaluation by independent D Not clear if 2 patient groups were comparable See also Hammons & Jamison (1967)
Lotzkar et al (62) (24) 1971 USA Prospective incremental design	To determine the qualitative & quantitative effects of assigning chairside duties to expanded duty dental nurses	D 7 EDDN 32 17 EDDN had 2+ years experience	Compared teams working conventionally (Phase 1) & where EDDN trained to perform additional functions (Phase 2) Phase 1 1D, 1DN Phase 2 1D, 1EDDN Procedures included • adult radiographs • alginate impressions • carving & polishing amalgam • charting • oral health instruction • placing amalgam • post-surgical instruction	Quality of procedures Level of patient satisfaction Time taken to complete procedures Average number of patients, procedures & time units per day	Phase 1 21 procedures carried out by EDDN 81% met standards for quality Phase 2 Acceptable procedures by EDDN - 73% Met required standards - 79% Figures in Phase 2 lower for • adult radiographs • carving compound amalgam • finishing synthetic restorations	DN can be successfully trained as EDDN	Patients had high treatment needs Carried out in specially designed experimental dental clinic See also Lotzkar (May 1971)
Lotzkar et al (63) (24) 1971 USA Prospective incremental design	To determine the qualitative & quantitative effects of assigning chairside duties to expanded duty dental nurses	D 6 EDDN 32 17 EDDN had 2+ years experience	In third phase, D worked as head of teams with varying numbers of EDDN over 3 years: A 1D, 2EDDN B 1D, 3EDDN C 1D, 4EDDN Procedures included • adult radiographs • alginate impressions • carving & polishing amalgam • charting • oral health instruction • placing amalgam • post-surgical instruction	Quality of procedures Level of patient satisfaction Time taken to complete procedures Average patients, procedures, time units per day	Quality 4/5 procedures met quality standards - 82% Independent evaluation Procedures acceptable- 72%	EDDN can perform delegated duties as well as D & in a reasonable length of time, although required more time to complete procedures	Study with 32 EDDN Conducted over 3 years Evaluation by D Not blind Patients had high treatment needs Specially designed experimental dental clinic See also Lotzkar (January 1971)

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN/	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS
Rosenblum (61) (24) 1971 USA Controlled trial	To determine the training needed for expanded duty dental nurses, & compare the quality & quantity of procedures to those of dental students	D(s) 30 EDDN 4 DN not stated EDDN recruited from Dental School, University of Minnesota	Compared performance of 20 experimental & 10 control teams over 9 months A 1D, 1EDDN, 1DN B 1D, 1DN Procedures included: • matrix band insertion • polishing Class I & Class II amalgam restorations • rubber dam & rubber dam clamp application Patients - 481	Quantity of procedures performed Time taken to complete procedures Quality of restorations	Number of unacceptable amalgam & stainless steel crown restorations Unacceptable Total A 30 851 B 6 333 In 5/16 procedures no significant difference between D/EDDN EDDN superior in: • rubber dam & rubber dam clamp application • matrix band insertion • polishing Class II amalgam restorations D(s) superior in: • polishing Class I amalgam restorations	No significant differences between speed & quality of performance between D & EDDN 3-month course is adequate for training	Random allocation of patients Evaluation not be blind Small number of operators Selected EDDN with widely varying abilities See also Brearley & Rosenblum (1972)
Hammons & Jamison (59) (24) 1967 USA Prospective observational study	To determine whether expanded duty dental nurses can carry out procedures traditionally carried out by dentists	D(s) not stated EDDN 5 DN 3 EDDN selected from among 68 high school graduates & DN	Controlled test to compare quality of procedures provided by EDDN with those by D(s) Procedures included: • inserting, carving, & polishing amalgam & silicate restoration • inserting temporary restorations • matrix band placement • rubber dam & rubber dam clamp application	Evaluation of quality of • matrix bands (12 criteria) • restorations (12 criteria) • rubber dams (9 criteria)	Finished amalgam restorations Excellent Unacceptable D(s) 50.6% 1.7% EDDN 69.2% 2.0% 45% 31% Finished silicate restorations Excellent Unacceptable D(s) 28.6% 1.6% EDDN 58.6% 3.6% Matrix band placement Excellent Unacceptable D(s) 38.7% 11.6% EDDN/DN 60.1% 3.8% Rubber dam placement Excellent Unacceptable Ds 40.0% 9.8% EDDN/DN 61.8% 1.7%	Carefully selected EDDN can be trained to perform as well as D(s) in numerous procedures traditionally carried out by dentists	EDDN were high school graduates Not clear whether 2 patient groups comparable Blind evaluation by independent D Examiners used the rating inapplicable in event of disagreement See also Hammons (1968) Hammons (1971)

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN/	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS
Abramowitz (57) (24) 1966 USA Controlled trial with crossover element	To determine the effectiveness of teams trained to carry out expanded duties	D 4 EDDN 4 DN 4 D selected on basis of work records EDDN had been working with the D	Compared 4 teams comprising 1 D & 2 DN in experimental & control settings A DN had expanded functions B DN had traditional functions Conducted over 40 & 25 days EDDN placed & carved restorations	Number of procedures Quality of Class II restorations	Random sample of Class II restorations: Satisfactory Unsatisfactory D 45% 28% EDDN 45% 31%	EDDN placed & carved Class II restorations of comparable quality to those provided by D	Blind evaluation by 2 independent D Examiner disagreement in 25% assessments Small number of operators See also Abramowitz & Berg (1973)
Ludwick et al (56) (23) 1964 USA Incremental controlled trial	To determine the effect of delegation on the productivity & quality & on dentists & expanded duty dental nurses over prolonged periods 3 tests each of 12 weeks	D 3 EDDN 12 12 EDDN selected from 16 DN	Phase 1 A 1D, 2DN, 1 chair B 1D, 3EDDN, 2 chairs C 1D, 4EDDN, 3 chairs Phase 2 A 1D, 2DN, 2 chairs B 1D, 3EDDN, 3 chairs C 1D, 5EDDN, 4 chairs Phase 3 Repeat most efficient team EDDN placed, carved & finished restorations Patients - 5,019	Hourly work rates Productivity Quality of restorations • satisfactory/unsatisfactory (Phase 1) no external assessment • satisfactory/unsatisfactory (Phase 2) – external assessment • as Phase 2 but with 4 ratings (Phase 3) Attitudes to expanded team	Phase 2 No differences in number of satisfactory restorations (37) Phase 3 Quality of 152 restorations showed no significant differences between experimental team, known control & unknown control	D working at 2 chairs delegating procedures can treat twice number of patients with significant increase in restorations compared with 1 chair Quality not affected	Conducted in a US Navy setting Patients had high treatment needs Random sample of quality of restorations evaluated in Phase 2 & Phase 3. Final score based on majority verdict. Used known & unknown control groups of D See also Ludwick (1963)
Ludwick et al (55) (23) 1963 USA Prospective observational study	To determine the amount of training expanded duty dental nurses require before they are capable of performing selected procedures	D 3 EDDN 12 12 EDDN selected from 16 DN	12 DN selected for 7-week training course in expanded duties 3 teams of 1D& 4EDDN Clinics - 1 Patients - 25 Restorations - 62	Evaluation of quality of restorations	In research teams, 2 restorations unsatisfactory' All restorations by control group were satisfactory	Special training for DN was sufficient to justify going on to 2nd phase of the study	Small number of operators 1 clinic Blind evaluation by 3 D Effects of previous experience of DN not discussed See also Ludwick (1964)

INCLUDED STUDIES: ORAL HEALTH PROMOTION (10)

APPENDIX 7

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS
Dolan et al (115) (37) 1997 USA Questionnaire & interview	To estimate the percentage of dentists & dental hygienists who offered advice on smoking cessation	D 1,746 DH 723 Random sampling with geographical stratification 44% D response rate	Questionnaire & telephone survey of D & DH with questions on background & smoking cessation advice given	% asking patients about tobacco use Number advising patients to stop Attitudes towards policies & education	Asked all/nearly all patients seen in previous 3 months if they smoked D 33% DH 25% Provided Tobacco Use Counselling (TUC) D 29% DH 32% Advised most/nearly all those who reported smoking to stop D 66% DH 60% D who employed DH more likely to provide TUC (34%)	Tobacco cessation activities is not a routine aspect of dental practice, with variations in activities & in attitudes to further training	Large scale questionnaire survey Concerned with different types of D than with differences between D & DH Random sample Self-reported data
Halling et al (114) (36) 1995 Sweden Questionnaire	To describe tobacco prevention activities by dental personnel	D } total DH } = DN } 2,628 Random sampling from registers D 11% DH 50% DN 6% 90% response rate	Questionnaire to dental personnel on demographic characteristics, attitudes to tobacco use & prevention (11 issues)	Self-reported data on taking smoking history Counselling about tobacco use Importance of prevention work	Thought participation in tobacco prevention important D 53% DH 72% DN 54% Asked for a tobacco history routinely D 32% DH 68% DN 10% Provided routine counselling D 5% D 15% DN 3%	DH had more positive attitude to tobacco prevention, took more tobacco histories & performed more counselling than rest of dental team	Large-scale survey 90% response rate Sampled higher % of DH than D & DN Self-reported data
Hastreiter et al (113) (36) 1994 USA Questionnaire	To determine the involvement of members of the dental team in tobacco prevention & cessation activities	D 462 DH 479 DN 436 Random sampling in Minnesota Response rates: D 73% DH 79% DN 62%	D, DH, & DN completed questionnaire on procedure & patient issues related to tobacco control (32 questions) Analysis of results	Personal tobacco use Practice policies & procedures Tobacco cessation activities	Including soft tissue examination D 98% DH 91% DN 79% Asking smokers about tobacco use D 55% DH 61% DN 20% Said educational materials available routinely D 34% DH 24% DN 20%	By acquiring tobacco intervention skills, D, DH & DN can take a leading role in reducing disease & mortality	Study indicates more DH than D ask smokers about tobacco use or document it in patient records Random sampling of members of the dental team Self-reported data

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS
Secker-Walker et al (112) (36) 1994 USA Questionnaire	To compare smoking cessation activities in female patients using 6 types of health workers including dentists & dental hygienists	D 97 DH 82 Sampling from registration lists Response rates D 80% DH 78%	Survey of 6 groups of health workers for data on smoking cessation activities Analysis of results Questions - 19	Number of patients per week Number of smokers per week Number professionals asking about smoking Mean time spent counselling patients	Number asking new patients about smoking New Old D 55% 33% DH 66% 47% Median time spent counselling patients 3 minutes for D & DH	Clear that there are opportunities for educational interventions that could increase effectiveness of health professionals	Small sample Self-reported data Study showed DH provided more advice than D Primarily a survey of 6 groups of health workers See also Secker-Walker (1987)
Little et al (111) (36) 1992 USA Randomised controlled trial	To test the effectiveness of an intervention to reduce use of smokeless tobacco delivered in context of oral health care	D not stated DH not stated Employees of an insurance system	Following baseline survey, smokeless tobacco users randomly assigned to routine care & intervention groups Intervention group had examination & smokeless tobacco intervention programme by DH Follow-up at 3 months Patients - 518	% patients reporting giving up smokeless tobacco at 3 months compared to baseline Defined as no smokeless tobacco or no tobacco use for previous 7 days	Rate of giving up Intervention group 32% Usual care 21% No tobacco use Intervention group 19% Usual care 12%	Significantly greater proportion of patients in intervention group reported stopping using smokeless tobacco compared to patients in usual care	Patients were assigned randomly Self-reported data Patients in usual care may have received advice from D/DH 88% patients included in the follow-up
Uitenbroek et al (109) (35) 1989 Netherlands Questionnaire	To assess the influence of dental hygienists on the attitudes & behaviour of their patients	Practices employing hygienists DH 10) 26% Practices not employing hygienists 9 39% Patients selected from 19 practices Response rates D 39% DH 40%	Questionnaire given to patients attending practices that did and did not employ DH Analysed influence of DH Questionnaires - 1,389 Responses - 559 Used - 461 Practices - 19	Results of scales of: • patients' knowledge • motivation • self-care • perception of change	Mean scores for dental knowledge D 10.0 DH 11.6 Motivation Self care D 14.2 14.7 DH 15.3 16.3 Perception of change D 12.9 DH 14.7 Regression analysis showed that on all scales, patients cared for by DH score higher	On all scales, patients cared for by DH score higher than patients not cared for by DH DH successful in behavioural aspect of work	Complex analysis where it is difficult to separate effects of D & DH Partly dependent on the validity of the scales Self-reported data Response rates given not accurate

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS
Wight & Blinkhorn & Blinkhorn et al (108/107) (35) 1988 Scotland Controlled before & after study	To assess effectiveness of 2 oral health education programmes led by dental hygienist & teachers	DH 1 E not stated Control group (C) Patients selected by invitation Response rate 69%	Children enrolled in: A oral health education advice by DH B school-based programme C control group with no advice Evaluated dental health at baseline & 2 years later Patients - 1,273 Schools - 9	Incidence of caries at baseline & 2 year examination Gingival health at same time Level of dental knowledge • dental caries • diet • oral hygiene • snacks • value of fluoride Costs	Mean DMFT increment over 2 years DH 1.45 E 1.88 C 1.81 Gingival health at final examination, 5+ sites/12 DH 13% E 12% C 20% Questionnaires indicated that more subjects in DH & E groups had better dental knowledge than C group Cost in terms of resource-related index units DH 3.45 E 2.21	Neither scheme could be recommended on clinical or economic grounds Preventive programmes generate extra costs with regard to treatment	Schools matched for socio-economic status Randomly allocated Not clear whether control group is usual care <u>Really a comparison between DH & E</u> 84% patients included in the follow-up
Secker-Walker et al (110) (35) 1987 USA Questionnaire	To survey health promotion activities of dentists & dental hygienists in relation to smoking	D 37 DH 27 Invitation to 61 D in 1 county in Vermont 61% D response rate	Questionnaires to D & their DH about health promotion & smoking (30 items) Survey of smoking habits of patients Patients - 256	Number D & DH • taking smoking history • advising & discussing with patients • willing to learn new methods of giving advice • patients who recalled being given advice	Took smoking history D 84% DH 86% Advised patients On smoking Cut down D 76% 41% DH 81% 53% Willing to learn new methods D 68% DH 89% Patients recalling advice Female Male D 31% 20% DH 26% 12%	No correlation between behaviour of D & DH in terms of taking a smoking history, % smokers advised against, & content/nature of advice	Study that directly compares D & DH Response rate was 61% Small sample size & small number of operators Self-reported data See also Secker-Walker (1994)
Axelsson (105) (34) 1981 Sweden Prospective interrupted time series	To see whether oral hygiene instruction & prophylaxis can prevent caries & progression of periodontitis	D not stated DH not stated) Patients volunteers	Following baseline examination, patients allocated to test & control groups Test group received oral hygiene instruction & oral prophylaxis by DH • once a month in first 2 years • every 3 months in next 4 years Patients - 456	Mean plaque scores Gingival inflammation scores Clinical pocket depth Clinical attachment levels Carious surfaces	In follow-up examinations: <u>Test group</u> : improved oral hygiene conditions & plaque scores. <u>Control group</u> : no improvement Test group: • low gingivitis scores • no changes in attachment levels • decreases in frequency distribution of probing depths >3mm <u>Test group</u> : did not develop caries <u>Control group</u> : developed caries	Preventive programme that stimulates individuals to adopt proper oral hygiene habits may prevent progression of periodontal disease & caries in adults Traditional dental care does not	Patients were assigned to test & control groups Unclear who is doing the health education 18% loss in follow-up See also Axelsson (1978)

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS
Tan et al (106) (35) 1981 Netherlands Controlled cohort study	To assess the effect of repeated dental health care education on gingival health, knowledge, attitude, behaviour, perceptions	D not stated DH not stated Patients military cadets & volunteers	Following baseline examination, patients allocated to experimental & control groups Experimental groups received health education & single prophylaxis from DH for one year (repeated) Examination at 1 year Patients - 214	Mean scores for: <ul style="list-style-type: none"> • anxiety • attitude • behaviour • knowledge • perception Dental indices at baseline & final examination	Post-test differences between experimental & control groups significant for: <ul style="list-style-type: none"> • knowledge • attitude • sweet consumption • toothbrushing frequency • perception of condition of gingiva • home care behaviour • dental care indices Experimental groups: <ul style="list-style-type: none"> • used dental floss & toothpicks more frequently • more often thought of diagnosing gingivitis • used fluoride toothpaste more 	Significant improvements in experimental groups knowledge, attitude, behaviour, perceptions of gingival status, ability to diagnose gingivitis & condition of tissues	Patients were military cadets with high socio-economic status in an atypical environment Unclear comparison with usual care Complex analysis with the separate effects of health education & prophylaxis not clear No information about operators

INCLUDED STUDIES: ACCEPTABILITY (13)

APPENDIX 8

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS																		
Friedrichsen et al (121) (41) 1992 USA Questionnaire	To compare the socio-economic status & choice patterns of patients of clinical dental technicians & dentists	D 104 CDT 31 Patients recruited from those attending public health "fairs" & cancer screening	Assisted questionnaire seeking data about patients' socio-economic status & use of services Patients - 135	Socio-economic data Choice patterns Reasons for provider choice Level of patient satisfaction	No statistically significant correlation between patients' choice of D or CDT in terms of age, sex, marital status, income, occupational status Main reasons for selecting operator <ul style="list-style-type: none"> • D recommendation & previous use of services • CDT price & recommendation Satisfaction <table border="0" style="margin-left: 20px;"> <tr> <td></td> <td>High</td> <td>Moderate</td> </tr> <tr> <td>D</td> <td>52%</td> <td>30%</td> </tr> <tr> <td>CDT</td> <td>68%</td> <td>16%</td> </tr> </table>		High	Moderate	D	52%	30%	CDT	68%	16%	History, choice of provider, & level of satisfaction remarkably similar in both groups	Study shows that patients of CDT were more satisfied with treatment than those of D Non-random sample Response rate not known All self-reported data									
	High	Moderate																							
D	52%	30%																							
CDT	68%	16%																							
Tuominen (120) (40) 1987 Finland Questionnaire	To see whether dentists & clinical dental technicians provide complete dentures services to different groups	D 98 CDT 46 Invitation to 150 D & 53 CDT D selected from registers CDT selected from membership lists	D & CDT distributed questionnaires to patients in one specific week Patients D - 144 Patients CDT - 456 Response rates D patients - 62% CDT patients - 60%	Characteristics of patients in terms of <ul style="list-style-type: none"> • age • education • income • location • sex Oral health status Level of satisfaction with treatment	No statistically significant difference in oral health status Patient satisfaction <table border="0" style="margin-left: 20px;"> <tr> <td></td> <td>Oral Health</td> <td>Current Dentures</td> </tr> <tr> <td>D</td> <td>74%</td> <td>94%</td> </tr> <tr> <td>CDT</td> <td>87%</td> <td>95%</td> </tr> </table> Attendance <table border="0" style="margin-left: 20px;"> <tr> <td></td> <td>Regular</td> <td>In Pain</td> </tr> <tr> <td>D</td> <td>20%</td> <td>60%</td> </tr> <tr> <td>CDT</td> <td>17%</td> <td>46%</td> </tr> </table>		Oral Health	Current Dentures	D	74%	94%	CDT	87%	95%		Regular	In Pain	D	20%	60%	CDT	17%	46%	Some differences in socio-economic backgrounds of patients of D & CDT, but similar levels of satisfaction Many complete denture patients only attended when had pain or discomfort Only 5% CDT patients had been advised to see D, indicating that co-operation between 2 types of operators is rare	Not primarily concerned with levels of patient satisfaction All self-reported data
	Oral Health	Current Dentures																							
D	74%	94%																							
CDT	87%	95%																							
	Regular	In Pain																							
D	20%	60%																							
CDT	17%	46%																							

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS
Milgrom et al (77) (40) 1983 USA Prospective observational study with crossover element	To assess the impact of using expanded duty dental nurses & expanded duty dental hygienists on productivity in private practice & the effect on patients	D 126 EDH not stated EDDN not stated 126/400D recruited approached (32%)	Patient questionnaires distributed to first 50 adult patients in each practice over 2-week period in 1979, 1980 & 1981 Practices - 126 Patients not stated	Structure & process of care Quality of restorations Patient satisfaction (13 dimensions)	Patients were satisfied with care Between 4.4-5.9 on scale of 1 – 6 No dissatisfaction with delegation Satisfaction with dentist/patient relations, patient waiting time, cost, & continuity of care was less when the delegation ratio was higher	Patients highly satisfied with dental services, including those provided by PCDs Evidence that patient satisfaction decreased when the delegation ratio was higher	Broad survey data from 126 practices that is mainly concerned with productivity Self-reported data Response rate not stated Not clear whether patient satisfaction was assessed at baseline Nature of comparison unclear See also Mullins (1983)
Mullins et al (74) (40) 1983 USA Prospective before & after study	To determine the effect of expanded duty dental hygienists & expanded duty dental nurses in practice & assess the future potential	D not stated EDH not stated EDDN not stated 14 practices selected from all practices in Kentucky	Practices in Kentucky took part in a programme to foster increased use of EDH & EDDN Analysed effect over 24 months (6 months baseline, 12 months training, 6 months demonstration) Practices - 14 Patients - not stated	Number of practices using EDH/EDDN in expanded duties Increases in productivity & income Changes in patient demand & operator turnover Patient satisfaction with work	Evidence of decrease in advanced bookings in 11 practices & increase in 1 Influenced decisions not to increase delegation in 7 practices Despite wide range of delegation in all practices, patient satisfaction scores did not change Narrow range indicated high patient satisfaction for all practices In interviews, D reported no major problems with patient accepting delegation	Evidence of decrease in patient demand following changes Patient satisfaction scores did not change	Summary of a study, but no actual data Uses patient demand as a proxy for acceptability to patients, along with scores & interviews with D Not clear extent to which patient satisfaction was assessed at baseline No data on patient satisfaction scores See also Mullins (1979) Chapko (1985)

