Journal of Orthodontics, Vol. 30, 2003, 72–78

FEATURES SECTION

How to … find the evidence

S. R. Bickley
University Dental Hospital of Manchester, UK

J. E. Harrison
Liverpool Dental Hospital, UK

Introduction

One of the most important and possibly time-consuming areas of research is literature searching. The availability of electronic databases allows us to search and access the results very quickly, but the quality of our search will be dependent upon a number of factors. In this paper we will provide information on some of these and consider how they impact on search results. We hope that this will be helpful and lead the reader to develop a more systematic approach to literature searching.

Electronic searching

At first glance, searching electronic databases appears to be an easy way of tracking down literature, but you should be aware that even the most experienced searchers will miss some relevant literature. For example, it has been shown that when a search is carried out for controlled clinical trials approximately half of the relevant trials on a topic may be missed in an electronic search, even though most of the missed citations are in the databases![1]

Electronic searches chiefly rely on two things:

- the controlled vocabulary terms assigned to the article by professional indexers;
- descriptors used by author/s in the title and abstract.

Lack of detail in these sections can influence the results of a search and, as by no means all publications have abstracts, this reduces the search potential even further, and some papers may only be identified by searching journals manually.

There is, fortunately, an increasing trend for journals to use structured abstracts. In this format the author systematically describes the objective, design, setting, subject, interventions, outcomes, results, and conclusions of a study. This should improve indexing of records and the quality of electronic searches in the future.[2–4] Structured abstracts are also one of the recommendations for the CONSORT guidelines.[5]

So how do you do a search?

An effective search will involve the following steps:

- Identify your research question and break it down into sections.
- Think through appropriate search terms for each section.
- Build a structured search strategy.
- Run your search.
- Review your search results.
- Revise your search strategy if necessary and re-run the search.

Identifying the sections of your research question

It is important to avoid the temptation to start searching before properly thinking through appropriate search terms for the question. A structured search strategy will be more controllable, and easier to check for inclusions and omissions than a jumbled list of search terms. Time spent identifying search terms and organizing them into the framework of the search strategy will be time well spent, and will save having to trawl through masses of papers that are not relevant to the research topic.

First, identify key section headings from the research question. These might include participants, their condition of interest, the intervention or exposure of interest, and outcome. Under the section headings, list appropriate terms to create the structure on which the search strategy will be built. An example of this can be seen in Figure 1, where the subject of the search is the effectiveness of powered versus manual toothbrushes for orthodontic patients.

Identifying search terms for each section

The aim of the search strategy should be to obtain a balance between sensitivity, i.e. a search wide enough to guard against missing relevant articles, but which will retrieve some non-relevant articles, and specificity, i.e. a

Address for correspondence: S. R. Bickley, Cochrane Oral Health Group, University Dental Hospital of Manchester, Higher Cambridge Street, Manchester M15 6FH, UK. Email: Sylvia.r.bickley@man.ac.uk

Population (orthodontic patients)	Intervention (tooth brushing)	Equipment variable 1 (manual)	Equipment variable 2 (powered)
ORTHODONTICS orthodontic*	TOOTHBRUSHING toothbrush* tooth NEAR clean* teeth NEAR clean*	manual* conventional* hand brush*	power* mechanical* electric* electronic* ultrasonic* sonic* 'motor driven' battery NEAR operate* automatic*

Fig. 1 Identifying and listing terms to create the framework on which a search strategy will be built to find papers comparing the effectiveness of manual and powered toothbrushes in orthodontic patients.

search so closely focused that it may exclude relevant articles. Where thoroughness of the search is essential, for example, when identifying randomized controlled trials (RCTs) for systematic reviews, the sensitivity of the search will be paramount.