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS															
Lobene (82) (39) 1979 USA Controlled trial	To test whether delegation increases productivity, reduces costs, & enables dentists to spend more time on challenging procedures	D not stated EDH 10 EDH recruited from DH graduating from 3 schools of dental hygiene	EDH trained for 47-weeks & evaluated over 14 months Assessed increases in: • acceptability to patients • costs • productivity • quality of work • speed & efficiency Clinics - 1 Patients - 2,668 Carried out in a specially designed clinic	Quality of cavity preparations & restorations using quality points Acceptability to patients Time usage by D Hourly & annual income	Evaluations completed by 1,200 patients - 45% Range of levels of patient satisfaction with aspects of care - 91%-99% Did not know which operator carried out the treatment - 39% Correctly identified operator as EDH - 46%	Patients expressed satisfaction with treatment that they received	Study deals with irreversible procedures Conducted in specially-designed experimental clinic Implicit comparison Patient response rate 45%															
Rantanen & Kononen (119) (40) 1979 Finland Questionnaire & interview	To assess the number of dentures supplied by dentists & clinical dental technicians & patients' intentions for future care & reasons for their choice	D not stated CDT not stated Random sample of population aged 18-64 in 2 towns, 1 rural & 1 municipal	Questionnaire & interview of edentulous patients & patients with 1 edentulous jaw to determine service use, future intentions & reasons Patients - 220	Number of dentures supplied by different providers Reasons for patient choice Degree of patient satisfaction with treatment	Supply of full dentures <table border="1"> <tr> <td></td> <td>Now</td> <td>Future</td> </tr> <tr> <td>D</td> <td>50%</td> <td>33%</td> </tr> <tr> <td>CDT</td> <td>41%</td> <td>56%</td> </tr> <tr> <td>Both</td> <td>10%</td> <td></td> </tr> <tr> <td>Not known</td> <td>11%</td> <td></td> </tr> </table> Patients of D reasons • good result • previous/existing treatment relationship Patients of CDT reasons • lower cost • thought better than/at least as good as D Only statistically significant correlation in terms of choice was with locality (P < 0.01)		Now	Future	D	50%	33%	CDT	41%	56%	Both	10%		Not known	11%		When health centre services become cheaper & more general, majority of edentulous will go to D, but many will go to CDT	Indirect assessment of degree of satisfaction Random selection of patients Response rates were 94% & 83% Self reported data
	Now	Future																				
D	50%	33%																				
CDT	41%	56%																				
Both	10%																					
Not known	11%																					

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Gilmore et al (116) (39) 1976 USA Questionnaire	To assess the attitudes of different types of operators & patients to expanded duties	D not stated D(s) not stated DH not stated DH(s) not stated DN(s) not stated 1,200 questionnaires sent to stratified sample of people in Massachusetts	Questionnaire to dental personnel & patients with semantic differential test on acceptability of dental auxiliaries carrying out selected tasks Patients - 67	Attitudes Acceptability of expanded duties	Except for DH(s) all types of operators & patients negative to PCDs cutting teeth Cavity restorations All perceived significant differences between D & other operators (means 1.04 & 1.89) Taking radiographs All groups perceived virtually no difference (means 2.03 & 2.02) Patients were the least positive about all procedures & perceived only moderate differences between operators	Patients more concerned with procedures than with type of operator	Patient response rate only 5% Patients were stratified geographically Little detail about patients Self-reported data
Martens et al (118) (40) 1975 USA Questionnaire	To determine whether patients who had been treated by expanded duty dental hygienists & expanded duty dental nurses were more positive towards them	D not stated EDH not stated EDDN not stated Historical	Questionnaire to 3 groups of patients about response to auxiliary performance: A TEAM clinic B dental school C private practice Procedures included: • fluoride treatment • impressions • oral hygiene instruction • polishing restorations • prophylaxis • radiographs • rubber dam Patients - 455	Positive & negative responses to range of procedures carried out by PCDs	Simpler procedures All patient groups highly favourable to delegation TEAM patients responded more favourably to delegation than patients in other groups TEAM patients who had experienced EDH & EDDN placing amalgam, cavity preparation, & anaesthesia more favourable to the delegation than patients who had not	TEAM patients more favourable to PCDs carrying out extended duties, eg cavity preparation, placing fillings & anaesthesia	72% response rate in the TEAM clinic Little detail about the dental school & private practice including response rates Self-reported data

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Sisty & Henderson (117) (39) 1974 USA Questionnaire	To see whether patients were as satisfied with operative & periodontal procedures carried out by expanded duty dental hygienists as by dentists	D(s) 8 EDH(s) 12 Patients receiving treatment at the University of Iowa College of Dentistry	Questionnaire on patient satisfaction with procedures by D(s) & EDH(s) distributed during 15 week period Operative procedures included: <ul style="list-style-type: none"> • Class I, II, III & V cavity preparations for amalgam & composite resin restorations • treatment planning • periodontal • gingivectomy • root planing • soft tissue curettage Patients - 1,161 Periodontal - 667 Operative - 494)	Patients' evaluation of satisfaction with operative & simple & advanced periodontal procedures	Operative procedures D(s) & EDH(s) rated similarly in 5/6 specific categories. 1 favoured EDH(s) Advanced periodontal procedures Patients rated EDH(s) as slightly better than D(s) in 5/6 categories. None statistically significant Other periodontal procedures Patients rated EDH(s) as better in all 6 specific categories. 3 statistically significant	Patients accepted operative & periodontal procedures carried out by EDH(s) at same level of satisfaction as those carried out by D(s)	Study conducted in a dental school 48% periodontal & 38% operative patients treated by EDH(s) correctly identified them Patient response rates 52% periodontal & 41% operative
Benson (87) (40) 1973 USA Randomised controlled trial	To train 4 expanded duty dental nurses to carry out all the intra-oral procedures involved in making complete dentures	D 3 D(s) not stated EDDN 4 EDDN selected from 2-year training programme	Phase 1: Training course Phase 2: Clinical programme <ul style="list-style-type: none"> • evaluations of treatment & dentures • patients' evaluation • written examination Procedures included: <ul style="list-style-type: none"> • face-bow transfer • preliminary & final impressions • recording vertical dimension & centric relation Patients - 28	Ability of EDDN to carry out a range of procedures Quality of dentures (7 characteristics) Patient satisfaction	Similar patient evaluation scores for dentures fitted by EDDN & D(s) Satisfaction with new dentures Not as good Same Better D(s) 5% 17% 78% EDDN 8% 25% 66%	Performance of EDDN comparable to that of D(s) EDDN need 1-2 year training programme to be completely proficient	Only study that looks at the clinical aspects of complete dentures On average EDDN patients had worn dentures longer D(s) patients randomly selected Different training for D(s) & EDDN Small number of operators & patients

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Soricelli (62) (39) 1972 USA Retrospective before & after study	To train & employ expanded duty dental nurses & assess its feasibility & advisability	D not stated EDDN 4 DN not stated EDDN selected from DN	7-month training programme for EDDN Various team mixes tried Evaluation of qualitative & quantitative results	Number of surfaces treated Number of patient visits per session Quality of performance Quality of restorations Patient acceptability	Acceptability to patients overwhelmingly favourable Evidence that broken appointment rate declined from 60% to almost zero after programme started Only 1 patient refused to be treated by EDDN in 2 years	EDDN trained for short periods of time can carry out dental procedures effectively	Broken appointments & refusals used as a proxy for acceptability to patients Response rate not known Assessment criteria not known Implicit comparison only Small number of operators See also Della Pelle (1973)
Lotzkar et al (62) (39) 1971 USA Prospective incremental design	To determine the qualitative & quantitative effects of delegating duties to expanded duty dental nurses in private practice	D 7 EDDN 32 17 EDDN had 2+ years experience	Phase 1 Compared teams working traditionally with Phase 2 After EDDN trained to carry out additional procedures Phase 1 1D, 1DN Phase 2 1D, 1EDDN Procedures included • adult radiographs • alginate impressions • carving & polishing amalgam • charting • oral health instruction • placing amalgam • post-surgical instruction Practices - 1 Patients - not stated	Quality of procedures Level of patient satisfaction Time taken to complete procedures Average number of patients, procedures in time units per day	Questionnaires distributed in Phase 2 indicated patients found 95% procedures satisfactory Equal to that indicated by patients during baseline phase Patients indicated care at baseline & Phase 2 compared favourably with care provided by D	DN can be successfully trained as EDDN	Patients had high treatment needs & little prior experience of dental care Specially designed experimental dental clinic Response rate not known See also Lotzkar (May 1971)

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Lotzkar et al (63) (39) 1971 USA Prospective incremental design	To determine the qualitative & quantitative effects of assigning chairside duties to expanded duty dental nurses	D 6 EDDN 32 EDDN: 17 had 2+ years experience	In third phase, D worked as teams leaders with varying numbers of EDDN over 3 years: A 1D, 2EDDN B 1D, 3EDDN C 1D, 4EDDN Procedures included <ul style="list-style-type: none"> • adult radiographs • alginate impressions • carving & polishing amalgam • charting • oral health instruction • placing amalgam • post-surgical instruction 	Quality of procedures Level of patient satisfaction Time taken to complete procedures Average patients, procedures, time units per day	95% patients very satisfied' Most of others fairly satisfied	EDDN can carry out delegated duties as well as D in a reasonable length of time EDDN required more time to complete procedures Dental care by D or EDDN was highly acceptable	Patients had high treatment needs & little prior experience of dental care Specially designed experimental dental clinic Response rate not known See also Lotzkar (January 1971)

INCLUDED STUDIES: PRODUCTIVITY (53)

APPENDIX 9

AUTHOR/REF/ PAGE/DATE/ COUNTRY STUDY DESIGN	PURPOSE	OPERATORS RECRUITMENT	INTERVENTION	OUTCOME/FOLLOW UP	STUDY RESULTS	AUTHORS' CONCLUSION	COMMENTS
Holst et al (146) (50) 1997 Sweden Prospective cohort study	To assess dental nurses' selection of children at risk of caries, & compare dental health & time spent in test clinic with rest of county	D not stated EDDN 1	EDDN screened all children at 1, 2, & 3 years Compared dental status at 4 years with risk assessment Patients – 102 (1990 birth cohort)	Sensitivity & specificity of risk assessment Caries at 4 years Time spent by D & EDDN	Prevalence of caries at age 4 Test clinic County 7% 24% Statistically significant Average time/child to age 4 Test clinic County D 14 mins 42 mins EDDN 152 mins 102 mins	Model used for caries prevention in pre-school children is effective & cost- effective.	Experiment with 1 EDDN. Sequel to Holst & Braune (1994)
Hannerz & Westerberg (164) (53) 1996 Sweden Prospective cohort study	To test for differences in 5- year caries incidence & economic efficiency between 2 skill mix models at dental clinic	D 3 DH 5 DN 4	Introduced new models of skill mix in test clinic & maintained existing in public dental clinic Test clinic A 1D, 5DH Existing model B 2D, 4DN Multiple logistic regression analysis to predict 5-year caries incidence in each clinic Patients - 80	Caries 5-year incidence & prevalence Net benefit & cost per patient	Mean initial prevalence (DMF); 5-year incidence during study: A 3.18 1.13 B 2.51 3.29 Net benefit per patient (A-B) 546 Swedish crowns Net cost per patient (A-B) 369 Swedish crowns	Lower caries incidence among patients in A, arguably due to difference in preventive measures. Clinic & initial DMF were significant predictors of 5- year incidence.	No details of treatment regime at either clinic. Need more patients & clinics for further generalisability.
Wang & Riordan (29) (50) 1995 Norway Uncontrolled before & after study	To test whether dental hygienists undertaking recall examinations affects quality of care	D not stated DH not stated	DHs took responsibility for recall examinations in districts A & B from 1988 Compared dental health of 18 year olds in A & B at baseline in 1987 & after intervention in 1989-91 Baseline patients 161 A + 139 B) Follow up patients 517 A + 439 B	Dental health % of surfaces interpretable on X-ray & sound Prevalence of caries Restoration threshold	Recall intervals increased from 12 months to 16-18 months. Radiographic quality improved in A but not in B % patients with caries increased significantly in B but not A.	Change in policy did not lead to major changes in recall interval or quality of care in short term. However very few surfaces that were sound or had caries only in enamel were restored	No details of DHs.
Wang (163) (53) 1994b Norway Questionnaire	To study which combinations of dentists & dental hygienists are economically efficient	D not stated DH not stated 137 clinics (83 with DH, 54 without) recruited by Wang (1994a)	Multiple regression analysis to estimate Cobb-Douglas production function from data collected by Wang (1994a)	Children treated	Clinics without DH treated mean of 600 fewer children Marginal product of D time D only 0.58 DH 0.61 Time per child Non-DH clinic 1.48 hours DH clinic D time 1.26 hours DH time 0.18 hours	Extended use of DH saves D time but not cost. DHs might be economically efficient with more delegation.	Comparability of clinics not clear. Analysed data from Wang (1994a).

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Wang (162) (53) 1994a Norway Population survey	To compare the amount of time spent by dentists & dental hygienists per child per year	D not stated DH not stated 137 of the 194 clinics in Norway Response rate 71%	Questionnaire to 137 clinics to measure productivity & independent variables Patients - not stated	D & dental care time/child/year	Time spent/child depends on: interval between examinations, proportion of male Ds, ratio DN/D, proportion of treatment by DH, proportion of all treatment time spent on child patients	Dental care time longer where DHs employed. DH working without D took longer than D.	Some aspects of comparison not clear. Data further analysed by Wang (1994b).
Holst & Braune (145) (50) 1994 Sweden Prospective cohort study	To assess dental nurses' selection of children at risk of caries, & compare dental health & time spent in test clinic with rest of county	D not stated EDDN 2	Specially-trained EDDNs in test clinic screened children likely to develop caries at 1, 2 & 3 years Prevalence of caries assessed by examination at 4 years Patients – 102 (1987 birth cohort)	Sensitivity & specificity of risk assessment Caries at 4 years Time spent by D & EDDNs	Prevalence of caries at age 4 Test clinic County 19% 23% Not statistically significant Average time / child to age 4 Test clinic County D 27 mins 60 mins EDDN 71 mins 90 mins	Model for caries prevention in pre-school children was cost-effective, but less effective with high risk patients.	Experiment with 2 EDDNs. Model for Holst et al (1997).
Brown et al (144) (49) 1994c Australia Sample survey	To compare the delivery of periodontal care between practices employing & not employing dental hygienists	D 75 DH 22 Response rate D 40% DH 55% From 18 DH practices & 29 non-DH practices.	Collected data on provision of services over 2 days by all Ds & up to 5 days by all DHs Adjusted results in DH practices to give average service provision by Ds & DHs combined over 2 days	Procedures & patient visits Periodontal services provided	Mean procedures Non-DH practice 68.8 DH practice(+42%) 97.9 Mean number of patients Non-DH practice 39.1 DH practice (+46%) 57.2 Periodontics as % of total Non-DH practice 23% DH practice 7%	Practices employing DHs provided more periodontic services, so DHs complemented services provided by Ds.	DH practices had more & younger dentists than the rest.
Brown et al (125) (44) 1994b Australia Partly randomised cluster trial	To evaluate an educational programme of periodontics in practices employing & not employing dental hygienists	D not stated DH not stated DH practices recruited in (1994a) became group C Non-DH allocated to A or B	Educational programme about periodontics. Practices without DH allocated to education or not. Evaluated effect on provision of care in intervention & 2 control groups: A Control without DH (12 practices) B Intervention without DH (12 practices) C Control with DH (12 practices) Patient records - 2,142	Periodontal procedures over 12 months	Mean increase in % of records with procedures Diagnosis Prevention All A 9% 2% 4% B 15% 2% 4% C 21% 15% 10%	Educational programme can lead to significant increases in provision of periodontal care. DH practices more receptive to educational programme	Randomisation of practices without DH between education or not is not relevant to this review. Sequel to Brown et al (1994a).

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Brown et al (143) (49) 1994a Australia Retrospective observational study using routine data	To compare periodontal records between practices employing & not employing dental hygienists	D 63 DH 6 13 DH practices by invitation (response 79%), random sample of 25 non- DH practices Response rate 71%	Recorded prevalence of periodontal diagnostic, preventive, & treatment items in patient records in the 2 types of practice Patient records - 2,300	Recorded items for diagnosis, prevention & treatment	DH practices recorded 5/12 diagnosis items 5/6 prevention items, 2/5 treatment items significantly more often than practices without DHs; & 1 diagnosis item significantly less often than practices without DHs.	DH practices recorded 13 out of 23 periodontal items significantly more often than practices without DHs. However there was little recording of many items by D or DH.	Validity of recording unclear. Not clear whether D or DH recorded these items. Baseline for Brown et al (1994b).
Utriainen & Widstrom (161) (53) 1990 Finland Prospective observational study	To estimate effectiveness, output & costs of dental care at different clinics & analyse relationships between these	D 367 EDDN 28 DN 470 Other PCD 35 16% random selection of 34 of 215 dental clinics in Finland	Multiple regression analysis of productivity in the Public Dental Service in Finland from 1982-85 with significant predictors including DMF scores by age group, proportion of 0- 18 year olds who were caries free, & proportion of population examined	Cost per dental visit & patient examined	Costs per visit +ve correlation with ratio DN:D [20% increase in cost when ratio increases by 1] & -ve correlation with financial capacity Costs per patient examined Analogous correlations [13% increase when ratio rises by 1].	Optimal ratio of PCDs to dentist not previously known. Increase in PCDs seemed to lower productivity	Large-scale study of randomly selected clinics. Apparent effect on productivity may be due to high existing number of DNs per D.
Nordengen et al (160) (52) 1990 Norway Cross-sectional study using routine data	To explore the benefit & costs of extending dental hygienists' duties	D not stated DH not stated	Modelled reduced need for Ds & costs of alternatives to status quo: (moderate) DHs carry out diagnostic & sealant work; or (radical) ditto plus anaesthesia & restorations Patients - 781	Estimated time for treatment procedures Numbers of Ds & DHs needed	Moderate alternative DH increase 16-198 D decrease 98-175 Radical alternative DH increase 138-225 D decrease 138-226	Moderate alternative could reduce number of Ds by 15%. Changes in distribution of dental staff could save 6% of cost of Public Dental Health Service	Limited to one region. Not clear how costs were estimated.
Spencer & Webster (142) (49) 1989 USA Sample survey	To examine the relationship between practices employing dental hygienists & provision of periodontal care	D 137 DH 101 Stratified sample yielded 56% response from 137 practices	Questionnaire to D to evaluate effect of employing DH	Periodontal procedures – number, % of total services & of total time	Employment of DHs significantly associated with number of periodontal procedures, % total services that were periodontal, % total time devoted to them, & more effective delegation	Employment of DHs is associated with higher output of services, periodontal services & restorative services.	Abstract only.
Sintonen (141) (49) 1986 Finland Sample survey	To compare the productivity of public & private dentists, & explore what factors explain difference	D 49(public) D 42(private) EDDN not stated DN not stated Systematic sample of 150 Finnish Ds with 65% response rate	'Stepwise' regression analysis of production function ln (output/D-hr) Of 5 models considered final model had 13 significant parameters including working hours of formally trained (L1) & job- trained (L2) DNs & EDDNs. R ² = 0.50.	Output per D-hr, visits/D-hr, procedures/D-hr, output per chairside D-hr (clinical productivity).	Increase in output/D-hr from: DN EDDN L1 31% 50% L2 39% 60% After adjusting for service mix, patient characteristics, & whether public or private.	No significant difference between L1 & L2. Public Ds had higher clinical productivity through more use of PCDs, but fewer chairside hours than private Ds.	EDDN & DN parameters may underestimate effects as EDDN & DN often work in same practice. No significant difference between L1 & L2

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Bentley et al (124) (44) 1984 USA Partly randomised cluster trial (patient groups allocated to private, EDDN or no EDDN)	To assess the effect of different treatment suppliers on dental health; & relationship between costs, location & staffing	D not stated EDDN not stated	Compared 3 forms of practice: A 2EDDN, 1D,1DN B 1D, 1DN C Treatment by private dentists Some treatment of patients in A or B delegated to private dentists. Effect of additional education factor (allocated by school) also assessed Patients with full records analysed by adjusting for state of teeth Patients - 1,859 (child) 1,452 had complete records 1,392 were treated > once	Cost per patient assigned & per patient treated > once Costs / relative value unit (RVU) Costs per patient	Cost / RVU A \$0.34 B \$0.35 C \$0.36 Cost/patient Assigned Treated A \$205 \$215 B \$216 \$229 C \$180 \$235 Adjusted cost/ patient treated A \$242 B \$265 C \$233	Mean cost of children in C lower than in A or B but less treatment given. A provided 3% more RVU at a 4% higher cost/patient than C; B provided 7% more RVU at a 14% higher cost/patient than C Cost of continuing programme unclear.	Large numbers of patients in 1 county. Randomisation may not have been secure. No details of skills mix in private sector. Conclusions therefore need caveat.
Mullins et al (74) (51) 1983 USA Before & after study with historical controls	To estimate the effect of expanded duty dental hygienists & expanded duty dental nurses on practices	All not stated 14 invited practices	Programme to promote use of EDDH & EDDN over 2 years	Increases in productivity & income performance Dental auxiliary turnover	3/5 Ds who increased delegation increased productivity by 14-18% & net income by 20-39% Productivity related to number of chairs (2 or 3) but not to delegation rate High unexplained turnover	Higher productivity is possible through basic delegation in regular practice. Not possible to isolate productivity & income increases caused by delegation alone.	Few data presented! Comparison unclear & sometimes contradictory Used data from Mullins et al (1979) as historical control.
Nixon (83) (49) 1980 USA Controlled before & after study	To assess the feasibility of increasing the role of expanded duty dental nurses to include all aspects of dentistry	D not stated DN 4 DNs in 4 practices selected to train as EDDNs	Trained 4 dental nurses in expanded duties including: • Class IV aesthetic restorations • complete dentures • pocket debridement • pulpectomy • removable prostheses • stainless steel crowns	Number & type of procedures Time taken Quality of procedure	Procedures Except for stainless steel crowns, increased by 55-233% Productivity Time taken decreased in 3/4 practices by 20, 16, 10, & --16 minutes/procedure	EDDNs are capable of providing large variety of reversible procedures at a quality level comparable to that of D.	Not clear if patients were comparable. Evaluation independent, but process not clear
Klock (159) (52) 1980 Sweden Prospective incremental design	To analyse the costs & benefits of a preventive programme	D not stated EDDN 1	EDDN provided extra preventive measures for children for 2 years Compared with usual care by CEA & CBA	Oral health status of children at 1 & 2 years Costs	Cost effectiveness ratio per surface saved = 186.1 Cost per child per year 1974/75 1976/77 EDDN 286 280 Usual 334 348	Usual dental care less expensive than preventive care. Preventive care can be less expensive if clinic focuses on prevention.	Compared 1 clinic with EDDN with 9 other clinics. Not clear if patients were comparable.

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Mullins et al (73) (49) 1979 USA Prospective incremental design with computer simulation	To estimate the effect of using expanded duty dental nurses on productivity, income & costs	D 2 EDDN 4 DN 2	Compared baseline period (6 weeks- A) with expanded phase (6 months- B) A 2D, 2 DN & 2 chairs B 2D, 4EDDN & 2DN Simulated several teams for solo practice, but reported only: A 1D, 1DN, 2 chairs B 1D, 2DN, 3 chairs C 1D, 2EDDN, 1DN, 3 chairs Baseline period - patient visits - 350 Expanded phase - 1,500	Patient visits Gross billings Total expenses Net income Quality of restorations	% increase of C over A B Patient visits 35% 11% Gross billings 36% 11% Total expenses 48% 16% Net income 19% 3% Quality of restorations Baseline Expanded Acceptable 97% 91%	Productivity & income increased by delegation of more complex functions in expanded phase. C was most efficient expanded configuration, B most efficient non-expanded configuration. With more training EDDN could improve productivity further	Differences in patient mix & number of operators adjusted by computer simulation. Evaluated quality of only a few restorations in each phase.
Overstreet et al (155) (51) 1978 USA Prospective incremental design with computer simulation	To estimate the optimum team mix for practices using expanded duty dental nurses	D 4 EDDN 3 DN not stated	Evaluated productivity over 11 months in: Control 1D, 2DN A 1D, 1EDDN, 2DN B 1D, 1EDDN, 3DN C 1D, 2EDDN, 2DN D 1D, 2EDDN, 4DN Enhanced analysis by computer simulation based on Pelton et al (1973a & b)	Procedures & patients/day Type of procedures Costs Annual income projections	Increases over control Procedures Patients A 50% 48% B 60% 62% C 75% 63% D 75% 64% Gross income Net income A 59% 62% B 69% 65% C 76% 51% D 76% 38%	Optimum team size was 1 D, 1 EDDN, 2 DN. 62% increase in annual net income in A over control. An extra DN improves this very little. Teams with 2 EDDN not financially productive.	Few operators in 1 practice Used data from Pelton et al (1973a & b) as historical control.
Kushman et al (158) (52) 1978 USA Retrospective observational study using data from national survey	To estimate the transcendental production function for non-solo general dentists & explore whether there are increasing returns to scale	D 3,980 DH 620 DTech 210 Clerks 1,100 All 29,316 US D sent survey in 1967-70 Response rate 85%	Estimate transcendental production function for D & DH visits / week. DTechs, DNs & clerks combined as 'aides' in the final model, as their effects did not differ significantly. This model has 23 significant parameters, also including dentists' ages, sexes, practice size & area. $R^2 = 0.43$.	% increase in visits / week Marginal product in visits/week Revenue/wages when adding one aide or DH	Increase in number of visits: 1 aide/D +11% 1 DH/D +48% Marginal product at mean: Aide 7.5 DH 40 (18 corrected) Marginal revenue/wages: Aide 1.1 DH 2.8 (1.2 corrected for bias in dentists estimates of DH work)	Ds use DHs & other 'aides' consistent with competitive maximisation of profits. The competitive model is therefore appropriate for analysing demand for dentistry.	Non-linear model so productivity of DH, DTech & DN dependent on hours worked. Scheffler & Kushman (1977) analysed all single- handed practices from the same survey.

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Davis et al (140) (48) 1978 USA Prospective observational study	To explore whether four-handed dentistry saves time & increases productivity	D(s) 21 DN 8	Time study to estimate effect of DAU programme In clinic with 21 chairs, 8 were assigned to DAU (1D(s) & 1DN), remainder to D(s) working alone (13) Patients - 312	Times taken for specified procedures	Preparing cavity Assisted 47.7 mins Unassisted 47.7 mins Placing cavity lining Assisted 8.9 ms Unassisted 10.0 mins Placing & carving filling Assisted 40.2 mins Unassisted 27.5 mins	Gains in productivity are less likely while DAU personnel are training, but more likely with experienced dentists.	Equipment differed between the 2 groups.
Tan & van Gemert (139) (48) 1977 Netherlands Prospective observational study	To compare & analyse time utilisation, productivity & costs of 2 types of service delivery in a group practice	D 2 EDDN 2 DN 2	Compared 2 types of care over 1 month: A 1D, 1DN, 1 chair B 1D, 2EDDN, 1DN, 2 chairs	Time utilisation Productivity by standard restorations per minute Costs	Standard restorations A 0.12 / min B 0.18 (+53%) % of dentist time spent Preparing Finishing A 11% 20% B 32% 9% Fixed costs in Dutch florins A 171,000 B 260,000 (+52%)	B can produce 53% more restorations than A, but costs increase by 52%.	Only activities that EDDN, but not DN, can do. Time utilisation data based on 8% sample. No data on general costs or quality of restorations
Scheffler & Kushman (157) (52) 1977 USA Retrospective observational study using data from national survey	To estimate the transcendental production function for solo dentists, & explore whether behaviour of dentists is consistent with efficient use of dental auxiliaries	D not stated DH not stated DN not stated DTech not stated Clerks not stated All 29,316 solo US D sent survey in 1967-70 Response rate 85%	Estimate transcendental production function (logarithmic regression model with some quadratic terms) for D & DH patient visits/ week. Main model has 17 significant parameters, including numbers of DH, DN, DTech, clerks (all with squared terms), chairs, chairside & non-chairside time, & dentist age & age squared. R ² = 0.45	% increase in patients / week Marginal product in visits / week Ratio marginal revenue / wages when adding DH, DN, DTech or clerk	Increase in number of visits DH +25% DN +13% DTech - 5% Marginal product at mean DH 16.1 DN 7.7 DTech -4.0 Clerk 6.2 Ratio of marginal revenue to wages DH 1.38 DN 1.05 Clerk 0.77	In model DNs efficiently employed (ratio revenue to wages >=1), DH under-used, clerks over-used. Technicians decrease visits, as their Ds have more complex case mix, & use more non-chair time. Ds act to maximise profits or utility of income & leisure.	Secondary analysis of large survey with high response rate. Form of model means no explicit comparison between D & aides and their productivity depends on other parameters. Kushman et al (1978) analysed practices with 2 or more Ds from same survey.

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Parker (138) (48) 1976 USA Prospective observational study	To estimate the increase in dental care provided when EDDNs are included in dental teams To estimate the cost-effectiveness of EDDNs	D not stated EDDN not stated DN not stated Dental teams at 30 US army bases(6 control & 24 test)	Compared most common configurations: A 1D, 1DN, 1 chair (control) B 1D, 1EDDN, 1DN, 2 chairs C 1D, 2EDDN, 1DN, 2 chairs D 1D, 2EDDN, 1DN, 3 chairs E 1D, 2EDDN, 2DN, 2 chairs F 1D, 2EDDN, 2DN, 3 chairs G 1D, 3 EDDN, 1 DN, 3 chairs H 1D, 3 EDDN, 2 DN, 3 chairs	Procedures performed Patients treated Chairs in use Cost per patient Cost per RVU	Average costs in \$ Patient RVU A 18 0.85 B 16 0.77 C 18 0.76 D 17 0.69 E 21 0.78 F 20 0.75 G 16 0.68 H 17 0.71 Patients RVUs /week /week A 38 810 (sd 24) (540) B 54 1,340 (sd 26) (1,050)	Dental team with EDDNs were significantly more productive than teams with no EDDNs for all productivity indicators. The use of EDDNs was cost-effective way of extending the treatment capability of dentists.	Large study in military setting Team composition could overlap, so numbers of distinct D & EDDN not clear Sequel to Heid (1973)
Mitry et al (154) (51) 1976 USA Computer simulation using routine data	To explore productivity measures & productive relations in dental health services	D not stated EDDN not stated DN not stated	Used computer simulation (non-linear model) to examine effect on productivity of adding 1 or 2 EDDN to different practice configurations: A 1D, 1DN, 3 chairs + 0, 1 or 2EDDN B 2D, 2DN, 6 chairs + 0, 1 or 2EDDN	Relative productivity units (RPU) per 7 hour working day. RPU and time data from different sources Gross annual income Dollars per hour	Effect of adding EDDN: 0 to 1 1 to 2 A 43 RPUs 33 RPUs B 45 RPUs 42 RPUs Increase in gross income A (1EDDN) \$56,000 B (1EDDN) \$59,000 Marginal product A (1EDDN) 36% A (2EDDN) 20%	Production function fits data, estimates of value of EDDN & indicates constant returns to scale.	Few operators. For computer simulation used Louienville data (Lotzkar et al, 1971a & b)
Douglass et al (71) (47) 1976 USA Prospective incremental design	To estimate the effect of introducing expanded duty dental nurses into 1 private practice	D 4 EDDN 2 DN not stated Selected from local practitioners for 1 or 2 days a week	Research laboratory organised to reflect a solo private practice with 3 chairs: Baseline 1D, 2DN A 1D, 2DN, 1EDDN B 1D, 2DN, 2EDDN following a training course for all staff C 1D, 3DN, 2EDDN	Productivity/day: Services Patients Gross income Net income Quality of restorations Acceptability	Increase over baseline Patients Gross/ Net Income A 3% 12% - 36% B 33% 30% 24% C 40% 41% 22% Restorative work, prevention, crown & bridge & endodontics increased throughout study	EDDN can perform tasks with quality equal to that of D & improve productivity & revenue, but must be used efficiently. Extra EDDN more than doubled preventive services, but 2 EDDNs in 1 practice under occupied	Productivity assessed through gross income. Equal number of chairs for all teams may have decreased impact of 2nd EDDN. Sequel to Douglass (1996)
Tappan & Fitch (90) (48) 1975 USA Prospective observational study	To compare the use of expanded duty dental nurses for supplying preventive care with dentists & dental hygienists	D 2 DH 2 EDDN 7 EDDN selected from Denver Neighbourhood Health Programme	EDDN trained for 9 weeks Compared D, DH & EDDN in application of fluoride with cyanoacrylate on children	Incidence of plaque Costs	From January-June 1973 EDDN treated 44% of children aged 5-14 Costs per treatment D \$8.13 DH \$2.79 EDDN \$1.79	EDDNs can be trained in 9 weeks to work with quality comparable to that of D & DH. They reduced costs & training also inexpensive.	Data on costs but not evaluation or criteria for it.

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Marcus et al (153) (51) 1975 USA Prospective observational study with computer simulation for some results only	To enhance dental productivity through examining components of the patient-provider interaction	D 5 DH 2 EDDN 4 DN 10	Patient contact records completed by 3 practices for 4 weeks Evaluated differences between practices and effects on productivity: A 1D, 1DH, 2DN B 3D, 1DH, 6DN C 1D, 4EDDN, 4DN	Patient visits Use of staff time on clinical tasks Practice cost/minute based on salaries of D, EDDN, DH, DN & clerical staff	C devoted most time (43%) to operative dentistry. C achieved most delegation: EDDNs & DNs devoted 46% of time to clinical tasks Cost per minute for adults A \$0.19 B \$0.20 C \$0.16	Delegation of tasks to dental auxiliaries reduced costs, but performance times are also a factor. Need more detailed analysis of productivity.	Complex analysis of self- reported data for 3 practices over 4 weeks.
Lipscomb & Scheffler (152) (51) 1975 USA Computer simulation validated by incremental design	To develop a model of dental practice to explore how expanded duty dental nurses can maximise net revenue	D 4 EDDN 1 Simulation used existing data	Developed a computer model to assess the effect of 1 or 2 EDDN on productivity of practices with 1, 2, 3 or 4 D from existing data	Total number procedures & % by EDDN % EDDN time used Total revenue, long-run total cost, net revenue	% increase in revenue if add: 1 EDDN 2 EDDN Solo practice Gross +112% - 2% Net +169% -13% 2D practice Gross +71% +20% Net +87% +18% 3D practice Gross +54% +21% Net +71% +14%	D in single practice can double revenue by hiring 1EDDN, but will not increase productivity further by hiring additional EDDN unless case mix changes. Even for 2D or 3D practices, a 2nd EDDN gives only a small marginal increase in productivity.	Assumes delegation of almost all non-reversible dental procedures. Validation practice increased by 12%, while model predicts increase of 25%.
Hobdell et al (150) (50) 1975a England Epidemiological survey & computer simulation	To develop a planning process for & highlight problems of meeting dental needs	D 5 DT 6 EDDN 6 DN 6	Simulated treatment needs of a long-stay (special needs) hospital population in Relative Value Units (RVUs) Evaluated most effective way to meet patients' needs from: A 1D, 1DN B 1D, 3DT, 1DN C 1D, 3DT, 2DN D 1D, 3EDDN E 1D, 3EDDN, 2DN Patients- 178	Dental & periodontal status Time to complete treatment Annual cost of running team Costs of total treatment needs in RVUs	Treatment needed 5,400 RVUs (4,400 RVUs excluding general anaesthetics) RVUs/session Total salary costs A 11 £5,200 B 25 £3,500 (-32%) C 24 £4,200 (-20%) D 23 £3,400 (-33%) E 22 £4,600 (-11%) Sessions to complete treatment A 403 B 174 C 182 D 195 E 202	Compared to team of 1D & 1DN, there were reductions in time & salary costs by employing larger teams including operating PCDs. Team of 1D, 3DT, 1DN can best meet dental care needs of this group.	Patients had high treatment needs. Previously reported in Allred & Hobdell (1974).

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Seal (137) (48) 1974 UK Retrospective observational study using routine data over 5 years & enhanced data over 1 year	To estimate the clinical output & productivity of auxiliaries employed in a Local Authority Dental Service (LADS)	1967-72 D 43 DT 10 1972 in detail D 54 DT 12 DH 0.6	Analysed activity by D, DT & DH staff in Hampshire LADS: <ul style="list-style-type: none">analysed summary treatment records to compare D & DT in each year (no DH until 1971)used case-mix to restrict productivity comparison to general treatment sessions, with values converted to adjusted fte	Courses of treatment Attendances <ul style="list-style-type: none">operationsrestorationsextractionsprophylaxisother	Mean per fte DT as % of D Courses 53% Attendances 64% Operations 73% (R 80%, E 8%, P 118%, O 76%) Mean per fte DT as % of DO Courses 62% Attendances 71% Operations 75% (R 88%, E 8%, P 104%, O 70%) Mean per fte DH as % of DO Attendances 88% Operations 106% (almost all P)	Mean clinical output per fte DT was just less than D. Some of the difference may be due to DTs treating more pre-school patients (23%) than Ds (6%). However DT salary is 43% of D. Hence DTs are economic.	Aggregated data only, none for individual practitioners. Workload of LADS not typical of general dental practice
Robinson & Bradley (70) (48) 1974 USA Controlled trial with crossover element	to compare training in expanded PCD management (TEAM) & Dental Auxiliary Utilisation (DAU) in quality, productivity, & cost	D 20 EDDN 1 DN 3	Compared treatment of patients in 2 different settings: A 1D, 1 DN (DAU) B 1D, 1 EDDN, 2DN (TEAM) A 35 clinic periods B 25 clinic periods Patients experimental - 90 Patients control - 61	Quality of treatment Time per patient Time per surface restored Costs	Mean time/patient A 84 B 64 (+24%) Mean fee/minute A \$0.37 B \$0.51 (+38%) Mean income/year (\$1,000s) A 44.5 B 61.2 (+16.7; 95% CI 6.8 to 26.6)	B performed enough extra services to pay for extra salaries (EDDN \$5,500, DN \$3,600), though lower confidence limit not quite enough to cover all costs. Patients stayed in chair longer in B but received more services.	Set in dental school, so artificial in some respects. Only some types of procedure eligible. Patients assigned 'arbitrarily' to operators.
Redig et al (136) (47) 1974 USA Prospective before & after study	To assess the effect on productivity of training dental nurses in private practice so that they can act as EDDNs	D 4 DN 6 DNs trained as EDDN after baseline phase Productivity data also available for 4 non-participating partners in A & B	Survey of financial & statistical data in 3 month baseline period compared with 1 year's data after training EDDNs in four practices: A 1D, 2 (DN then EDDN) B 1D, 1 (DN then EDDN) C 2D, 2 (DN then EDDN) D 1D, 1 (DN then EDDN) Non-participating partners: A 3D, 2(DN then EDDN) part time B 1D, no DN or EDDN Productivity data not available for C	Types of procedure Degree of delegation Productivity Costs Income Quality of procedures Acceptability	%EDDN time with patients A 64% B 45% C 62% D 56% Patient visits per 8 hours A +25% (partners +8%) B +3% (partner+2%) D +23% Restorations per 8 hours A +31% (partners 0%) B +41% (partner +7%) D +37% Gross income per 8 hours A 33% (partners +9%) B 24% (partner -10%) D 24% Net income per 8 hours A 44% (partners 11%) B +38% (partner - 27%) D +26%	Using EDDN is economically feasible as the D can deliver more services in less time. Differences between practices are due to variations in practice characteristics & structure	Few operators in private practices. Difficult to assess impact of EDDN, as each effectively replaced DN.

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Kilpatrick & Mackenzie (148) (50) 1974 USA Computer simulation using routine data	To assess the effect on productivity of using expanded duty dental nurses	D not stated EDDN not stated Model tested on 2 actual practices	Analysed effects of number of EDDNs (1-4) & skill levels (1-4) using computer simulation. Skill levels 3 or 4 are full EDDN. Level 4 also does scaling & history taking.	System capacity Patient waiting time Personnel utilisation Gross & net revenue	Greatest marginal gain in capacity is gained from going from level 2 to 3 Per year 1 level 1 3 level 3 Visits 2,000 4,000 Gross income (\$1000s) 55 147 Net income(\$1000s) 23 77	EDDNs can significantly extend capacity of the solo dental practice. With only one EDDN, level does not affect productivity. With 3 level 3 EDDNs patient volume increases by 169% & net revenue by 233%. Level 4 gives no further gain.	Computer simulation in need of clinical validation. Used Louisville data (Lotzkar, 1971a & b). Previously reported in Kilpatrick et al (1972) Model described in Kilpatrick et al (1976).
Douglass (135) (47) 1974 USA Prospective incremental design	To estimate the effectiveness of expanded duty dental nurses in one private practice	D 4 EDDN 4 DN 8	Compared baseline with 2 experimental phases over 12 months: A 1D, 2DN, 3 chairs B 1D, 1EDDN, 2DN, 3 chairs C 1D, 1EDDN, 2DN, 3 chairs + training course for D	Gross & net income Time spent on different procedures Time taken to place restorations Acceptability	Gross income per day A \$270 Increase B \$300 13% C \$340 27% Net income per day A \$120 Increase B \$100 - 15% C \$150 30% Time spent More crown & bridge work (28% v 22%), prevention (13% v 6%) & less on diagnosis	Addition of 1 EDDN can increase productivity in private practice, but D must be willing to delegate. EDDN recently trained & likely to improve with time. More study is needed into how attitudes & personalities of D & EDDN affect outcomes.	Used a surrogate practice but attempted to validate it Productivity was assessed through gross & net income. See also Douglass et al (1996).
Curry et al (134) (47) 1974 Canada Prospective observational study	To conduct a feasibility study of using a dental team supervised by a dentist to provide services for children under 12 in Saskatchewan	D 1 DT 2 EDDN 3 Control not stated	Dental team provided 3 treatment series in the Oxbow region 1970-73: Series I (8.5 month) 1,300 children Series II (6 months) 1,500 children Series III (6 months) 1,600 children Dental surveys in 1971 (baseline) & 1973 were used to compare Oxbow with 4 other areas (2 with prevention service, 2 without)	Oxbow only: time per child • volume of services • number & % of unsatisfactory restorations • cost per child Survey: • DMFT levels	Average cost of care per child Oxbow Actual Standard fees Series 1 \$37 \$70 Series 2 \$29 \$53 Series 3 \$28 \$44 Average number DMFT/child Area 1971 1973 Oxbow 4.7 4.0 Prevention 5.0 5.0 No prevention 5.5 5.0	It is possible to use DN to provide an acceptable level of dental care at reasonable cost. Dentists should be trained in utilising dental nurses & assistants.	Not clear whether patients were similar in each area.