Most of us will probably start searching with MEDLINE. This is the US National Library of Medicine's (NLM) premier bibliographic database that contains over 11 million references to journal articles and can be accessed free of charge via website http://www.ncbi.nlm.nih.gov/PubMed. It should be stressed that effective searching is an art that can only be learned through practice, and gaining knowledge and understanding of the rules that must be applied to searching individual databases. Information and guidance can be obtained from medical libraries or database providers' point of access, e.g. NLM, PubMed, OVID, Silver Platter, etc., via Internet webs sites or directly from the database help files. Ideally, a good first step is to seek the guidance of a medical librarian or information specialist. Their expertise in literature searching, combined with the clinician's subject knowledge, will provide the complementary skills needed to build the most appropriate and effective search strategy.

The mechanics and technicalities of electronic searching

The search terms should include controlled vocabulary and free-text terms. Controlled vocabulary refers to the subject headings (indexing terms) that are used in electronic databases. Some databases, such as MEDLINE, EMBASE, and CINAHL, use subject headings that are arranged in a hierarchically structured format like the branches of a tree, with broader concepts near the top and more specific terms lower down. In MEDLINE this is called the MeSH® Tree (MeSH standing for 'Medical Subject Headings') and in EMBASE–EMTREE®. Other databases may use a structured thesaurus of concepts arranged alphabetically. Using the hierarchically structured trees or thesauri will allow you to broaden or narrow your search. You will also find the NLM's MeSH Browser, which has full details of MeSH terms, their indexing and hierarchy, a valuable resource. This can be found at www.nlm.nih.gov/mesh/MBrowser.html or a hard copy may be found in the reference section of medical libraries.

The section of the MeSH tree presented in Figure 2 shows a dental example where the broadest subject heading is 'orthodontics' with more specific headings in the branches below. Any point in the hierarchy can be searched to include the terms indented beneath it by applying the 'explode' function in the database's search engine. Linking the instruction 'explode' to the term 'orthodontics' would automatically include all the terms presented in the orthodontic hierarchy below. Alternatively, the search can be focused on a specific area of interest within orthodontics by applying the 'explode' function to a branch lower down the tree. For example, applying 'explode' to the subject heading 'orthodontic-appliances-functional' would focus the search to retrieve only articles indexed with the terms 'orthodontic-appliances-functional or activator-appliances' (Figure 2).

Controlled vocabulary and free-text terms

MeSH headings (controlled vocabulary terms), which appropriately describe the subject, are assigned to an article by experienced indexers at the National Library of Medicine. When using controlled vocabulary, only the exact indexing term (unless it has been 'exploded')

will be searched for in the indexing field. It is important to realize that terms selected directly from controlled vocabulary will only be searched for in the dedicated indexing field, whereas free-text terms can be searched for anywhere in the record.

However, do not be misguided into thinking that using free-text only is a 'catch all' option, because the search will be confined to finding the exact match of the text word/s in the title, abstract, or indexing field of the reference. Your search will also miss things that exploded indexing will pick up. For example, take the phrase 'maxillofacial abnormalities'; used as free-text this will only pick up articles where this exact phrase appears. On the other hand, if the same phrase is used as an 'exploded' MeSH term, not only will articles be picked up where this term appears, but also articles containing the subordinate terms beneath it in the MeSH tree as presented in Figure 3.

In general, using only controlled vocabulary may restrict retrieval of relevant records, while using free-text only is more likely to miss some relevant records and produce many non-relevant records, which will be time consuming to work through. Be aware that controlled vocabulary and free-text terms might be expressed or spelt differently. For example 'apicectomy' or 'anaesthetics' may be used as free-text terms, but the MeSH controlled vocabulary terms are 'APICOECTOMY' and 'ANESTHETICS'. Another example would be 'topical fluoride', which is how the phrase is likely to be expressed as free-text, but is indexed as 'FLUORIDES-TOPICAL' in MeSH.

Orthodontics
- Orthodontic-appliance-design
- Orthodontic appliances
  - Occlusal splints
  - Orthodontic appliances functional
    - Activator appliances
  - Orthodontic appliances removable
    - Activator appliances
    - Extra-oral traction appliances
  - Orthodontic brackets
  - Orthodontic retainers
  - Orthodontic wires
- Orthodontics—corrective
  - Occlusal—adjustment
  - Orthodontic space-closure
  - Palatal expansion technique
  - Tooth movement
- Orthodontics—interceptive
  - Serial extraction
- Orthodontics—preventive
  - Space maintenance

Fig. 2 Section of MeSH® Tree 2002 showing hierarchically structured format.