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Romcke & Lewis (67) (47) 1973 Canada Prospective incremental design	To assess whether expanded duty dental hygienists can increase the productivity of dentists to an extent that is economically feasible in private practice	D not stated EDDN 6 DN not stated	Children's clinic – 7 phases in 2.5 years: A practice (no data) B 1D, 1DN, 2 chairs C: 1D, 2DN, 2 chairs D 1D, 1 EDDN, 2DN, 3 chairs E 1D, 2EDDN, 3DN, 4 chairs F 1D, 2EDDN 3DN, 4 chairs G 1D, 2EDDN, 3DN, 4 chairs 6 private practices -- 6 weeks baseline, 3 months study period	Productivity in Relative Value Units (RVUs) Costs & benefits Quality Acceptability to patients	Increase in RVUs/day B 189 C 233 23% D over C 404 73% E over C 545 134% F over C 498 114% G over C 479 106% Private practices 37% C reduced mean cost 12% D reduced mean cost 30%	Addition of EDDN increased productivity of D in a public clinic & is economically feasible. In private practices, benefits far exceed costs.	Examines both public clinic & private practices. Few operators.
Pelton et al (133) (47) 1973b USA Prospective incremental design	To assess the economic implications of adding 2 expanded duty dental nurses & 2 dental nurses to a practice	D 1 EDDN 2 DN 4	Compared 3 teams over time: A 1D, 2DN B 1D, 1EDDN, 3DN C 1D, 2EDDN, 4DN A & B derived from Pelton (1973a)	Procedures & patients per day Annual gross income & net revenue Use of dentists' time	Average theoretical gross revenue per day increased C over A 64% C over B 19% Average number patients per day increased C over A 62% C over B 21%	Addition of 2nd EDDN can substantially increase productivity.	Patients had high treatment need. Not clear how much increased productivity attributable to EDDN & DN Sequel to Pelton (1973a)
Pelton et al (132) (47) 1973a USA Prospective incremental design	To assess the economic implications of adding 1 expanded duty dental nurse & 1 dental nurse to a practice	D 1 EDDN 1 DN 3	Compared 2 teams over 4 months: A 1D, 2DN B 1D, 1EDDN, 3DN	Procedures & patients per day Annual gross revenue & net income Use of dentists' time	Productivity in B over A Procedures per day +26% Patients per day +21% D time at chair -11% Gross revenue +37% Net income +21% Average costs A \$180 B \$300	D can increase gross income by about 37% by adding 1 EDDN & 1 DN to a team of 2 DN.	Patients had high treatment need Not clear how much increased productivity attributable to EDDN & DN. Baseline for Pelton (1973b)
Heid (131) (46) 1973 USA Prospective observational study	To examine the effect on productivity when expanded duty dental nurses & extra chairs are added to a conventional team	D 15 EDDN 20 D volunteered EDDN selected	Evaluated productivity of 15 teams over 1 year (3 months baseline, 9 months intervention): A 1D, 1DN, 1 chair (baseline) B 1D, 1EDDN, 1DN, 2 chairs (12 teams) C 1D, 2EDDN, 1DN, 3 chairs (3 teams): Patient visits - 25,000	Patient visits, treatments, procedures & time	Average increases in productivity over baseline Visits B 50% C 142% Treatments B 54% C 210% Procedures B 59% C 195% % of patient visits that were preventive A (baseline) 5% B 25% C 50%	All teams showed increases in productivity compared with baseline. Adding 2 EDDN & 2 chairs can increase effectiveness of conventional team by 3 to 9 times that of a team of with 1 EDDN & 1 chair. Larger teams more effective than smaller.	Military setting. Procedures not described. Not clear how data were recorded. See also Parker (1976).

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Feldstein (156) (51) 1973 USA Retrospective observational study using routine survey data from 1950-70	To provide an economic analysis of financing dental care	D not stated Types PCDs not stated	Using routine data from surveys, compared gross income & number of PCDs employed by D & estimated unused capacity	Gross income Productivity (gross income corrected for inflation) Number of patient visits	Increased productivity over 1D 1 PCD 33% 2 PCDs 92% 3 PCDs 161% 4 PCDs 218% In 1970 all D provided only 82% of potential visits if each had employed 3 PCDs, & 58% if each had employed 4 PCDs	D can achieve significant increases in productivity using PCDs.	Assumes that all Ds are equally productive, & uses gross income as proxy measure of output. Does not distinguish between different types of PCDs
Abramowitz & Berg (58) (45) 1973 USA Prospective incremental design	To assess the feasibility of using expanded duty dental nurses & the effects on quality, productivity & costs in US Indian Health Service	D 8 EDDN 20 DN 12 Only 4 D used for quality data EDDN performed expanded & normal functions in later phases	Compared different dental teams in 4 phases each of 100 days: A 2D, 3DN B 1D, 3EDDN C 1D, 4EDDN D 1D, 5EDDN	Number of procedures Time taken to complete procedures in Relative Time Units (RTUs) Quality	Productivity in RTUs Increase in B over A 58% Increase in C over B 18% Increase in D over C 2% Cost per RTU A \$2.54 B \$2.31 C \$2.28 D \$2.26 Net income A \$28,000 B \$35,000 C \$38,000 D \$39,000	Restorations by EDDNs were of comparable quality to those by Ds. Using EDDN led to an increase in the number of patients that D could treat, & to decreased costs per service. Increase in examinations & topical fluorides, but decrease in restorations, between A & D.	Used 4 locations in US Indian Health Service clinics. See also Abramowitz (1966)
Soricelli (64) (46) 1972 USA Retrospective before-after study	To train dental nurses & assess the feasibility & advisability of employing them	D not stated EDDN 4 DN not stated	7-month training programme for EDDN. Tried various team mixes & evaluated qualitative & quantitative results	Restorations & patients/session Quality of restorations Acceptability to patients	Per session Restorations Patients D 10.3 6.3 EDDN 13.8 6.8 Team of 1 D, 3 EDDN, 2 DN can increase productivity & income by 400% compared with 1D	EDDNs trained for short periods of time can deliver dental services effectively. EDDN salaries were about half those of public dentists & one quarter those of private dentists.	Many aspects not fully explained. Dependent on routine data Only restorations

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Brearley & Rosenblum (68) (46) 1972 USA Incremental controlled trial	To explore the effect on productivity, quality & acceptability when a second dental nurse is added to a team of a dental student, dental nurse & expanded duty dental nurse	D(s) 30 EDDNa 10 EDDNb 10 DN 40 D chosen from 103 EDDNa no experience EDDNb with 1 year experience	Compared 20 experimental & 10 control teams over 1 year: A 1D(s), 1EDDNa, 1DN B 1D(s), 1EDDNb, 1DN C 1D(s), 1DN Procedures • adapting stainless steel crown • applying, wedging, removing matrix • placing & polishing restorations – classes i, ii & v • prophylaxis • rubber dam clamp Patients experimental - 298 Patients control 198	Number of patients treated Numbers of specific procedures & time required to complete each Quality	Total number of procedures A & B 1,700 C 740 Productivity A & B increased by 33% over C Of 7 procedures EDDNa faster than Ds for 1 EDDNb faster than Ds for 3 EDDNb faster than EDDNa for 1 Quality No difference between EDDN & D. EDDNb better than EDDNa in 1st quarter but not in last quarter	Productivity of dental teams can be increased by EDDN & further by an additional DN. Additional training can improve performance.	Aspects of design & execution unclear. Sequel to Rosenblum (1971).
Rosenblum (61) (46) 1971 USA Controlled trial	To estimate the training needed for expanded duty dental nurses & the quality & quantity of procedures compared with dental students	D(s) 30 EDDN 4 DN not stated EDDN recruited from Minnesota Dental School	Compared performance of 20 experimental & 10 control teams over 9 months: A 1D(s), 1EDDN, 1DN B 1D(s), 1DN Patients - 481	Number of procedures Mean time to complete procedures Quality of restorations	Procedures over 30 weeks A 620 B 440 A 40% more productive than B Mean times Differences between D(s) & EDDN not statistically significant	No significant differences between speed & quality of performance between Ds & EDDNs. 3 months is adequate for training.	Small-scale study with 4 EDDNs of varying abilities. Model for Brearley & Rosenblum (1972)
Lotzkar et al (63) (46) 1971b USA Prospective incremental design	To estimate the qualitative & quantitative effects of delegating chairside duties to expanded duty dental nurses	D 6 EDDN 28 DN not stated 17 EDDN had >2 years experience	In Phase 3 Ds worked as team leaders with varying numbers of EDDN over 3 years: A 1D, 2EDDN (no results given), 1DN B 1D, 3EDDN, 1DN C 1D, 4EDDN, 1DN Compared with Lotzkar (1971a) Phase 1 Procedures included: • charting • alginate impressions • amalgam polishing • synthetic finishing Patients - 6,400	Time taken to complete procedures Mean number of: patients procedures time units/day Quality of procedures	Mean time for 26 procedures 5 min 5-10 10+ EDDN 7 13 5 Increase over Phase 1 Patients B 62% C 110% Procedures B 84% C 133% Time Units B 84% C 123%	EDDNs perform delegated duties as well as Ds. EDDNs needed more time than D from Phase 1 to complete procedures but less than during training in Phase 2.	Patients had heavy treatment needs. Special experimental dental clinic. B & C used different dentists so had different baselines. Sequel to Lotzkar (1971a).

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Lotzkar et al (62) (46) 1971a USA Prospective incremental design	To estimate the qualitative & quantitative effects of assigning chairside duties to expanded duty dental nurses	D 7 EDDN 32 EDDN all but 2 had formal DN training & 17 had >2 years experience as DN	Compared baseline Phase 1, with Phase 2, where EDDN were trained to carry out additional duties: Phase 1 1D, 1DN Phase 2 1D, 1 EDDN(s) Procedures included: • alginate impressions • amalgam polishing • charting • synthetic finishing	Time taken to complete procedures Quality of procedures Level of patient satisfaction	Mean time for 26 procedures <5 mins 5-10 10+ D 11 10 5 EDDN 1 14 11 EDDN time as % of D time Range 102% to 288% Longest times by EDDN • radiographs for children & adults • pumice prophylaxis • carving amalgam restorations	DN can be successfully trained as EDDN. EDDN during training slower than baseline D. General quality of procedures by Ds & EDDNs comparable but 4 EDDNs not satisfactory.	Patients had heavy treatment needs. Specially designed experimental dental clinic. Phase 1 acted as baseline for Lotzkar (1971b).
Kilpatrick (130) (46) 1971 USA Prospective incremental design	To estimate the effect of chairside assistance on productivity	D 6 DN 8	Studied time & efficiency of various procedures undertaken by D working alone, with 1DN or 2 DN	Operating time saved by adding extra 1 or 2 DN % of time saved for amalgam restorations only	Time saved by D D & 1 DN 16% D & 2 DN 29% Average time saved for specific procedures between 2 & 30 minutes	DN can save D one third to one half of working time. DN can increase efficiency by 16-70% (no data!).	Few operators. Data incomplete.
Sutcliffe (129) (46) 1969 England Retrospective before-after study using routine data	To estimate the productivity of one dentist working with one dental therapist	D 1 EDDN 1	Compared treatment in a School Dental Service clinic over 37 months under 2 models: A 1D B 1D, 1EDDN Patients - 6,881 in 1 clinic	Mean number per day of: • patients • total procedures • specific procedures	Mean patients/day A 17 B 28 (increase 64%) Mean procedures/day A 34 B 51 (increase 51%) B increased most procedures, especially restorations	Use of the EDDN led to 64% increase in patients; 51% in operations; 79% in restorations; & 29% in extractions.	Retrospective study dependent on routine data. Experiment with 1 EDDN.
Baird et al (128) (45) 1967 Canada Prospective incremental design	To estimate the personnel, accommodation & equipment needed to support a dentist in the most productive & efficient way in the Canadian airforce	D not stated DH not stated EDDN not stated DN not stated	Evaluated productivity in pre-study & 6 stages: Pre-study 1 D, 1 DN, 1 chair A 1 D, 1 DN, 1 chair B 1 D, 2 DN, 1 chair C 1 D, 2 DN, 2 chairs D 1 D, 1 EDDN, 2 DN, 3 chairs E 1 D, 1 EDDN, 2 DN, 1C, 3 chairs F 1 D, 1 EDDN, 1 DH, 2 DN, 1C, 4 chairs	Number of: • operations • time points • filled surfaces Relative Value Units (RVUs): total & restorative dentistry	Productivity in RVUs Pre-study 95 A 114 (+20%) B 135 (+42%) C 142 (+49%) D 207 (+119%) E 191 (+101%) F 256 (+169%) D total chairside time A 78% F 85%	Most effective team was 1 D, 1 EDDN, 2 DN, 3 chairs. Productivity increases exceeded salaries of auxiliaries. EDDN & DH should not be employed on same team as functions overlap.	Complex study in military setting. Few operators in 1 clinic Main study of Baird et al (1963).

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Abramowitz (57) (45) 1966 USA Controlled trial with crossover element	To estimate the effectiveness of dental teams trained to carry out additional duties	D 4 EDDN 4 DN 4	Compared 4 teams of D + 2 DN in experimental & control settings over 40 & 25 days: A DN had expanded duties B DN carried out usual duties	Number of services Quality of Class II restorations	A teams provided in 65 days 27% more topical fluorides 5% more other services 2% fewer restorations 14% fewer surfaces A teams provided in 80 days 2% more restorations 1% more topical fluorides 15% fewer surfaces 28% fewer other services	EDDN carried out Class II restorations of comparable quality to those of D.	Carefully-designed study. Few operators. Precursor of Abramowitz & Berg (1973).
Ludwick et al (55) (45) 1964 USA Incremental controlled trial	To estimate the effects of delegation on productivity & quality & on dentists & dental nurses over prolonged periods	D 10 EDDN 12 DN 2	3 phases each of 12 weeks: Phase 1 (3D rotate + 1 reserve) A 1D, 2 DN, 1 chair B 11D, 3 EDDN, 2 chairs C 11D, 4 EDDN, 3 chairs Phase 2 (3D rotate + 2 reserves) B2 1D, 3 EDDN, 2 chairs C2 1D, 4 EDDN, 3 chairs D 1D, 5 EDDN, 4 chairs In B-D, 1 EDDN acted as DN Phase 3 Repeat most efficient team set-up (n patients = 5,000)	Hourly work rates Productivity Quality of restorations (4 ratings) Attitudes to the expanded team	Productivity increase over A Phase 1 Phase 2 B 46% 89% C 100% 112% D 142% Phase 3 D & EDDN did not find 3 chairs tiring, though 4 chairs in phase 2 was less acceptable Quality Not affected by team composition	D working at 3 chairs & delegating procedures can treat twice number of patients with significant increase in restorations compared with 1 chair. 1 core D was much slower than other 2 in all phases.	Patients had heavy treatment needs. Balanced allocation of D to teams & EDDN within teams, changing each week.
Baird et al (127) (45) 1963 Canada Prospective incremental design	To confirm earlier findings on training & assess the effect of expanded duty dental hygienists on productivity in Canadian airforce	D 1 EDDN 1 DN 2 D chosen for interest in PCDs & high productivity EDDN representative of trainees (3.5 years experience as DH)	Compared 3 teams over 13, 30 & 26 days: A 1D, 1DN, 1 chair (baseline) B 1D, 1.5DN, 2 chairs C 1D, 1EDDN, 2DN, 3 chairs	Productivity in time points per duty day Costs % time spent operating by DH & D	Output: time points/duty day Before study 108 A 110 B 151 C 219 Cost increase A-C = 34% Time DH performed 4.9 D hours per duty day, of which: Prophylaxis 41% Operative dentistry 54%	DH can be trained to high standard & make valuable contribution to the dental team. Composition of team should be flexible in response to local needs.	Military setting Few operators in 3 clinics. Pilot study for Baird et al (1967).

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Ref Number	Study	Included in review	Excluded from review
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2.	Anon. <i>Expanded functions for dental auxiliaries.</i> JADA 1967; 75 (3): 563		X
3.	Anon. <i>Island hygienists boost productivity: Prince Edward Island dental manpower study.</i> J Can Dent Assoc 1971; 2: 50-53		X
4.	Anon. <i>Changing patterns of oral health and implications for oral health manpower: Part 1: Report of a working group convened jointly by the Federation Dentaire Internationale and the World Health Organisation.</i> Int Dent J 1985; 35: 235-251		X
5.	<i>An Oral Health Strategy For England.</i> Department of Health, 1994.		Text ref 11
6.	Abernathy J R, Graves R C, Bohannan H M, Stamm J W, Greenberg B G, Disney J A. <i>Development and application of a prediction model for dental caries.</i> Community Dent Oral Epidemiol 1987; 15: 24-28		X
7.	Abramowitz J. <i>Expanded functions for dental assistants: a preliminary study.</i> JADA 1966; 72: 386-391	Text ref 57	
8.	Abramowitz J. <i>Planning for the Indian Health Service.</i> J Pub Health Dent 1971; 31 (2): 70-78		x
9.	Abramowitz J. <i>The implementation of a program for utilising auxiliaries: the experience of the Indian Health Service.</i> J Pub Health Dent 1972; 32 (3): 142-148		x
10.	Abramowitz J, Berg L E. <i>A four-year study of the utilisation of dental assistants with expanded functions.</i> JADA 1973; 87: 623-635	Text ref 58	
11.	Abramowitz J, Mecklenburg R E. <i>Quality of care in dental practice: the approach of the Indian Health Service.</i> J Pub Health Dent 1972; 32 (2): 90-97		x
12.	Abrams S H. <i>Denturists: do they really provide more affordable care in Ontario?</i> J Can Dent Assoc 1997; 63 (10): 771-774		x
13.	Adair S M, Leverett D H, Shaffer C L. <i>Interexaminer agreement for readings of dip slide tests for Salivary Mutans Streptococci and Lactobacilli.</i> Caries Res. 1994; 28: 123-126	Text ref 43	
14.	Aker D S, Zaki H A. <i>The dental hygienist as a preventodontist.</i> JADA 1972; 84: 140-142		x
15.	Allan. <i>The role of the dental hygienist in the prevention, control, and treatment of Dilantin hyperplasia.</i> Probe 1986; 20 (4): 139-43		x
16.	Allred H. <i>Assessment of Quality of Dental Care</i> (London, 1977)		x
17.	Allred H. <i>The Training and Use of Dental Auxiliary Personnel. Report on a Study.</i> 1977. World Health Organisation. Regional Office for Europe. Copenhagen. 1-70		x
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23.	Axelsson P, Lindhe J. <i>The effect of a plaque control program on gingivitis and dental caries in schoolchildren.</i> J Dent Res 1977; Special Issue C: 142-148		x
24.	Axelsson P, Lindhe J. <i>Effect of controlled oral hygiene procedures on caries and periodontal disease in adults.</i> J Clin Periodontol 1978; 5: 133-51		Text ref 104
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26.	Axelsson P, Lindhe J, Waseby J. <i>The effect of various plaque control measures on gingivitis and caries in schoolchildren.</i> Community Dent Oral Epidemiol 1976; 4: 232-239		x
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28.	Bader J D. Ed. <i>Risk Assessment in Dentistry: Proceedings of a Conference June 2-3, 1989, Chapel Hill, North Carolina.</i> 1990. Chapel Hill.		x

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Ref Number	Study	Included in review	Excluded from review
	University of North Carolina		
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30.	Bader J D, Mullins R, Lange K. <i>Technical performance on amalgam restorations by dentists and auxiliaries in private practice.</i> JADA 1983; 106: 338-341	Text ref 76	
31.	Bader-J D, Shugars-D A. <i>Variation in dentists' clinical decisions.</i> J-Public-Health-Dent. 1995 Summer; 55(3): 181-8		Text ref 51
32.	Baderstein A, Egelberg J, Kock G. <i>Effect of monthly prophylaxis on caries and gingivitis in schoolchildren.</i> Community Dent Oral Epidemiol 1975; 3: 1-4		x
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35.	Baird K M, Purdy E C, Protheroe D H. <i>Pilot study on advanced training and employment of auxiliary dental personnel in the Royal Canadian Dental Corps: final report.</i> J Can Dent Ass 1963; 29 (12): 778-787	Text ref 127	
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41.	Barata M-C, Schoen D H. <i>Comparison of two instructional approaches in preclinical dental hygiene.</i> J Dent Educ 1993; 57 (10): 766-769		x
42.	Barker G J, Taylor T S, Barker B F. <i>Implementation of a tobacco cessation program in the student clinics.</i> J Dent Educ 1995; 59 (8): 850-855		x
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56.	Bergner M, Milgrom P, Chapko M K, Beach B, Skalabrin N. <i>The Washington State dental auxiliary project: quality of care in private practice.</i> JADA 1983; 107: 781-786	Text ref 78	
57.	Berman D S. <i>Utilisation of the dental auxiliary - school dental nurse.</i> Int Dent J 1969; 19 (1): 24-40		x

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Ref Number	Study	Included in review	Excluded from review
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73.	Brown L F, Keily P A, Spencer A J. <i>Evaluation of a continuing education intervention 'Periodontics in General Practice'</i> . Community Dent Oral Epidemiol 1994b; 22: 441-447	Text ref 125	
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78.	Burman N T C. <i>Attitudes to the training and utilisation of dental auxiliaries in Western Australia</i> . Aust Dent J 1987; 32 (2): 132-135		x
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80.	Burt B A. <i>Diagnostic and preventive services in a national incremental dental plan for children</i> . J Pub Health Dent 1977; 37 (1): 31-46		x
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86.	Carpay J J, Nieman F H M, Konig K G, Felling A J A, Lammers J G M. <i>Quality of dental restorations and dental treatment in Dutch schoolchildren</i> . Community Dent Health 1990; 7: 43-51	Text ref 79	

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Ref Number	Study	Included in review	Excluded from review
87.	Cecchini J J, Frieman N. <i>Investigation of dental hygiene students' and dental students' anxiety and dental stressors.</i> Internat J Psychosom 1986; 33 (2): 43-47		x
88.	Chambers A K, Corbin D E. <i>Tobacco control activities of Iowa dental hygienists.</i> J Community Health 1996; 21 (5): 375-387		x
89.	Chapko M K. <i>Time to adoption of an innovation by dentists in private practice: Sealant utilisation.</i> J Pub Health Dent 1991; 51 (3): 144-151		x
90.	Chapko M K, Bergner M, Green K, Beach B, Milgrom P, Skalabrin N. <i>Development and validation of a measure of dental patient satisfaction.</i> Med Care 1985; 23 (1): 39-49		x
91.	Chapko M K, Bergner M, Beach B, Green K, Milgrom P, Skalabrin N. <i>Development of a measure of job satisfaction for dentists and dental auxiliaries.</i> Community Dent Oral Epidemiol 1986; 14: 76-79		x
92.	Chapko M K, Milgrom P, Bergner M, Conrad D, Skalabrin N. <i>Delegation of expanded functions to dental assistants and hygienists.</i> Am J Pub Health 1985; 75: 61-65		x
93.	Chaytor D V. <i>Expand the hygienist's role in prosthodontics.</i> J Can Dent Assoc 1971; 8: 286		x
94.	Christensen G J. <i>Increasing patient service by effective use of dental hygienists.</i> JADA 1995; 126: 1291-1294		x
95.	Chu. <i>Understanding the determinants of preventive oral health behaviours.</i> Probe 1996; 30 (10): 12-18		x
96.	Clark D C. <i>The relationship between the number of sound, decayed, and filled permanent tooth surfaces and the number of sealed surfaces in children and adolescents.</i> J Pub Health Dent 1997; 57 (3): 171-175		x
97.	Cline J T, Messer L B. <i>Long term retention of sealants applied by inexperienced operators in Minneapolis.</i> Community Dent Oral Epidemiol 1979; 7: 206-212		x
98.	Cohen L A. <i>Some variables affecting dentists' desire to use expanded duty dental auxiliaries.</i> JADA 1978; 97: 970-977		x
99.	Cohen L A, Horowitz A M. <i>Community-based sealant programs in the United States: Results of a survey.</i> J Pub Health Dent 1993; 53 (4): 241-245		x
100.	Cohen L A, Silversin J B, Kress G C, Yacovone J A. <i>Correlates of dentists' attitudes toward continuing education in TEAM.</i> J Dent Educ 1977; 41 (11): 677-683		x
101.	Cohen L, Singer J, LaBelle A. <i>Characteristics of employment and job satisfaction in non-traditional dental hygiene practice settings.</i> J Pub Health Dent 1987; 47 (2): 88-93		x
102.	Cohen L K. <i>How the study was designed.</i> Int Dent J 1976; 26 (3): 293-298		x
103.	Collett W K. <i>Intraoral radiographic errors in films submitted for orthodontic consultation.</i> Oral Surg 1980; 49 (4): 370-372		x
104.	Cooper M D. <i>A survey of expanded duties usage in Indiana: A pilot survey.</i> J Dental Hygiene 1993; 67 (5): 249-256		x
105.	Cooper T M. <i>Four-handed dentistry in the team practice of dentistry.</i> Dent Clin N Am 1974; 18 (4): 739-753		x
106.	Corry R D, Cannavale L F. <i>Expanded functions training for dental assistants in the Indian Health Service.</i> JADA 1972; 85: 1343-1348		x
107.	Crandell C E. <i>Cause and frequency of intraoral X-ray errors by dental and hygiene students.</i> J Dent Educ 1958; 22: 189-196		x
108.	Cessford. C, Kravtsov N. <i>Restorative dental services and the Manitoba dental hygienist</i> Probe 1994; 28 (1): 25-9		x
109.	Croxson L J. <i>A simplified periodontal screening examination: the Community Periodontal Index of Treatment Needs (WHO) in general practice.</i> Int Dent J 1984; 34: 28-34		x
110.	Cunningham M. <i>Dental assisting: Influence on hygienists and students.</i> Educ Dir 1980; 5 (1): 25-30		x
111.	Curry T M, McPhail C W B, Peacock G H, Robinson J A, Paynter K J, Thompson G W. <i>Saskatchewan studies with the British dental auxiliary model.</i> In Lucaccini L F, Handley J. Eds. <i>Research in the Use of Expanded Function Auxiliaries.</i> 1974. Bethesda, Maryland. US Department of Health, Education, and Welfare. DHEW Publication No. (HRA) 75-14. 25-41	Text ref 134	
112.	Curtis. <i>Student dental hygienists work values: A measure of an emerging profession?</i> Probe 1997; 31 (2): 41-8		x
113.	Daniel S J, Scruggs R R, Grady J J. <i>The accuracy of student self-evaluations of dental sealants.</i> J Dent Hygiene 1990; 64 (7): 339-342	Text ref 95	
114.	Davis J. <i>Ontario Dent Assoc</i> 1964; 41: 9-12		x
115.	Davis T E, Rakow B, Ponce M L, Holmes L W, Eleccko R S, Littman H. <i>Study of sophomores shows their use of dental auxiliaries does not increase productivity.</i> Dent Stud 1978; 56 (7): 45-48	Text ref 140	
116.	Davison D, Chiswell C L, Spohn E E. <i>Expanded Duty Dental Hygiene Experiment 1974-75:</i> University of Kentucky: Report to the Robert Wood		x

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Ref Number	Study	Included in review	Excluded from review
	Johnson Foundation, 2 October 1975		
117.	DeFriesse G H, O'Shea R M, Meskin L, Pfister J, Barker B D. <i>The Kentucky and Washington State demonstrations: expanded-function dental auxiliary personnel in private general practice.</i> JADA 1983; 107: 773-776		Text ref 122
118.	De Jongh A, Stouthard M E A. <i>Anxiety about dental hygienist treatment.</i> Community Dent Oral Epidemiol 1993; 21: 91-95		x
119.	Della Pelle N, Soricelli D A, Bronstein E. <i>Training technotherapists for use in an urban dental care program.</i> Health Services Rep 1973; 88 (2): 181-186		x
120.	De Paola P F, Alman J. <i>Assessment of the reliability of radiographic diagnosis in a clinical caries trial.</i> J Dent Res 1972; 51 (5): 1431-1437		x
121.	Department of Health Press Release 97/151.		Text ref 4
122.	Devlin N J. <i>The effects of denturism: New Zealand dentists' response to competition.</i> Am J Pub Health 1994; 84 (10): 1675-1677		x
123.	DeVore C H, Beck F M, Clark P M, Goorey N J. <i>Cognitive style as related to emotional empathy.</i> J Dent Educ 1989; 53 (9): 538-541		x
124.	Dickersin K, Scherer R, Lefebvre C. <i>Identifying relevant studies for systematic reviews.</i> BMJ 1994; 309: 1286-91.		Text ref 8
125.	Dilworth J B, Pelton W J. <i>Computer simulation of a dental practice using therapists.</i> J Dent Educ 1972; 36 (6): 35-39		x
126.	Dirks O Backer, Houwink B, Kwant G W. <i>The results of 6 1/2 years of artificial fluoridation of drinking water in the Netherlands: The Tiel - Culemborg experiment.</i> Arch Oral Biol 1961; 5: 284-300		x
127.	Disney J A, Abernathy J R, Graves R C, Mauriello S M, Bohannon H M, Zack D D. <i>Comparative effectiveness of visual/tactile and simplified screening examinations in caries risk assessment.</i> Community Dent Oral Epidemiol 1992; 20: 326-32	Text ref 25	
128.	Disney J A, Graves R C, Stamm J W, Bohannon H M. <i>The University of North Carolina Caries Risk Assessment Study. II. Baseline caries prevalence.</i> J Pub Health Dent 1990; 50 (3): 178-185		x
129.	Disney J A, Graves R C, Stamm J W, Bohannon H M, Abernathy J R, Zack D D. <i>The University of North Carolina Caries Risk Assessment Study: further developments in caries risk prediction.</i> Community Dent Oral Epidemiol 1992; 20: 64-75		x
130.	Doherty N, Hussain I. <i>Costs of providing dental services for children in public and private practices.</i> Health Serv Res 1975; 10: 244-253		x
131.	Dolan A K, Milgrom P. <i>Why not an independent practice for dental hygienists.</i> WomHealth 1980; 5 (2): 31-48		x
132.	Dolan T A, McGorray S P, Grinstead-Skigen C L, Mecklenburg R. <i>Tobacco control activities in US dental practices.</i> JADA 1997; 128: 1669-1679	Text ref 115	
133.	Domer L R, Bauer J C, Bomberg T J. <i>Attitudes towards the use of expanded-function dental auxiliaries as a function of provider characteristics and participation in expanded-function training.</i> J Pub Health Dent 1977; 37 (1): 9-22		x
134.	Douglass C W. <i>Utilisation of expanded duty dental assistants in a solo private practice.</i> In Lucaccini L F, Handley J. Eds. Research in the Use of Expanded Function Auxiliaries. 1974. Bethesda, Maryland. US Department of Health, Education, and Welfare. DHEW Publication No. (HRA) 75-14. 2-8	Text ref 135	
135.	Douglass C W, Cole K O. <i>Utilisation of dental services in the United States.</i> J Dent Educ 1979; 43 (4): 223-238		x
136.	Douglass C W, Lindahl R L, Gillings D B, Moore S. <i>Laboratory model of private practice: Method for studying new systems of health care delivery in dental schools.</i> J Dent Educ 1973; 37 (12): 8-14		x
137.	Douglass C W, Lipscomb J. <i>Expanded function dental auxiliaries: Potential for the supply of dental services in a national dental program.</i> J Dent Educ 1979; 43 (10): 556-567		x
138.	Douglass C W, Moore S, Lindahl R L, Gillings D B. <i>Expanded duty dental assistants in solo private practice.</i> J Amer Coll Dent 1976; 43: 144-163	Text ref 71	
139.	Douglass C W, Stacey D C. <i>Public and professional acceptance of auxiliaries.</i> J Pub Health Dent 1972; 32 (1): 58-60		x
140.	Downer-M C, Kay-E J. <i>Restorative treatment decisions from bitewing radiographs--performance of dental epidemiologists and general dental practitioners.</i> Community-Dent-Oral-Epidemiol. 1996 Apr; 24(2): 101-5.		Text ref 53
141.	Dragoo M R, Wheeler B G. <i>Clinical evaluation of subgingival debridement with ultra sonic instruments used by trained and untrained operators.</i> Gen Dent 1996; 44 (3): 234-237		x
142.	Duffy M B, Bernet J K, Chovanec G K, Majerus G J, Frazier P J, Newewll K J. <i>Dental hygienists' knowledge, opinions, and use of pit and fissure sealants: A comparison of two states.</i> J Pub Health Dent 1987; 47 (3): 121-133		x

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Ref Number	Study	Included in review	Excluded from review
143.	Dunn R. <i>Role of the general practitioner and dental hygienist in oral cancer control program.</i> Virginia Dent J 1975; 52 (4): 57-61		x
144.	Dunning J M. <i>Extending the field for dental auxiliary personnel in the United States.</i> Am J Pub Health 1958; 48 (8): 1059-1064		x
145.	Dunning J M. <i>Deployment and control of dental auxiliaries in New Zealand and Australia.</i> JADA 1972; 85: 618-626		x
146.	Dunning J M. <i>An international look at school-based children's dental services.</i> Am J Public Health 1978; 68: 664-668		x
147.	Dworkin S F, LeResche L, DeRouen T. <i>Reliability of clinical measurement in temporomandibular disorders.</i> Clin J Pain 1988; 4 (2): 89-99	Text ref 44	
148.	Dworkin S F, LeResche L, DeRouen T, Von Korff M. <i>Assessing clinical signs of temporomandibular disorders: reliability of clinical examiners.</i> J Prosthet Dent 1990; 63 (5): 574-579	Text ref 45	
149.	Eaton K A, Widstroem E A, Renson C E. <i>Changes in the numbers of dentists and dental caries levels in 12 yr olds in the countries of the EU and the economic area.</i> J Roy Soc of Health 1998; 118 (1): 40-8		x
150.	Eden G T. <i>Clinical evaluation of a pit and fissure sealant for young adults.</i> J Prosthet Dent 1976; 36 (1): 51-57		x
151.	Eijkman M A J, De With C. <i>Answers from dentists, dental hygienists and dental assistants to questions asked by patients concerning preventive dental matters.</i> Community Dent Oral Epidemiol 1980; 8: 339-346		x
152.	Eiser H M A. <i>A comparative study of the evaluation of quality of dental care delivered by dentists and dentist-technotherapist teams in a closed panel dental health program.</i> Division of Dental Health, Philadelphia, Department of Public Health.		Text ref 65
153.	Elderton R J; Nuttall N M. <i>Variation among dentists in planning treatment.</i> Br-Dent-J. 1983; 154(7): 201-6.		Text ref 47
154.	Ellis R L, Hoard A B, Thompson G W. <i>Ontario Dental Association. Demonstration project phase two. A subjective analysis of expanded functions for dental auxiliaries.</i> Ont Dent 1974; 51 (2): 15-18		x
155.	Espelid I, Tveit A B, Riordan P J. <i>Radiographic caries diagnosis by clinicians in Norway and Western Australia.</i> Community Dent Oral Epidemiol 1994; 22: 214-219	Text ref 28	
156.	Fee A D. <i>The dental mechanics of Canada.</i> J Prosthet Dent 1974; 31 (1): 10-21		x
157.	Feldman R S, Douglass C W, Loftus E R, Kapur K K, Chauncey H H. <i>Interexaminer agreement in the measurement of periodontal disease.</i> J Periodontol Res 1982; 17: 80-89		x
158.	Feldstein P J. <i>Financing Dental Care: An Economic Analysis.</i> 1973. Lexington, Massachusetts. Lexington Books	Text ref 156	
159.	Fernandez. <i>Follow-up of a pilot program for training of dental auxiliaries in oral health promotion and prevention.</i> Odontologia Chilena 1988; 36 (1): 33-7		x
160.	Fishwick M R, Ashley F P, Wilson R F. <i>Can a workplace preventive programme affect periodontal health?</i> Brit Dent J 1998; 184: 290-293		x
161.	Fleiss J L, Chilton N W. <i>The measurement of interexaminer agreement on periodontal disease.</i> J Periodontol Res 1983; 18: 601-606		x
162.	Fleiss J L, Chilton N W, Park M H. <i>Inter- and intra-examiner variability in scoring supragingival plaque: II. Statistical analysis.</i> Pharmacol Ther Dent 1980; 5: 5-9		x
163.	Fleiss J L, Slakter M J, Fischman S L, Park M H, Chilton N W. <i>Inter-examiner reliability in caries trials.</i> J Dent Res 1979; 58 (2): 604-609		x
164.	Fletcher C F. <i>Combating the illegal practice of dentistry.</i> J Prosthet Dent 1976; 35 (1): 92-96		x
165.	Foreman F J. <i>Effects of delegation, state practice acts, and practice management techniques upon sealant utilisation: A national survey of paediatric dentists.</i> ASDC J Dent Child 1993; 60 (3): 193-200		x
166.	Foreman F J, Matis B A. <i>Retention of sealants placed by dental technicians without assistance.</i> Paediatr Dent 1991; 13 (1): 59-61		Text ref 100
167.	Foreman F J, Matis B A. <i>Sealant retention rates of dental hygienists and dental technicians using differing training protocols.</i> Paediatr Dent 1992; 14 (3): 189-190		Text ref 101
168.	Frank J E, Law F E, Scholz Spitz G, Galagan D J. <i>School dental care in a community with controlled fluoridation.</i> Pub Health Rep 1964; 79 (2): 113-124		x
169.	Freed J R, Perry D A, Kushman J E. <i>Aspects of quality of dental hygiene care in supervised and unsupervised practices.</i> J Pub Health Dent 1997; 57 (2): 68-75		x
170.	Frencken J E, Makoni F, Sithole W D. <i>Atraumatic Restorative Treatment and glass-ionomer sealants in a school oral health programme in Zimbabwe: Evaluation after 1 year.</i> Caries Res 1996; 30: 428-33		x
171.	Frencken J E, Makoni F, Sithole W D, Hackenitz E. <i>Three-year survival of one-surface ART restorations and glass-ionomer sealants in a school</i>	Text ref 99	

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Ref Number	Study	Included in review	Excluded from review
	<i>oral health programme in Zimbabwe. Caries Res 1998; 32: 119-126</i>		
172.	Frencken J E, Pilot T, Songpaisan Y, Phantumvanit P. <i>Atraumatic Restorative Treatment (ART): rationale, technique, and development. J Pub Health Dent 1996; 56 (3): 135-140</i>		x
173.	Frencken J E, Songpaisan Y, Phantumvanit P, Pilot T. <i>An Atraumatic Restorative Treatment (ART) technique: evaluation after one year. Int Dent J 1994; 44: 460-464</i>		x
174.	Fried J L. <i>Dental hygienists' anti-tobacco role: Educational perspectives. J Dent Educ 1989; 53 (12): 712-717</i>		x
175.	Fried J L, Rubinstein L. <i>Attitudes and behaviours of dental hygienists concerning tobacco use. J Pub Health Dent 1990; 50 (3): 172-177</i>		x
176.	Friedman J W. <i>The New Zealand School Dental Service: Lesson in radical conservatism. JADA 1972; 85: 609-617</i>		x
177.	Friedrichsen S W, Herzog A E, Christie C A. <i>A socio-economic comparison of patients receiving prostheses in a two-tier delivery system. J Prosthet Dent 1992; 67 (3): 348-357</i>	Text ref 121	
178.	Fulton J T. <i>Experiment in Dental Care: Results of New Zealand's Use of School Dental Nurses. 1951. WHO. Geneva. 1-87</i>		Text ref 17
179.	Fylkesnes K, Matlhare R K. <i>Developing alternative systems of oral health care delivery: The Botswana case. African Dent J 1988; 2: 8-14</i>		x
180.	Galli M. <i>Das zeiser-modellsystem: Aus der sichte des zahntechnikers. Swiss Dent 1987; 8 (6): 21-22</i>		x
181.	Garfunkel E. <i>The consumer speaks: How patients select and how much they know about dental health care personnel. J Prosthet Dent 1980; 43 (4): 380-384</i>		x
182.	General Accounting Office. <i>Increased Use of Expanded Function Dental Auxiliaries Would Benefit Consumers, Dentists, and Taxpayers. 1980. Washington. General Accounting Office. HRD-80-51</i>		x
183.	General Dental Council. <i>Final Report on the Experimental Scheme for the Training and Employment of Dental Auxiliaries. 1966. London. General Dental Council. 1-100</i>		x
184.	Gerbert B, Badner V, Maguire B. <i>AIDS and dental practice. J Pub Health Dent 1988; 48 (2): 68-73</i>		x
185.	Gibson B, Freeman R, Ekins R. <i>The role of the dental nurse in general practice. Brit Dent J 1999; 186 (5): 213-215</i>		x
186.	Gibson G B, Richardson AV S, Waldman R. <i>The effectiveness of a chemically polymerised sealant in preventing occlusal caries: Five-year results. Paediatr Dent 1982; 4 (4): 309-310</i>		x
187.	Gierl. <i>What contribution to quality control can qualified dental assistants perform in the dental practice? Quintessenz J 1990; 20 (2): 161-4</i>		x
188.	Gift H C. <i>Utilisation of auxiliaries and attitudes of dentists towards the delegation of duties. JADA 1976; 93: 1080-1085</i>		x
189.	Gift H C, Frew R, Hefferen J J. <i>Attitudes toward and use of pit and fissure sealants. ASDC J Dent Child 1975; 42 (6): 460-466</i>		x
190.	Gilbert G H, Duncan R P, Campbell A M. <i>Evaluation for an observation effect in a prospective cohort study of oral health outcomes. Community Dent Oral Epidemiol 1998; 26: 233-240</i>		x
191.	Gilmore N D, Stevens C, Pierce V, Giddon D B. <i>Consumer and provider attitudes toward dentist and expanded auxiliary functions. JADA 1976; 93: 614-621</i>	Text ref 116	
192.	Godin M C. <i>The effect of visual feedback and self-scaling on plaque control behaviour. J Periodontol 1976; 47 (1): 34-37</i>		x
193.	Gonzalez C D, Frazier P J, Messer L B. <i>Sealant use by general practitioners: A Minnesota survey. ASDC J Dent Child 1991; 58 (1): 38-45</i>		x
194.	Gould K A, Eickhoff-Shemek J M, Stacy R D, Mecklenburg R E. <i>The impact of National Cancer Institute training on clinical tobacco use cessation services by oral health teams. JADA 1998; 129: 1442-1449</i>		x
195.	Gourley J M. <i>A two-year study of a fissure sealant in two Nova Scotia communities. J Pub Health Dent 1975; 35 (2): 132-137</i>		x
196.	Graves R C, Abernathy J R, Disney J A, Stamm J W, Bohannon H M. <i>University of North Carolina Caries Risk Assessment Study. III. Multiple factors in caries prevalence. J Pub Health Dent 1991; 51 (3): 134-143</i>		x
197.	Grembowski D, Fiset L, Spadafora A. <i>How fluoridation affects adult dental caries: systematic and topical effects are explored. JADA 1992; 123: 49-54</i>		x
198.	Gruebel A O. <i>Report on the study of dental public health services in New Zealand. Parts I - III. JADA 1950; 41: 275-283, 422-436, 574-589</i>		Text ref 16
199.	Gruner J L, Tharp D R. <i>Patient attitudes towards expanded duties: A survey of former IUSD team clinic patients. J Indiana Dent Assoc 1981; 60 (2): 33-34</i>		x
200.	Gruythuysen R J M, Vertin A A. <i>Dental hygienists - independent practice and pain control services. Community Dent Oral Epidemiol 1994; 22:</i>		x