MAXILLOFACIAL-ABNORMALITIES (major MeSH term)
- JAW-ABNORMALITIES
  - CLEFT PALATE
  - MICROGNATHISM
  - PIERRE–ROBIN SYNDROME
  - PROGNATHISM
  - RETROGNATHISM

'Exploding' the term MAXILLOFACIAL ABNORMALITIES will automatically include all these terms

Fig. 3 The effect of exploding MeSH terms.**[Q2]**

Truncators and operators

'Truncators' can be used to expand search terms, and 'operators' to include or exclude specific terms and locate terms that are close to each other. If a truncation symbol is inserted at the end of a free-text word it will expand the search to retrieve multiple suffix variations of the word. An example of this would be when placing a truncation symbol (in this example an asterisk) at the end of a word, e.g. orthodontic*, which will also retrieve articles containing the words orthodontics or orthodontically (see Figure 4a).

For the search strategy to be comprehensive, it will need to include both controlled vocabulary and free-text terms linked systematically by appropriate search operators such as 'AND', 'OR', 'NEAR', and 'NOT'. The operator 'AND' is used when the paper must contain both search terms and the operator; 'OR' is used when a paper may contain either search term. Figures 4a and b give examples. Placing the operator 'NOT' between two terms will have the search retrieve papers that contain the first word, but not the second term. For example, 'neoplasm NOT breast'. Used in a similar way, proximity searching, using the operators 'NEAR', 'NEXT', or 'ADJACENT' can be helpful for focusing a search. Be aware that operators might be used or expressed differently across databases.

Building the search strategy

Returning to the example in Figure 1 and the list of controlled vocabulary terms, (identified by upper case text) and free-text terms (lowercase), the next stage is to enter