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Ref Number	Study	Included in review	Excluded from review
	198-200		
201.	Halling A, Uhrbom E, Bjerner B, Solen G. <i>Tobacco habits, attitudes and participating behaviour in tobacco prevention among dental personnel in Sweden.</i> Community Dent Oral Epidemiol 1995; 23: 254-255	Text ref 114	
202.	Hammons P E. <i>Expansion of auxiliaries' duties to stretch dental manpower.</i> Illinois Dent J 1968; 37 (6): 359-362		x
203.	Hammons P E. <i>Expanded functions for dental assistants.</i> Dental Assistant 1968; 37 (3): 19-25		x
204.	Hammons P E, Jamison H C. <i>Expanded functions for dental auxiliaries.</i> JADA 1967; 75: 658-672	Text ref 59	
205.	Hammons P E, Jamison H C. <i>New duties for dental auxiliaries – the Alabama experience.</i> Am J Public Health 1968; 58 (5): 882-886		x
206.	Hammons P E, Jamison H. <i>Increasing the productivity of dental personnel.</i> J Amer Coll Dent 1968; 35: 154-160		x
207.	Hammons P E, Jamison H C, Wilson L L. <i>Quality of service provided by dental therapists in an experimental program at the University of Alabama.</i> JADA 1971; 82: 1060-1066	Text ref 60	
208.	Hamp S E, Lindhe J, Fornell J, Johansson L A, Karlsson R. <i>Effect of a field program based on a systematic plaque control on caries and gingivitis in schoolchildren after 3 years.</i> Community Dent Oral Epidemiol 1978; 6: 17-23		x
209.	Hankin R A. <i>The cost of providing restorative dentistry in an alternative delivery mode.</i> J Pub Health Dent 1977; 37 (3): 217-223		x
210.	Hannah A. <i>Executive summary of the report: New Zealand dentists, dental therapists and dental hygienists workforce analysis 1998. A resource paper for the Dental Council of New Zealand.</i> NZ Dent J 1998; 94: 150-151		x
211.	Hannerz H, Westerberg I. <i>Economic assessment of a six-year project with extensive use of dental hygienists in the dental care of children: a pilot study.</i> Community Dent Health 1996; 13: 40-43	Text ref 164	
212.	Hansard. Coll311/312. 12 June 1996		Text ref 3
213.	Harris M B, Holburn S, Dempsey T J, Sawey J, Jackman L E, Tonigan J S, Herlan M. <i>Patients' attitudes toward dentists and hygienists.</i> J Amer Coll Dent 1988; 55 (3): 8-15		x
214.	Hartshorne J E, Carstens I L, Engelbrecht J J, Hattings D. <i>Dental and oral hygiene student's knowledge of HIV infection and AIDS.</i> J Dent Assoc S Afr 1994; 49: 161-167		x
215.	Hastreiter R J, Bakdash B, Roesch M H, Walseth J. <i>Use of tobacco prevention and cessation strategies and techniques in the dental office.</i> JADA 1994; 125: 1475-1484	Text ref 113	
216.	Hastreiter R J, Roesch M H, Heckert K A, Danila R N. <i>Infection control practices and beliefs of Minnesota dental hygienists and dental assistants.</i> J Dent Hygiene 1990; 64 (8): 376-381		x
217.	Haugejorden O. <i>A study of intra-examiner error associated with recording of radiographic caries at different diagnostic levels.</i> Acta Odontol Scand 1975; 33: 169-181		x
218.	Haugejorden O. <i>The construction and use of diagnostic standards for primary radiographic caries.</i> Acta Odontol Scand 1976; 34: 69-77	Text ref 22	
219.	Hawley G M, Wainwright-Stringer Y, Craven R, Blinkhorn A S. <i>An investigation into the use of a dental hygienist in school screening</i> Community Dent Health 1999 Dec;16(4):232-5	Text ref 34	
220.	Hay I S, Batchelor P A. <i>The future role of dental therapists in the UK: A survey of District Dental Officers and General Practitioners in England and Wales.</i> Brit Dent J 1993; 175: 61-66		x
221.	Heid T H. <i>Dental Therapy Assistant: Effect on Team Productivity.</i> 1973. Fort Sam Houston, Texas. Health Care Research Division, Academy of Health Sciences, US Army. AD-759 139	Text ref 131	
222.	Heid T H, Barr J H. <i>Dental Therapy Assistant: Quality of Restorations Placed and Finished.</i> 1973. Fort Sam Houston, Texas. Health Care Research Division, Academy of Health Sciences, US Army. AD-759 140	Text ref 68	
223.	Heid T H, Bair J H. <i>Expanded-duty assistants: attitudes of Army dentists.</i> JADA 1973; 87: 872-877		x
224.	Heine. Geriatr Dent 1983; 3: 217-21		x
225.	Hetland L, Midtun N, Kristoffersen T. <i>Effect of oral hygiene instructions given by paraprofessional personnel.</i> Community Dent Oral Epidemiol 1981; 10: 8-14		x
226.	Hewat R E T, Eastcott D F, Bibby J B. <i>The prevalence of caries in deciduous teeth of NZ children.</i> NZ Dent J 1952; 48: 160-173		x
227.	Hobdell M H, Burt B A, Longhurst P. <i>A method of planning a dental treatment program for an institutionalised population.</i> Community Dent Oral	Text ref 150	

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Ref Number	Study	Included in review	Excluded from review
	Epidemiol 1975; 3: 166-173		
228.	Hobdell M H, Sheiham A, Allred H. <i>Dental auxiliaries: An annotated bibliography on the use of ancillary workers in dentistry. Parts I and II.</i> Quintessence Int 1975; 5: 63-68; 6: 67-73; 7: 71-79		x
229.	Holcomb J D, Mullen P D, Fasser C E, Smith Q, Martin J B, Parks L A, Wentz S M. <i>Health behaviours and beliefs of four allied health professions regarding health promotion and disease prevention.</i> J Allied Health 1985; 14 (4): 373-385		x
230.	Holcomb J D, Mullen P D, Thomson W A, Parks L A, Newland J R, Nathanson J. <i>Health promotion/disease prevention: Registered dental hygienists' beliefs and practice behaviours.</i> Dent Hyg 1986; 60: 158-165		x
231.	Hollis M J. <i>Dental caries experience of New Zealand children over a twenty-year period.</i> NZ Dent J 1970; 66: 167-174		x
232.	Holloway P J, Davies G N, Downer M C. <i>The Danish oral health care service for children: A comparison with alternative systems.</i> Int Dent J 1983; 33 (3): 238-244		x
233.	Holmgren C J, Pilot T. <i>Discussion from the symposium 'Minimal Intervention Techniques for Caries'.</i> J Pub Health Dent 1996; 56 (3): 161-163		x
234.	Holst A, Braune K. <i>Dental assistants' ability to select caries risk-children and to prevent caries.</i> Swed Dent J 1994; 18: 243-249	Text ref 145	
235.	Holst A, Hallonsten A-L, Schroder U, Ek L, Edlund K. <i>Prediction of behaviour-management problems in 3-year-old children.</i> Scand J Dent Res 1993; 101: 110-114		x
236.	Holst A, Martensson I, Laurin M. <i>Identification of caries risk children and prevention of caries in pre-school children.</i> Swed Dent J 1997; 21: 185-191	Text ref 146	
237.	Holt R D. <i>An evaluation of the role and clinical contribution of New Cross dental auxiliaries.</i> University of London. PhD thesis. 1979		x
238.	Holt R D, Murray J J. <i>An evaluation of the role and clinical contribution of New Cross dental therapists.</i> J Roy Soc Med 1980; 73: 187-190		x
239.	Holt R D, Murray J J. <i>An evaluation of the role of New Cross dental auxiliaries and of their clinical contribution to the community dental services. Parts I and II.</i> Brit Dent J 1980; 149: 227-230, 259-262		x
240.	Holt R D, Winter G B, Fox B, Askew R, Lam Lo G. <i>Dental health education through home visits to mothers with young children.</i> Community Dent Oral Epidemiol 1983; 11: 98-101		x
241.	Hord A B, Ellis R L. <i>ODA Demonstration Project Phase One: a training program of expanded functions for dental auxiliaries.</i> J Ont Dent Assoc 1972; 49 (11): 306-310		x
242.	Hord A B, Thompson G W, Ellis R L. <i>The Ontario Dental Association Demonstration Project on dental auxiliaries with expanded duties.</i> Ontario Dent 1974; 51 (6): 14-18	Text ref 69	
243.	Horst G ter. <i>AIDS and infection control: Dutch dental hygienists surveyed.</i> Community Dent Oral Epidemiol 1993; 21: 86-90		x
244.	Howat A P, Cannell S J. <i>Value of operating auxiliary personnel for caries diagnosis in dental epidemiology.</i> Community Dent Oral Epidemiol 1979; 7: 165-169	Text ref 23	
245.	Hughes J T, Rozier R G, Ramsey D L. <i>Natural History of Dental Diseases in North Carolina, 1976-77.</i> 1982. Durham, North Carolina. Carolina Academic Press	Text ref 14	
246.	Hull, R H, Darby M L. <i>ADHA graduate student/faculty research project: Continuing education.</i> J Dent Hygiene 1989; 63 (9): 415-421		x
247.	Humphris G M, Peacock L. <i>Occupational stress and job satisfaction in the community dental service of North Wales: a pilot study.</i> Community Dent Health 1992; 10: 73-82		x
248.	Ibikunle S A. <i>The implications of changing patterns in oral health for the general practice of dentistry.</i> Int Dent J 1985; 35: 73-77		x
249.	Ingber J S, Rose L F. <i>The problem-oriented record: clinical application in a teaching hospital.</i> J Dent Educ 1975; 39 (7): 472-482		x
250.	Ingersoll T G, Ingersoll B D, Seime R J, McCutcheon W R. <i>A survey of patient and auxiliary problems as they relate to behavioural dentistry curricula.</i> J Dent Educ 1978; 42 (5): 260-263		x
251.	Ismail A I, King W, Clark D C. <i>An evaluation of the Saskatchewan pit and fissure sealant program: A longitudinal follow-up.</i> J Pub Health Dent 1989; 49 (4): 206-211		x
252.	Jager. <i>Modern Prophylaxis in the dental office. 1. Instructions on prophylactic measures by the dental assistant</i> [German Quintessenz J 1990; 20 (1): 31-8		x
253.	Jago. <i>Getting dental services to the rural 85 per cent Papua New Guinea.</i> Med J 1991; 34 (4): 250-4		x

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Ref Number	Study	Included in review	Excluded from review
254.	Janczuk Z. <i>O wykorzystaniu higienistek stomatologicznych w opiece zdrowotnej w polsce.</i> Czas Stomatol 1985; 38 (9): 605-611		x
255.	Janczuk Z. <i>Dental hygienists as a new element in the oral health service in Poland.</i> Community Dent Oral Epidemiol 1987; 15: 117-118		x
256.	Jeboda. <i>Opinions of British dental providers on the training, employment, and utilisation of dental therapists in the United Kingdom.</i> Odontostomatol-Trop 1983; 6 (2): 91-105		x
257.	Jerman A C, Christen A G, Rahe A J. <i>A comparison of preventive dentistry attitudes among three Air Force professional subgroups.</i> Mil Med 1980; 145: 847-848		x
258.	Johnson C N. <i>The possibilities of professional service through co-operation between the dentist and his assistant.</i> JADA 1925: January: 44-48		x
259.	Johnson V B, Pinkham J R, Kerber P. <i>Stress reactions of various judging groups to the child dental patient.</i> J Dent Res 1979; 58 (7):1664-1671		x
260.	Jullien J A, Downer M C, Speight P M, Zakrzewska J M. <i>Evaluation of health care workers' accuracy in recognising oral cancer and pre-cancer.</i> Int Dent J 1996; 46: 334-339	Text ref 41	
261.	Kaplan A L. <i>Clinical quality and delegation in a private dental office utilising expanded-function dental auxiliaries.</i> J Pub Health Dent 1980; 40 (2): 118-125	Text ref 72	
262.	Kaplan A L, Bader J D, Mullins M R, Lange K W. <i>Measurement of effects of a state dental practice Act on potential delegation and production in general dental private practice.</i> J Pub Health Dent 1983; 43 (2): 161-167		x
263.	Kaplis N A, Bentley M. <i>Costs of training EFDAs for a TEAM program.</i> J Dent Educ 1979; 43 (5): 303-305		x
264.	Katz L, Ripa L W, Petersen M. <i>Nursing caries in Head Start children, St Thomas US Virgin Islands: assessed by examiners with different dental backgrounds.</i> J Clin Paediatr Dent 1992; 16 (2): 124-128	Text ref 26	
265.	Kay E J, Locker D. <i>Is dental health education effective? A systematic review of current evidence.</i> Community Dent Oral Epidemiol 1996; 24: 231-235		x
266.	Kay E, Locker D. <i>Effectiveness of Oral Health Promotion: A Review.</i> 1997. London. Health Education Authority		Text ref 103
267.	Kay E, Locker D. <i>A systematic review of the effectiveness of health promotion aimed at improving oral health.</i> Community Dent Health 1998; 15: 132-144		x
268.	Kay E J, Nuttall N M, Knill-Jones R. <i>Restorative treatment thresholds and agreement in treatment decision-making.</i> Community-Dent-Oral-Epidemiol. 1992 Oct; 20(5): 265-8.		Text ref 50
269.	Keenan G W. <i>The Saskatchewan dental nurse: An expanded duty auxiliary.</i> J Can Dent Assoc 1975; 6: 344-345		x
270.	Kennedy D P. <i>New Zealand's dental auxiliary programme.</i> WHO Chron 1971; 25: 65-69		x
271.	Kilpatrick H C. <i>Production increases due to chairside assistance.</i> JADA 1971; 82: 1367-1372	Text ref 130	
272.	Kilpatrick K E, Mackenzie R S. <i>Computer simulation model for manpower research.</i> In Lucaccini L F, Handley J. Eds. Research in the Use of Expanded Function Auxiliaries. 1974. Bethesda, Maryland. US Department of Health, Education, and Welfare. DHEW Publication No. (HRA) 75-14. 9-24	Text ref 148	
273.	Kilpatrick K E, Mackenzie R S, Delaney A G. <i>Expanded-function auxiliaries in general dentistry: a computer simulation.</i> Health Serv Res 1972; 7: 288-300	Text ref 147	
274.	Kilpatrick K E, Mackenzie R S, Kisko T H. <i>Dental practice analysis using computer simulation.</i> J Dent Educ 1976; 40: 745-9.		Text ref 149
275.	Kinnby C G, Widenheim J. <i>Evaluation of information on dental health care at child health centres: Factors in caries prevention - opinions of dental personnel and their relation to parental attitudes.</i> Acta Odontol Scand 1994; 52: 266-270		x
276.	Kinsey R B. <i>The Dental and Dental Auxiliary Education Profile System: a report to the membership.</i> J Dent Educ 1977; 41 (12): 739-745		x
277.	Kirkpatrick E. <i>The dental auxiliary's role in pain and anxiety control.</i> Dental Assist 1982; 51 (1): 26-28		x
278.	Klein H. <i>Civilian dentistry in war-time.</i> JADA 1944; 31: 648-661		Text ref 126
279.	Klock B. <i>Economic aspects of a caries preventive program.</i> Community Dent Oral Epidemiol 1980; 8: 97-102	Text ref 159	
280.	Klock B, Krasse B. <i>A comparison between different methods for prediction of caries activity.</i> Scand J Dent Res 1979; 87: 129-139		x
281.	Koerner K R. <i>Dynamic transition in dentistry: Expanded functions for auxiliaries.</i> J Pub Health Dent 1971; 31 (2): 123-140		x
282.	Koerner K R, Osterholt D A. <i>Student survey report: Washington dentists questioned on expanded duties.</i> JADA 1973; 86: 995-1000		x
283.	Koot A C. <i>Values of dental hygienists.</i> Ed Dir Dent Aux 1978; 3 (4): 13-18		x

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Ref Number	Study	Included in review	Excluded from review
284.	Kudrle R T. <i>The implications of foreign dental coverage for US national health insurance.</i> J Health Polit Policy Law 1981; 5 (4): 653-686		x
285.	Kushman J, Scheffler R, Miners L, Mueller C. <i>Nonsolo dental practice: incentives and returns to size.</i> J Econ and Bus 1978; 31 (1): 29-39	Text ref 158	
286.	Kwan S Y L. <i>Attitudes towards using clinical dental auxiliaries as examiners in epidemiological surveys among dentists and clinical dental auxiliaries in Community Dental Services in Yorkshire.</i> Dent Health 1999; 38 (2): 5-10		x
287.	Kwan S Y L, Prendergast M J. <i>The use of clinical dental auxiliaries as examiners in caries prevalence surveys in the United Kingdom: a feasibility study.</i> Community Dent Oral Epidemiol 1998; 26: 194-200	Text ref 30	
288.	Kwan S Y L, Prendergast M J, Williams S A. <i>The diagnostic reliability of clinical dental auxiliaries in caries prevalence studies – a pilot study.</i> Community Dent Health 1996; 13: 145-149	Text ref 31	
289.	Kwasman R, Handelman S L, MacIntyre, Barrett G. <i>Comparison of the effects of two handpiece locations on dental team performance.</i> JADA 1975; 91: 1203-1209		x
290.	Laatsch L J, Milson L M, Zimmer S E. <i>Use of interdisciplinary education to foster familiarisation among health professionals.</i> J Allied Health 1986; 15 (1): 33-42		x
291.	Lakies D W. <i>A comparison of the perceptual skill threshold levels of dental hygiene students to the skill level of the general population.</i> Ed Dir Dent Hyg 1986; 11 (2): 20-6		x
292.	Lathrop R L. <i>Expanding the functions of dental assistants: An evaluation of suggestions.</i> J Pub Health Dent 1968; 28 (2): 83-118		x
293.	Lautar. <i>Towards the professional status of dental hygiene in Alberta.</i> Probe 1996; 30 (3): 93-8		x
294.	Law F E, Johnson C E, Knutson J W. <i>Studies on dental care services for school children: First and second treatment series, Woonsocket R I.</i> Pub Health Rep 1953; 68 (12): 1192-1198		x
295.	Law F E, Johnson C E, Knutson J W. <i>Studies on dental care services for school children: Third and fourth treatment series, Woonsocket R I.</i> Pub Health Rep 1955; 70 (4): 402-409		x
296.	Leake J L, Martinello B P. <i>A four year evaluation of a fissure sealant in a public health setting.</i> J Can Dent Assoc 1976; 8: 409-415	Text ref 91	
297.	Le Gallee-Byle B L. <i>Trends in dental assistant utilisation: A comparative study. Parts I and II.</i> Dental Assist 1989; 58 (1): 17-25, 58 (2): 17-21		x
298.	Leske G S, Leverett D H. <i>Variables affecting attitudes of dentists towards the use of expanded function auxiliaries.</i> J Dent Educ 1976; 40 (2): 79-85		x
299.	Leske G S, Pollard S, Cons N. <i>The effectiveness of dental hygienist teams in applying a pit and fissure sealant.</i> J Prevent Dent 1976; 3 (2): 33-36		x
300.	Leslie G H. <i>New Zealand's external aid in dental health.</i> NZ Dent J 1966; 62: 199-211		x
301.	Leverett D H. <i>Meeting prosthodontic needs with expanded-function auxiliaries.</i> J Prosthet Dent 1976; 35 (1): 68-70		x
302.	Leverett D H, Handelman S L. <i>Review of training and deployment of expanded function auxiliaries in the United States.</i> New York State Dent J 1975; 41: 596-605		x
303.	Leverett D H, Handelman S L, Iker H P. <i>A computerised system for the evaluation of community dental programs.</i> Community Dent Oral Epidemiol 1977; 5: 145-150		x
304.	Lewis D W, Thompson G W. <i>A comparison of moderate and high users of Alberta's universal dental plan for the elderly.</i> Am J Pub Health 1995; 62 (12): 938-945		x
305.	Lewis D W, Thompson G W. <i>Alberta's Universal Dental Plan for the Elderly: Differences in use over 6 years by two cohorts.</i> J Can Dent Assoc 1996; 85 (10): 1408-1411		x
306.	Liang J N, Ogur J D. <i>Restrictions on Dental Auxiliaries: An Economic Policy Analysis.</i> 1987. Washington. Bureau of Economics Staff Report to the Federal Trade Commission		x
307.	Lindahl R L, Douglass C W, Huff S. <i>A survey of the attitudes of dentists toward expanding auxiliaries' duties.</i> Health Serv Rep 1973; 88 (5): 423-426		x
308.	Lindhe J, Axelsson P. <i>The effect of controlled oral hygiene and topical fluoride application on caries and gingivitis in Swedish schoolchildren.</i> Community Dent Oral Epidemiol 1973; 1: 9-16		x
309.	Lindhe J, Axelsson P, Tollskog G. <i>Effect of proper oral hygiene on gingivitis and dental caries in Swedish schoolchildren.</i> Community Dent Oral		x

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Ref Number	Study	Included in review	Excluded from review
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311.	Lindhe J, Nyman S. <i>The effect of plaque control and surgical pocket elimination on the establishment and maintenance of periodontal health: A longitudinal study of periodontal therapy in cases of advanced disease.</i> J Clin Periodontol 1975; 2: 67-79		x
312.	Lipscomb J, Douglass C W. <i>Are larger dental practices more efficient? An analysis of dental services production.</i> Health Serv Res 1986; 21 (5): 635-661		x
313.	Lipscomb J, Scheffler R M. <i>Impact of expanded-duty assistants on cost and productivity in dental care delivery.</i> Health Serv Res 1975; 10 (1): 14-35	Text ref 152	
314.	Little S J, Stevens V J. <i>Dental hygiene's role in reducing tobacco use: A literature review and recommendations for action.</i> J Dent Hygiene 1991; 65: 346-350		x
315.	Little S J, Stevens V J, Severson H H, Lichtenstein E. <i>An effective smokeless tobacco intervention for dental hygiene patients.</i> J Dent Hygiene 1992; 66 (4): 185-190	Text ref 111	
316.	Llewellyn-Saunders J. <i>The New Zealand School Dental Nurse: Comments on recent reports.</i> NZ Dent J 1951; 47: 48-53		x
317.	Llodra J C, Bravo M, Delgado-Rodriguez M, Baca P, Galvez R. <i>Factors influencing the effectiveness of sealants – a meta-analysis.</i> Community Dent Oral Epidemiol 1993; 21: 261-268	Text ref 97	
318.	Lobene R R. <i>A Study of New Duties for Dental Hygienists: Final Report: Dental Centre, Boston, Sept 30 1975</i>		x
319.	Lobene R R. <i>The Forsyth Experiment: An Alternative System for Dental Care.</i> 1979. Cambridge, Massachusetts. Harvard University Press	Text ref 82	
320.	Lobene R R, Berman K, Chaisson L B, Karelas H A, Nolan L F. <i>The Forsyth study of new duties for dental hygienists.</i> In Lucaccini L F, Handley J. Eds. <i>Research in the Use of Expanded Function Auxiliaries.</i> 1974. Bethesda, Maryland. US Department of Health, Education, and Welfare. DHEW Publication No. (HRA) 75-14. 42-84		x
321.	Lobene L, Berman K, Chaisson L B, Karelas H A, Nolan L F. <i>The Forsyth experiment in training of advanced skills hygienists.</i> J Dent Educ 1974; 38 (7): 369-379		x
322.	Locker D. <i>Work-related stress and its predictors among Canadian dental assistants.</i> Community Dent Oral Epidemiol 1989; 17: 263-266		x
323.	Locker D. <i>Work stress, job satisfaction and emotional well-being among Canadian dental assistants.</i> Community Dent Oral Epidemiol 1996; 24: 133-137		x
324.	Lotzkar S, Johnson D W, Thompson M B. <i>Experimental program in expanded functions for dental assistants: phase 1 base line and phase 2 training.</i> JADA 1971; 82: 101-122	Text ref 62	
325.	Lotzkar S, Johnson D W, Thompson M B. <i>Experimental program in expanded functions for dental assistants: phase 3 experiment with dental teams.</i> JADA 1971; 82: 1067-1081	Text ref 63	
326.	Louie R. <i>Dental care in the People's Republic of China.</i> Med Care 1978; 16 (7): 584-597		x
327.	Lovdal A, Arno A, Schei O, Waerhaug J. <i>Combined effect of subgingival scaling and controlled oral hygiene on the incidence of gingivitis.</i> Acta Odontol Scand 1961; 19: 537-555		x
328.	Ludwick W E, Schnoebelen E O, Knoedler D J. <i>Greater Utilisation of Dental Technicians. I. Report of Training.</i> 1963. US Naval Training Centre Great Lakes, Illinois. Dental Research Facility, Naval Administrative Command	Text ref 55	
329.	Ludwick W E, Schnoebelen E O, Knoedler D J. <i>Greater Utilisation of Dental Technicians. II. Report of Clinical Tests.</i> 1964. US Naval Training Centre Great Lakes, Illinois. Dental Research Facility, Naval Administrative Command	Text ref 56	
330.	Lussi-A. <i>Validity of diagnostic and treatment decisions of fissure caries.</i> Caries-Res. 1991; 25(4): 296-303.		Text ref 49
331.	Mafeni J O, Messer L B. <i>Parental knowledge and attitudes towards pit and fissure sealants.</i> Aust Dent J 1994; 39 (3): 172-180		x
332.	Magne P, Magne M, Belser U. <i>Restauration des dents anterieures.</i> Rev Mens Suisse Odonto-Stomatol 1993; 103: 319-324		x
333.	Mallow P K, Durward C S, Klaipo M. <i>Restoration of permanent teeth in young rural children in Cambodia using the Atraumatic Restorative Treatment (ART) technique and Fuji II glass ionomer cement.</i> Int J Paediatr Dent 1998; 8: 35-40		x
334.	Mandall N A, Read M J. <i>The effectiveness and efficiency of hygienists in carrying out orthodontic auxiliary procedures.</i> Br J Orthod 1999 Sep;26(3):229-32	Text ref 89	

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Ref Number	Study	Included in review	Excluded from review
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336.	Manz M C, Weyant R J, Adelson R, Sverha S K, Durnan J R, Geboy M J. <i>Impact of HIV on VA dental services: Report of a survey.</i> J Pub Health Dent 1994; 54 (4): 197-204		x
337.	Marcus S H, Grover P L, Revicki D A. <i>The method of information synthesis and its use in the assessment of health care technology.</i> Int J Technology in Health Care 1987; 3: 497-508.		Text ref 6
338.	Marcus M, Van Baelen A, Forsythe A, Bleich D. <i>Dental productivity: a perspective.</i> Inq 1975; 12: 204-215	Text ref 153	
339.	Markkanen H, Paunio K, Paunio I, Rajala M. <i>Reproducibility of a clinical screening method for assessing gingival inflammation, pockets and plaque retentions.</i> Community Dent Oral Epidemiol 1985; 13: 33-36	Text ref 38	
340.	Markkanen H, Rajala M, Paunio K. <i>Periodontal treatment need of the Finnish population aged 30 years and over.</i> Community Dent Oral Epidemiol 1983; 11: 25-32	Text ref 37	
341.	Martens L V, Loupe M J, Modlin L D, Diangelis A J. <i>Patient views on team dentistry and expanded duties.</i> Dent Hyg 1975; 49: 305-310	Text ref 118	
342.	Martin L M, Bouquot J E, Wingo P A, Heath C W. <i>Cancer prevention in the dental practice: Oral cancer screening and tobacco cessation advice.</i> J Pub Health Dent 1996; 56 (6): 336-340		x
343.	Masouredis C M, Hilton J F, Grady D, Gee L, Chesney M, Hengl L, Ernster V, Walsh M M. <i>A spit tobacco cessation intervention for college athletes: three-month results.</i> Adv Dent Res 1997; 11 (3): 354-359		x
344.	Mauriello S M, Bader J D, Disney J A, Graves R C. <i>Examiner agreement between hygienists and dentists for caries prevalence examinations.</i> J Pub Health Dent 1990; 50 (1): 32-37	Text ref 24	
345.	Maurizi A. <i>Economic Essays on the Dental Profession.</i> 1969. Iowa City. University of Iowa		x
346.	McClellan T E, Cox J L. <i>Description and evaluation of dentist-dental assistant team training in efficient dental practice management.</i> JADA 1968; 76: 548-553		Text ref 123
347.	McCloskey F S. <i>Survey of non-traditional functions performed by hygienists.</i> J Dent Educ 1977; 41 (11): 693-4		x
348.	McConaughy F L, Lukken K M, Toevs S E. <i>Health promotion behaviours of private practice dental hygienists.</i> J Dent Hygiene 1991; June: 222-230		x
349.	McDermott P T, Mayhall J T, Leake J L. <i>Dental therapists and the delivery of dental care in Canada's Northwest Territories.</i> Circumpolar Health 1991; 90: 668-671		x
350.	McIntyre J M. <i>The role of the hygienist in dental practice.</i> Aust Dent J 1982; 27 (2): 124-128		x
351.	McIntyre J M. <i>The utilisation of dental hygienists' services in South Australia.</i> Aust Dent J 1984; 29 (2): 96-100		x
352.	McKendrick A J W. <i>Control of dental caries by the school dental service: The application of preventive treatment and incremental care.</i> Brit Dent J 1970; 128 (4): 185-193		x
353.	McKendrick A J W. <i>The economics of caries prevention by dental hygienists.</i> Publ Hlth 1971: 85: 219-227		x
354.	McKenna E F, Grundy G E. <i>Glass ionomer cement fissure sealants applied by operative dental auxiliaries - retention rate after one year.</i> Aust Dent J 1987; 32 (3): 200-203		x
355.	McKenzie N, Born D O. <i>Dentists' attitudes toward expanded duties auxiliaries.</i> JADA 1973; 86: 1001-1008		x
356.	McManus R J, Wilson S, Delaney B C, Fitzmaurice D A, Hyde C J, Tobias R S, Jowett S, Hobbs F D R. <i>Review of the usefulness of contacting other experts when conducting a literature search for systematic reviews.</i> BMJ 1998; 317: 1562-3.		Text ref 10
357.	Mertz-Fairhurst E J, Fairhurst C W, Williams J E, Della-Giustina V E, Brooks J D. <i>A comparative clinical study of two pit and fissure sealants: 7-year results in Augusta, GA.</i> JADA 1984; 109: 252-255		x
358.	Mescher K D. <i>Comparison of traditional and experimental expanded function dental hygiene students in hand scaling.</i> J Dent Educ 1978; 42 (3): 142-146		x
359.	Messer L B, Calache H, Morgan M V. <i>The retention of pit and fissure sealants placed in primary schoolchildren by Dental Health Services, Victoria.</i> Aust Dent J 1997; 42 (4): 233-239		x
360.	Mileman P A, van-der-Weele L T. <i>Accuracy in radiographic diagnosis: Dutch practitioners and dental caries.</i> J-Dent. 1990 Jun; 18(3): 130-6.		Text ref 48

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Ref Number	Study	Included in review	Excluded from review
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362.	Miller D L. <i>Re-entry: manpower issues related to nonpracticing dental hygienists.</i> J Dent Hygiene 1990; 64 (5): 226-234		x
363.	Minervini. <i>Dent Hyg</i> 1981; 55 (5): 36-4		x
364.	Ministry of Health. <i>Report of United Kingdom Dental Mission on New Zealand School Dental Nurses.</i> NZ Dent J 1951; 47: 62-78		x
365.	Ministry of Health, Department of Health for Scotland, Ministry of Education. <i>New Zealand School Dental Nurses: Report of United Kingdom Dental Mission.</i> 1950. London. HMSO. 1-43		x
366.	Mitchell L, Murray J J. <i>Fissure sealants: a critique of their cost-effectiveness.</i> Community Dent Oral Epidemiol 1989; 17: 19-23		x
367.	Mitry D J. <i>Economics of expanded functions.</i> Dent Assist 1976; 45 (5): 23-25		x
368.	Mitry D J, Johnson K, Mitry N W. <i>Specification of the production function for dentistry: measurement and the paraprofessional input.</i> Inq 1976; 13: 152-157	Text ref 154	
369.	<i>Modernising NHS Dentistry – Implementing the NHS Plan.</i> Department of Health. 2000.		Text ref 5
370.	Mojon P, Favre P, Chung J P, Budtz-Jorgensen-E. <i>Examiner agreement on caries detection and plaque accumulation during dental surveys of elders.</i> Gerodontology. 1995 Jul; 12(1): 49-55.		Text ref 52
371.	Molvar M P. <i>An assessment of dental students as dental assistants.</i> J Dent Educ 1982; 46 (9): 563-564		x
372.	Moosbrucker J B, Jaffarian P J. <i>Team efficiency and length of education for dental assistants.</i> J Dent Educ 1967; 31:2: 185-190		x
373.	Morch T, Barman O. <i>Bruk av tannpleiere i kariesprofilaksen.</i> Nor Tannlaegeforen Tid 1976: 340-344		x
374.	Morgan M V, Crowley S J, Wright C. <i>Economic evaluation of a pit and fissure dental sealant and fluoride mouthrinsing program in two nonfluoridated regions of Victoria, Australia.</i> J Pub Health Dent 1998; 58 (1): 19-27		x
375.	Mourshed F. <i>A study of intraoral radiographic errors made by dental students.</i> Oral Surg 1971; 32 (5): 824-828		x
376.	Mourshed F, McKinney A L. <i>A comparison of paralleling and bisecting radiographic techniques as experienced by dental students.</i> Oral Surg 1972; 33 (2): 284-296		x
377.	Mullins M R, Armstrong S R. <i>Patients given high marks to expanded-duty assistants.</i> Dent Survey 1974; 50 (10): 21-24		x
378.	Mullins M R. JADA 1978; 43: 144-63		x
379.	Mullins M R, Kaplan A L, Bader J D, Lange K W, Murray B P, Armstrong S R, Haney C A. <i>Summary results of the Kentucky dental practice demonstration: a co-operative project with practising general dentists.</i> JADA 1983; 106: 817-825		Text ref 74
380.	Mullins M R, Kaplan A L, Mitry D J, Armstrong S R, Lange K W, Steuer R E, Johnson K H. <i>Production-economic effects of delegation and practice size in a private dental office.</i> JADA 1979; 98: 572-577	Text ref 73	
381.	Murtomaa H, Haanpaa U M, Roos M. <i>The role of dental hygienists in dental health education.</i> Proc Finn Dent Soc 1983; 79: 187-190		x
382.	Murtomaa H, Haugejorden O. <i>Finnish dentists' attitudes towards, and experience of, expanded-duty dental hygienists.</i> Community Dent Health 1987; 4: 143-150		x
383.	Murtomaa H, Meuramn J H, Rantama A, Levo S. <i>Interexaminer variability in common ratings in reading Streptococcus mutans dip-slides with or without a microscope.</i> Scand J Dent Res 1987; 95: 144-150		x
384.	Myers S E. <i>Comparative findings in school systems.</i> J School Health 1968; 38 (9): 604-10		x
385.	Nawrot B, Plonka B. <i>Porównanie zasad rejestracji i okreslenia wydajnosci pracy technikow dentystycznych w Polsce I nrd.</i> Prot Stom 1987; 37 (1): 43-46		x
386.	Nederfors T, Paulsson G, Isaksson R, Fridlund B. <i>Ability to estimate oral health status and treatment need in elderly receiving home nursing--a comparison between a dental hygienist and a dentist.</i> Swed Dent J 2000;24(3):105-16	Text ref 42	
387.	Needleman H L, MacGregor S S, Lynch L M. <i>Effectiveness of a state-wide child abuse and neglect educational program for dental professionals.</i> Paediatr Dent 1995; 17 (1): 41-45		x
388.	<i>New Zealand Dental Nurses Report of United Kingdom Dental Mission.</i> London HMSO, 1950.		Text ref 15
389.	Nixon J R. <i>Dental Assistant Evaluation Index: A technic to evaluate the work performance of Indian Health Service dental assistants.</i> J Pub Health Dent 1978; 38 (2): 172-183		x

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Ref Number	Study	Included in review	Excluded from review
390.	Nixon J R. <i>The Indian Health Service study of the expanded-duty dental auxiliary II (EDDA II)</i> . J Pub Health Dent 1980; 40 (2): 99-117	Text ref 83	
391.	Nordengen R E, Fylkesnes K, Sogaard A J. <i>Effektivisering I offentlig tannhelsetjeneste: er det mulig a spare ved okt delegering til tannpleier?</i> Nor Tannlegeforen Tid 1990; 100: 152-158	Text ref 160	
392.	Obuhoff O N. <i>Growth to maximum use of auxiliaries</i> . Gen Dent 1977; 25 (2): 36-39		x
393.	O'Donnell D. <i>Use of the SADP for measurement of attitudes of Chinese dental students and dental surgery assistants toward disabled persons</i> . Spec Care Dentist 1993; 13 (2): 81-85		x
394.	Odrich J. <i>The dental hygienist: A primary care provider</i> . J Pub Health Dent 1985; 45 (2): 64-69		x
395.	Ohrn K, Crossner C-G, Borgesson I, Taube A. <i>Accuracy of dental hygienists in diagnosing dental decay</i> . Community Dent Oral Epidemiol 1996; 24: 182-186	Text ref 32	
396.	Oliver R G, Griffiths J. <i>Different techniques of residual composite removal following debonding – time taken and surface enamel appearance</i> . Brit J Orthod 1992; 19: 131-137	Text ref 88	
397.	Olivier M, Brodeur J-M, Simard P L. <i>Efficacy of APF treatments without prior toothcleaning targeted to high-risk children</i> . Community Dent Oral Epidemiol 1992; 20: 38-42		x
398.	Ooi C L, Tan G C. <i>A two-year study on the retention of pit and fissure sealants applied by different dental operators</i> . Singapore Dent J 1986; 11 (1): 15-17	Text ref 93	
399.	Orschel N L, Gatchell S E, Bradshaw N J, Wiebe D P, Libstug. <i>Light up your smile - quit smoking: A smoking cessation program for the patients of dental health professionals</i> . Ont Dent 1997; 74 (9): 41-44		x
400.	Oscarson N, Kallestal C, Karlsson G. <i>Methods of evaluating dental care costs in the Swedish public dental health care sector</i> . Community Dent Oral Epidemiol 1998; 26: 160-165		x
401.	O'Shea R M, Cohen L K. <i>Some public attitudes towards the use of dental auxiliaries</i> . J Pub Health Dent 1968; 28 (4): 255-257		x
402.	O'Shea R M, Cohen L K. <i>Some public attitudes toward the use of auxiliaries, 1968</i> . J Pub Health Dent 1970; 30 (4): 255-257		x
403.	O'Shea R M, Sielski K A, Creola P, Geraci G M, Haberer J, Sowinski J A. <i>Helping patients quit smoking: The dental hygienist's role</i> . Dent Hygiene 1987; 61 (8): 373-377		x
404.	Overstreet G A, Dilworth J B, Legler D W. <i>Productivity and economic implication of a simulated practice using expanded duty dental assistants</i> . Community Dent Oral Epidemiol 1978; 6: 233-239	Text ref 155	
405.	Pack A R C, Bradley S D, Kennedy D T. <i>Hygienists and operating auxiliaries: The opinions of New Zealand dental practitioners</i> . NZ Dent J 1991; 87: 87-92		x
406.	Parker W A. <i>Dental therapy assistant: cost performance analysis</i> . Fort Sam Houston, TX: Health Care Research Division, Academy of Health Sciences, US Army; 1976: Publication (HSCD) 76-006R.	Text ref 138	
407.	Pebley H C. <i>The effect of new technologies in the training and utilisation of dental auxiliaries in the US armed forces - Navy</i> . Int Dent J 1976; 26 (2): 165-170		x
408.	Pelton W J, Bethart H, Goller K S. <i>The ability of dental therapists to perform oral prophylaxes</i> . JADA 1972; 84: 611-615	Text ref 84	
409.	Pelton W J, Dilworth J B, Overstreet G A, Embry O H. <i>Comparison of computer-generated data with actual use of therapists</i> . J Dent Educ 1973; 37 (2): 21-25		x
410.	Pelton W J, Embry O H, Overstreet G A, Dilworth J B. <i>Economic implications of adding two expanded-duty dental assistants to a practice</i> . JADA 1973; 87: 604-609	Text ref 133	
411.	Pelton W J, Overstreet G A, Embry O H, Dilworth J B. <i>Economic implications of adding one therapist to a practice</i> . JADA 1973; 86: 1301-1309	Text ref 132	
412.	Peretz B, Kaplan R, Stabholtz A. <i>The influence of a patient-management course to dental hygiene students on the dental anxiety of their patients</i> . J Dent Educ 1997; 61 (4): 368-373		x
413.	Perry D A, Freed J R, Kushman J E. <i>Characteristics of patients seeking care from independent dental hygienist practices</i> . J Pub Health Dent 1997; 57 (2): 76-81		x
414.	Petersson GH, Bratthall D. <i>Caries risk assessment: a comparison between the computer program 'Cariogram', dental hygienists and dentists</i> . Swed Dent J 2000;24(4):129-37	Text ref 35	

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416.	Pipe, Ratcliffe P A, Watts T, Parr R W. <i>Plague control instruction for the dental team. VI. Evaluating your performance.</i> Dent Assistant 1972; 41 (5): 16-20		x
417.	Pitiphat W, Phantumvanit P, Songpaisan Y, Frencken J, Pilot T. <i>Atraumatic Restorative Treatment (ART) - evaluation after one year.</i> J Dent Res 1994; 73: 1014 (abstract 24)		x
418.	Postlethwaite K M. <i>The orthodontic skill mix in Sweden.</i> Brit Dent J 1990; 168: 122-124		x
419.	Poulsen S, Agerbaek N, Melsen B, Korts D C, Glavind L, Rolla G. <i>The effect of professional toothcleansing on gingivitis and dental caries in children after 1 year.</i> Community Dent Oral Epidemiol 1976; 4: 195-199		x
420.	Poulsen S, Carlsen J W, Duus J, Lundsager Hansen J, Hansen J, Jespersen S, Munck L, Riishede M, Risager J. <i>Development of a Danish preventive program for preschoolchildren based on co-operation with key-persons.</i> Community Dent Oral Epidemiol 1983; 11: 137-42		x
421.	Poulsen S, Risager J. <i>Effect on dental caries of a dental public health program for Danish schoolchildren.</i> Community Dent Oral Epidemiol 1975; 3: 161-165		x
422.	Powell W O, Sinkford J C, Henry J L, Chen M S. <i>Comparison of clinical performance of dental therapist trainees and dental students.</i> J Dent Educ 1974; 38 (5): 268-272	Text ref 80	
423.	Pugh C R. <i>The Yukon school dental care experiment.</i> J Can Dent Assoc 1969; 35 (7): 336-341		x
424.	Ramanathan J, Leclercq M-H, Mendis B R R N, Barmes D E. <i>Gathering data on oral mucosal diseases: A new approach.</i> World Health Forum 1995; 16: 299-304		x
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431.	Rich, S K, Smorang J. <i>Survey of 1980 California dental hygiene graduates to determine expanded-function utilisation.</i> J Pub Health Dent 1984; 44 (1): 22-27		x
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434.	Richardson A S; Gibson-GB; Waldman-R J-Can-Dent-Assoc. 1980 Apr; 46(4): 259-6072		x
435.	Riordan P J. <i>Secular changes in treatment in a school dental service.</i> Community Dent Health 1995; 12: 221-225		x
436.	Riordan P J. <i>Can organised dental care for children be both good and cheap?</i> Community Dent Oral Epidemiol 1997; 25: 119-125		x
437.	Riordan P J, Espelid I, Tveit A B. <i>Radiographic interpretation and treatment decisions among dental therapists and dentists in Western Australia.</i> Community Dent Oral Epidemiol 1991; 19: 268-71	Text ref 27	
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440.	Ripa L W. <i>The current status of pit and fissure sealants: A review.</i> J Can Dent Assoc 1985; 5: 367-380		x
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Ref Number	Study	Included in review	Excluded from review
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443.	Robinson G E, Wuehrmann A H, Sinnott G M, McDevitt E J. <i>Four-handed dentistry: The whys and wherefores.</i> JADA 1968; 77: 573-579		x
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445.	Rock W P, Gordon P H, Bradnock G. <i>The effect of operator variability and patient age on the retention of fissure sealant resin.</i> Brit Dent J 1978; 145: 72-75		x
446.	Rock W P, Weatherill S, Anderson R J. <i>Retention of three fissure sealant resins: The effects of etching agent and curing method: Results over 3 years.</i> Brit Dent J 1990; 168: 323-325		x
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448.	Roder D M. <i>The school dental therapist of South Australia.</i> J Pub Health Dent 1972; 32 (2): 70-82		x
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450.	Roder D M. <i>Diagnosis, treatment planning and referral by school dental therapists.</i> Aust Dent J 1974; 19 (4): 242-249		x
451.	Roder D M. <i>The effect of treatment provided by dentists and therapists in the South Australian School Dental Service: The second report.</i> Aust Dent J 1976; 21 (2): 147-152		x
452.	Roder D M. <i>The employment of dental nurses.</i> J Pub Health Dent 1978; 38 (2): 159-171		x
453.	Rolla G. <i>Er tannpleiere egnet til kariesdiagnose?</i> Nor Tannlegeforen Tid 1994; 104 (18): 858		x
454.	Romcke R G, Lewis D W. <i>Use of expanded function dental hygienists in the Prince Edward Island dental manpower study.</i> J Can Dent Assoc 1973; 4: 247-262	Text ref 67	
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457.	Rosenblum F N. <i>Experimental pedodontic auxiliary training program.</i> JADA 1971; 82: 1082-1089	Text ref 61	
458.	Rosenstein D I. <i>Professional encroachment: Comparison of emergence of denturists in Canada and Oregon.</i> J of Marketing for Professions 1980; 1 (10): 21-5		x
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465.	Sanders M J. <i>Comparing two methods of teaching plaque control.</i> Dent Hygiene 1976; 50: 505-507		x
466.	Sankaranarayanan R. <i>Health care auxiliaries in the detection and prevention of oral cancer.</i> Oral Oncol, 1997 May, 33:3, 149-54.		Text ref 21
467.	Saparamadu K D G. <i>Preventive dentistry - a priority in Sri Lanka.</i> Int Dent J 1996; 46: 97-102		x
468.	Sarll D W, Jones J H, Ashton M A. <i>Cross-infection control: The role of 'in-training' dental nurses.</i> J Dent 1996; 24: 349-353		x
469.	Saskatchewan Department of Health. <i>New Zealand School Dental Service: Report of Observation Mission from Saskatchewan, July 1962 (Regina, 1965)</i>		x
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Ref Number	Study	Included in review	Excluded from review
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473.	Schwarz E. <i>Is caries prevention cost-effective? Does anybody care?</i> Acta Odontol Scand 1998; 56: 187-192		x
474.	Scruggs R R, Daniel S J, Larkin A, Stolz R F. <i>Effects of specific criteria and calibration on examiner reliability</i> . J Dent Hygiene 1989; 63 (3): 125-129	Text ref 94	
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476.	Seal E. <i>New Cross dental auxiliary utilisation</i> . London: University of London; 1974: MSc dissertation.	Text ref 137	
477.	Secker-Walker R H, Hill H C, Solomon L J, Flynn B S. <i>Smoking cessation practices in dental offices</i> . J Pub Health Dent 1987; 47 (1): 10-15	Text ref 110	
478.	Secker-Walker R H, Solomon L J, Flynn B S, Dana G S. <i>Comparisons of the smoking cessation counselling activities of six types of health professionals</i> . Prevent Med 1994; 23: 800-808	Text ref 112	
479.	Secker-Walker R H, Solomon L J, Haugh L D, Welsh D, Tatro M, Witham L, Hill H C, Mercier S M. <i>Smoking cessation advice delivered by the dental hygienist: A pilot study</i> . Dent Hygiene 1988; April: 186-192		x
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487.	Simonsen R J. <i>Cost effectiveness of pit and fissure sealant at 10 years</i> . Quintessence Int 1989; 20 (2): 75-82		x
488.	Simonsen R J. <i>Retention and effectiveness of dental sealant after 15 years</i> . JADA 1991; 122: 34-42		x
489.	Sintonen H. <i>Comparing the productivity of public and private dentistry</i> . In Culyer A J, Jonsson B. Eds. Public and Private Health Services: Complementarities and Conflicts. 1986. Oxford. Basil Blackwell. 219-233	Text ref 141	
490.	Sisty-LePeau N, Boyer E M, Lutjen D. <i>Dental hygiene licensure specifications pain control procedures</i> . J Dent Hygiene 1990; 64 (4): 179-185		x
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494.	Sisty N L, Henderson W G, Paule C L. <i>Review of training and evaluation studies in expanded functions for dental auxiliaries</i> . JADA 1979; 98: 233- 248		x
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Ref Number	Study	Included in review	Excluded from review
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500.	Smith L W, Suomi J D, Greene J C, Barbano J P. <i>A study of intra-examiner variation in scoring oral hygiene status, gingival inflammation and epithelial attachment level</i> . J Periodontol 1970; 41: 671-674		x
501.	Snyder G A. <i>Pennsylvania dental hygienists' knowledge, attitudes, and infection control practices in relation to AIDS and AIDS patients</i> . J Dent Hygiene 1993; 67 (4): 188-196		x
502.	Songpaisan Y. <i>Manpower and the future role of dentistry in developing countries</i> . Int Dent J 1985; 35: 78-82		x
503.	Soricelli D A. <i>Implementation of the delivery of dental services by auxiliaries – the Philadelphia experience</i> . Am J Pub Health 1972; 62 (8): 1077-1087	Text ref 64	
504.	Spencer A J, Webster D. <i>Employment of hygienists and provision of periodontal services</i> . J Dent Res 1989; 68: 540, abstract 16	Text ref 142	
505.	Spratley M H. <i>Supply and demand for prosthetic treatment in Victoria, Australia</i> . Community Dent Oral Epidemiol 1978; 6: 151-158		x
506.	Sprod A J, Anderson R, Treasure E T. <i>Effective Oral Health Promotion: Literature Review</i> . 1996. Cardiff. Health Promotion Wales Technical Report 20		Text ref 102
507.	Stach D J, Hatch R A, Tilliss T S I, Cross-Poline G N. <i>Change in occlusal height resulting from placement of pit and fissure sealants</i> . J Prosthetic Dent 1992; 68: 750-753		x
508.	Stamm J W, Disney J A, Graves R C, Bohannon H M. <i>The University of North Carolina Caries Risk Assessment Study. I: Rationale and content</i> . J Pub Health Dent 1988; 48 (4): 225-232		x
509.	Stephen K W, Kirkwood M, Young K C, Gillespie F C, MacFadyen E E, Campbell D. <i>Fissure sealing of first permanent molars: An improved technique applied by a dental auxiliary</i> . Brit Dent J 1978; 144: 7-10		x
510.	Stephens C D, Keith O, Witt P, Sorfleet M, Edwards G, Sandy J R. <i>Orthodontic auxiliaries - a pilot project</i> . Brit Dent J 1998; 185 (4): 181-187		x
511.	Sterritt G R, Frew R A. <i>Evaluation of a clinic-based sealant program</i> . J Pub Health Dent 1988; 48 (4): 220-224		x
512.	Stewart A J, D'Amelio S. <i>The employment of dental auxiliary personnel in private practice: A survey report</i> . Aust Dent J 1984; 29 (3): 172-174		x
513.	Stiefel D J. <i>Inclusion of a program of instruction in care of the disabled in a dental school curriculum</i> . J Dent Educ 1985; 43 (5): 262-270		x
514.	Stiefel D J, Lubin J H, Truelove E L. <i>A survey of perceived oral health needs of homebound patients</i> . J Dent Educ 1979; 39 (1): 7-15		x
515.	Stiefel D J, Truelove E L. <i>A postgraduate dental training program for treatment of persons with disabilities</i> . J Pub Health Dent 1979; 49 (2): 85-90		x
516.	Stiles H M, Ward G T, Woolridge E D, Meyers R. <i>Adhesive sealant clinical trial: comparative results of application by a dentist or dental auxiliaries</i> . J Prevent Dent 1976; 3 (3): 8-11	Text ref 92	
517.	Stokes A N, Anderson H K, Cowan T M. <i>Lay and professional knowledge of methods for emergency management of avulsed teeth</i> . Endod Dent Traumatol 1992; 8: 160-162		x
518.	Strack B B, McCullough M A, Conine T A. <i>Compliance with oral hygiene instruction and hygienists' empathy</i> . Dent Hygiene 1980; 54 (4): 181-184		x
519.	Stratford N M, Burden D J. <i>Clinical assistant training in orthodontics - how effective is it?</i> Brit Dent J 1998; 184 (9): 448-452		x
520.	Studstill Z D. <i>The case for the Alabama dental hygiene program</i> . CDS Rev 1991; 84 (2): 36-39		x
521.	Suomi J D, Greene J C, Vermillion J R, Doyle J, Change J J, Leatherwood E C. <i>The effect of controlled oral hygiene procedures on the progression of periodontal disease in adults: Results after third and final year</i> . J Periodontol 1971; 42: 152-160		x
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523.	Swallow J N, van Groenestijn M A J, Maas-De Waal C J, Mileman P A. <i>Examiner variability in the assessment of dental restorations</i> . Community Dent Oral Epidemiol 1978; 6: 256-263		x
524.	Swenson H M. <i>Preventive periodontics and the control therapist</i> . J Indiana Dent Assoc 1972; 51 (1): 14-17		x
525.	Tan H H. <i>Effect of dental health care instruction and prophylaxis on knowledge, attitude and behaviour in Dutch military personnel</i> . Community Dent Oral Epidemiol 1979; 7: 252-258		x
526.	Tan H H, Ruiters E, Verhey H. <i>Effect of repeated dental health care education on gingival health, knowledge, attitude, behaviour and perception</i> . Text ref 106	Text ref 106	

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Ref Number	Study	Included in review	Excluded from review
	Community Dent Oral Epidemiol 1981; 9: 15-21		
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528.	Tan H H, Theunissen B A H M, Crielaers P J A. <i>De kwaliteit van restauraties vervaardigd door tandartsen en mondhygienisten met uitgebreid takenpakket</i> . Ned Tijdschr Tandheelkd 1979; 86: 121-127	Text ref 75	
529.	Tan H H, van Gemert H G. <i>Time utilisation, productivity and costs of solo and extended duty auxiliary dental practice</i> . Community Dent Oral Epidemiol 1977; 5: 151-155	Text ref 139	
530.	Taniguchi. <i>Control of gingival inflammation and teamwork with the dental hygienist</i> [Japanese]. Dental Outlook 1985; 65 (1): 109-21		x
531.	Tappan M W, Fitch M A. <i>The training and utilisation of paraprofessional personnel in a public health dental program of prevention</i> . J Pub Health Dent 1975; 35 (1): 35-39	Text ref 90	
532.	Taylor. <i>The use of expanded duty dental auxiliaries</i> NZ Dent J 1976; 72: 143-7		x
533.	<i>The Education and Training of the Personnel Auxiliary to Dentistry</i> . The Nuffield Foundation, 1993.		Text ref 1
534.	<i>The Professionals Complementary to Dentistry</i> . The General Dental Council, 1998.		Text ref 2
535.	Thomson W M, Brook J A, Brook R J. <i>Exploring dental operators' perceptions of their clinical tasks</i> . Community Dent Health 1994; 11: 17-23		x
536.	Thylstrup A, Poulsen S. <i>Retention and effectiveness of a chemically polymerised pit and fissure sealant after 12 months</i> . Community Dent Oral Epidemiol 1976; 4: 200-204		x
537.	Thylstrup A, Poulsen S. <i>Retention and effectiveness of a chemically polymerised pit and fissure sealant after 2 years</i> . Scand J Dent Res 1978; 86: 21-24		x
538.	Tilliss T S I, Stach D J. <i>Recognition of HIV/AIDS-associated oral lesions by the dental team</i> . Clin Prevent Dent 1991; 13 (6): 5-11	Text ref 39	
539.	Tilliss T S I, Vojir C P. <i>Identification of HIV/AIDS-associated oral lesions</i> . J Dent Hygiene 1993; 67 (1): 30-36	Text ref 40	
540.	Trainer J L. <i>The introduction of preventive ancillaries</i> . Brit Dent J 1973; June: 547-549		x
541.	Tuominen R. <i>Dentists and special dental technicians in the supply of complete denture services in Finland</i> . Proc Finn Dent Soc 1984; 80: 131-135		x
542.	Tuominen R. <i>A comparison of dentists' and denturists' complete denture patients</i> . Proc Finn Dent Soc 1987; 84 (1): 53-59	Text ref 121	
543.	Turner P J. <i>Training hygienists for an auxiliary role in orthodontics</i> . Brit Dent J 1993; 175: 209-213		x
544.	Uitenbroek D G, Schaub R M H, Tromp J A H, Kant J H. <i>Attitudes of two groups of dentists towards dental hygienists</i> . Community Dent Oral Epidemiol 1989; 17: 11-13		x
545.	Uitenbroek D G, Schaub R M H, Tromp J A H, Kant J H. <i>Dental hygienists' influence on the patients' knowledge, motivation, self-care, and perception of change</i> . Community Dent Oral Epidemiol 1989; 17: 87-90	Text ref 109	
546.	University of York NHS Centre for Reviews and Dissemination. <i>Undertaking Systematic Reviews of Research on Effectiveness: CRD Guidelines for Those Carrying Out or Commissioning Reviews</i> : CRD Report Number 4. University of York, 1996.		Text ref 9
547.	Utriainen P, Widstrom E. <i>Economic aspects of dental care in Finnish health centres</i> . Community Dent Oral Epidemiol 1990; 18: 235-238	Text ref 161	
548.	Utriainen. Hallinnon Tutkimus 1993; 12: 40-6		x
549.	Van Ostenbury P R. <i>Economic analysis of a dental hygienist in the hospital</i> . Journal of Ambulatory Care Management 1983; 6 (3): 28-35		x
550.	Vehkalahti. J Soc Med 1992; 29: 173-80		x
551.	Wadhwa P. <i>A team approach in the practice of periodontics</i> . Ed Dir Dent Aux 1978; 3 (4): 8-11		x
552.	Wagner I-V, Carlsson G E, Ekstrand K, Odman P, Schneider N. <i>A comparative study of assessment of dental appearance by dentists, dental technicians, and laymen using computer-aided image manipulation</i> . J Esthetic Dent 1996; 8 (5): 199-205		x
553.	Waldman H B. <i>The edentulous population: Its use and need of dental services</i> . J Prosthet Dent 1987; 58 (5): 643-646		x
554.	Wallace M J, Berger P K, Harris J. <i>Behaviourally based measures for assessing the non-clinical performance of expanded function dental auxiliaries in team settings</i> . J Dent Res 1979; 58 (7): 1672-1680		x
555.	Waller R R. <i>Expanded duties of auxiliaries: A survey of opinions of Georgia dentists</i> . JADA 1973; 86: 1009-1019		x
556.	Walsh J. <i>International patterns of oral health care - the example of New Zealand</i> . NZ Dent J 1970; 66: 143-152		x

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Ref Number	Study	Included in review	Excluded from review
557.	Walsh M M. <i>The economic contribution of dental hygienists' activities to dental practice: Review of the literature..</i> J Pub Health Dent 1987; 47 (4): 193-197		x
558.	Walsh M M, Hannebrink R, Kerner J, Heckman B H. <i>The effect of expanded duties legislation on dental hygiene education and practice in California.</i> Dent Hygiene 1987; 61 (10): 457-461		x
559.	Wang N J. <i>Productivity in dental care for children: factors influencing the time spent delivering dental care.</i> Community Dent Health 1994a; 11: 227-232	Text ref 162	
560.	Wang N. <i>Efficiency in the Public Dental Service for Children in Norway: Change in the Use of Dental Hygienists and Recall Intervals'</i> (PhD thesis, University of Oslo) 1991.		x
561.	Wang N J. <i>Use of dental hygienists and returns to scale in child dental care in Norway.</i> Community Dent Oral Epidemiol 1994b; 22: 409-414	Text ref 163	
562.	Wang N J. <i>Preventive dental care of children and adolescents in the 1990s: Denmark, Iceland, Norway, and Sweden.</i> Acta Odontol Scand 1998; 56: 169-172		x
563.	Wang N J, Holst D. <i>Individualising recall intervals in child dental care.</i> Community Dent Oral Epidemiol 1995; 23: 1-7		x
564.	Wang N J, Kallestal C, Petersen P E, Arnadottir I B. <i>Caries preventive services for children and adolescents in Denmark, Iceland, Norway and Sweden: Strategies and resource allocation.</i> Community Dent Oral Epidemiol 1998; 26: 263-71		x
565.	Wang N, Marstrand P, Holst D, Ovrum L, Dahle T. <i>Extending recall intervals - effect on resource consumption and dental health.</i> Community Dent Oral Epidemiol 1992; 20: 122-124		x
566.	Wang N J, Riordan P J. <i>Recall intervals, dental hygienists and quality in child dental care.</i> Community Dent Oral Epidemiol 1995; 23: 8-14	Text ref 29	
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568.	Warnakulasuriya K A, Nanayakkara B G. <i>Reproducibility of an oral cancer and precancer detection program using a primary health care model in Sri Lanka.</i> Cancer Detect Prev 1991;15(5):331-4.		Text ref 20
569.	Waterman G E. <i>Effective use of dental assistants.</i> Pub Health Rep 1952; 67 (4): 390-4		x
570.	Waterman G E. <i>Pub Health Rep 1953; 67: 75-80</i>		x
571.	Waterman G E. <i>The Richmond-Woonsocket studies on dental care services for school children.</i> JADA 1956; 52: 676-684		x
572.	Waterman G E, Knutson J W. <i>Studies on dental care services for school children - first and second treatment series, Richmond, Ind.</i> Pub Health Rep 1953; 68 (6): 583-589		x
573.	Waterman G E, Knutson J W. <i>Studies on dental care services for school children - third and fourth treatment series, Richmond, Ind.</i> Pub Health Rep 1954; 69 (3): 247-254		x
574.	Watt R G, Fuller S S. <i>Oral health promotion - opportunity knocks!</i> Brit Dent J 1999; 186 (1): 3-6		x
575.	Webster D B, Mink J R. <i>Evaluation of the quality of restorations in a children's dental program.</i> ASDC J Dent Child 1981; 48 (2): 134-137		x
576.	Weintraub J A. <i>The effectiveness of pit and fissure sealants.</i> J Pub Health Dent 1989; 49 (5): 317-330		x
577.	Weintraub J A. <i>Prevention of early childhood caries: A public health perspective.</i> Community Dent Oral Epidemiol 1998; 26: Suppl 1: 62-66		x
578.	Weintraub J A, Stearns S C, Burt B A, Beltran E, Eklund S A. <i>Soc Sci Med 1993; 36 (11): 1483-1493</i>		x
579.	Weissman D D, Longhurst G E. <i>Clinical evaluation of a rectangular field collimating device for periapical radiography.</i> JADA 1971; 82: 580-582		x
580.	Whyte R J, Leake J L, Howley T P. <i>Two-year follow-up of 11,000 dental sealants in first permanent molars in the Saskatchewan Health Dental Plan.</i> J Pub Health Dent 1987; 47 (4): 177-181		x
581.	Wiedenfield K R, Draughn R A, Goltra S E. <i>Chairside veneering of composite resin to anterior stainless steel crowns: Another look.</i> ASDC J Dent Child 1995; 62 (4): 270-273		x
582.	Wight C, Blinkhorn A S. <i>An assessment of two dental health education programmes for school children in the Lothian region of Scotland.</i> J Paediatr Dent 1988; 4: 1-7	Text ref 108	
583.	Wilson S G, Tsutsui P T, Farnoush A. <i>An assessment of the relationship of time to fine motor skill acquisition in scaling and root planing procedures.</i> Quintessence Int 1985; 6: 407-413	Text ref 85	
584.	Wilson S G, Tsutsui P T, Checchi L. <i>Dati comparativi sulla abilita clinica degli studenti in odontoiatria e delle igieniste sul tecnicismo dello</i>		x

APPENDIX 10

Ref Number	Study	Included in review	Excluded from review
	<i>scaling e root planing.</i> Mondo Odontostomatol 1985; 1: 53-59		
585.	Winter G B. <i>Dental Health Education in Hillingdon</i> (London, 1981)		x
586.	Wood A J, Saravia M E, Farrington F H. <i>Cotton roll isolation versus Vac-Ejector isolation.</i> ASDC J Dent Child 1989; 56: 438-441	Text ref 96	
587.	Wood G J, Cecchini J J, Nathason N, Hiroshige K. <i>Office-based training in tobacco cessation for dental professionals.</i> JADA 1997; 128: 216-224		x
588.	Wood P J. <i>Infection control practices of Rhode Island dental hygienists and certified dental assistants.</i> J Dent Hygiene 1995; 69 (5): 212-222		x
589.	Woodward G L, Csima A, Leake J L, Ryding W H, Main P A. <i>Estimation of procedure times in a publicly funded dental programme.</i> Community Dent Health 1995; 12: 155-160		x
590.	Woolgrove J, Boyles J. <i>Operating dental auxiliaries in the United Kingdom - a review.</i> Community Dent Health 1984; 1: 93-99		x
591.	Woolley J M. <i>Changing oral hygiene attitudes and habits.</i> Int Dent J 1980; 30 (3): 249-256		x
592.	World Health Organisation. <i>Expert Committee on Auxiliary Dental Personnel: Report.</i> 1959. Geneva. WHO Technical Report Series No. 163. 1-32		x
593.	World Health Organisation. <i>Alternative Systems of Oral Care Delivery: Report of a WHO Expert Committee.</i> 1987. Geneva. WHO Technical Report Series No. 750. 1-58		x
594.	Wright F A C. <i>Comparison of oral health status of young persons from Dunedin, New Zealand, and Heidelberg, Australia.</i> Community Dent Oral Epidemiol 1984; 12: 292-296		x
595.	Wyche C J, Kerschbaum W E. <i>Michigan hospice oral healthcare needs survey.</i> J Dent Hygiene 1994; 68 (1): 35-41		x
596.	Yap W L. <i>Extended duties' orthodontic auxiliaries - an insight into the training and practice in America and Canada.</i> Brit Dent J 1993; 175: 141-142		x
597.	Yoneyama T, Aiba T, Ota M, Hirota K, Miyake Y, Hashimoto K, Okamoto H. <i>Treatment of gingivitis in elderly patients in a nursing home.</i> Jpn J Geriatr 1997; 34: 120-124		x
598.	Young N A. <i>Problem-based learning: Using cases to drive the learning process.</i> J Dent Educ 1998; 62 (3): 235-241		x
599.	Zappa U, Rothlisberger J,P, Simona C, Case D. <i>In vivo scaling and root planning forces in molars.</i> J. Periodontol 1993; 64: 349-354.	Text ref 86	