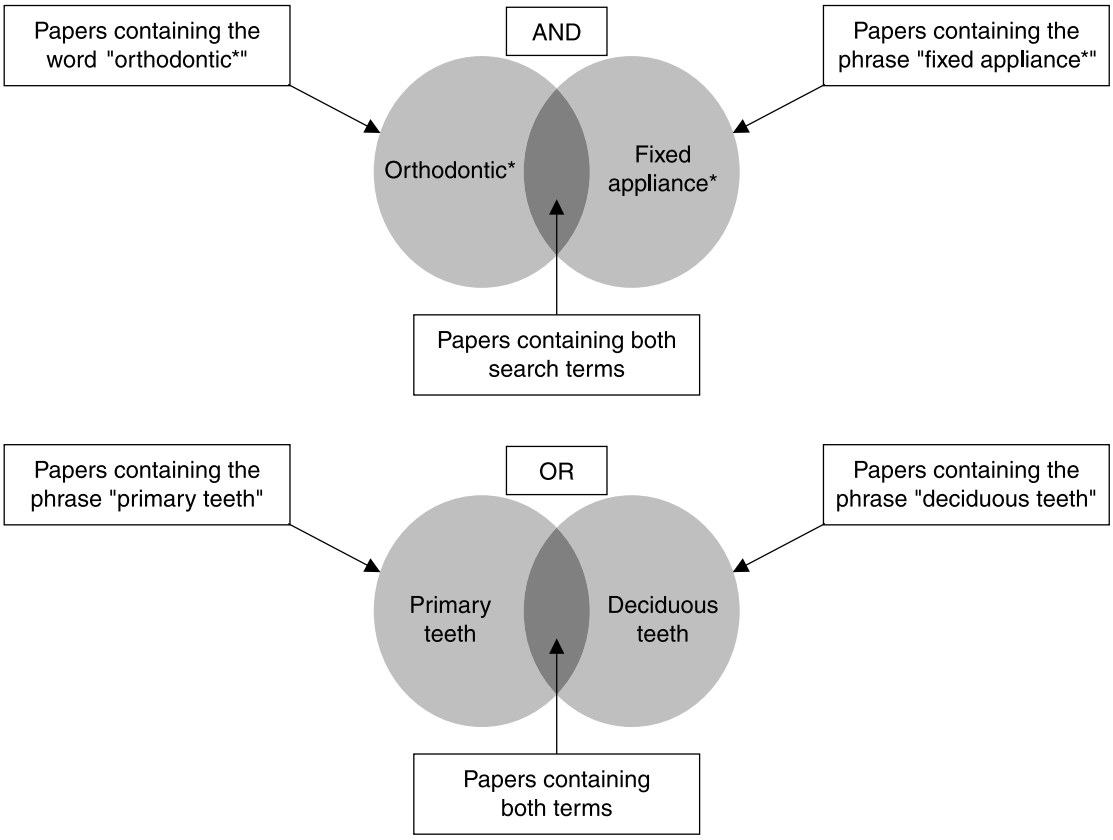

Fig. 4 (a) The effect of linking search terms with the operator 'AND'. (b) The effect of linking search terms with the operator 'OR'. There will be some overlap where papers contain both terms, but all papers will be of interest to the searcher.

the search strategy into the search engine. In the worked example the search was applied to the Cochrane Controlled Trials Register (CCTR). Figure 5 shows how the search terms from the initial framework have been presented and linked using truncators and operators. Once all the search terms or strings from one section have been searched line by line, the results of these are then 'OR'd' together to combine the search for the section (lines 3, 8, 11, and 21). When all the sections have been searched, the cumulative searches for each section are linked with the operator AND (line 22). This focuses retrieval of citations by ensuring that at least one search term from each section will feature in the retrieved citations and should therefore be relevant to the research topic. Remember though, that the more sections you include in your search framework, the more focused the search will be. To protect the sensitivity of the search, keep the search framework to essential section headings and ensure that a wide range of search terms for each section is included.

Building a well thought-out search strategy will take concentration and is time-consuming. Fortunately, most database providers enable the search strategy to be saved so that, once built, it can be recalled and re-run. It is also good advice to save the search strategy at intervals as it is built, so that if a mistake is made, the last save can be recalled, rather than having to start from the beginning again.

Running, reviewing, and revising your search strategy

Once the search strategy has been developed and run, the retrieved articles should be examined to identify whether the search needs revision or not. In general, if the search produces large numbers of irrelevant references it should be refined further. Likewise if fewer references than expected are retrieved revise the search strategy to increase sensitivity.

What to search: choosing the best resource for your needs

It must be appreciated that no single resource can be relied upon to provide all the evidence. Where thoroughness and search quality are important, searching a range

#1 ORTHODONTICS [explode ME] [321]
#2 orthodontic* [637]
#3, #1 OR #2 [687]
#4 TOOTHBRUSHING [324]
#5 toothbrush* [745]
#6 tooth **NEAR** clean* [128]
#7 teeth **NEAR** clean* [90]
#8, #4 OR #5 OR #6 OR #7 [880]
#9 manual* [3111]
#10 conventional* [10409]
#11, #9 OR #10 [13254]
#12 power* [7217]
#13 mechanical* [3802]
#14 electric* [3709]
#15 electronic* [2793]
#16 ultrasonic* [869]
#17 sonic* [101]
#18 'motor driven' [29]
#19 'battery operated' [19]
#20 automatic* [1017]
#21 #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 [17765]
#22 #3 AND #8 AND #11 AND #21 = [19]

Explanatory notes: (ME) = MeSH terms (controlled vocabulary) are shown in upper case; free-text in lower case. Operators are shown in bold upper case. As each line of the search is executed the number of records retrieved is shown in square brackets as shown above. This example shows the number of records retrieved from the Controlled Trials Database (CENTRAL/CCTR) in the Cochrane Library, Issue 2 2002. As the searches from each group are combined it can be seen how the record retrieval becomes more focused to the subject of the research question. This can be seen at search line 22, where search Group 1 (the population – orthodontic patients) has been added to Group 2: (intervention – tooth brushing); then added to Group 3, equipment variable 1; and finally to Group 4, equipment variable 2, giving a total of 19 records retrieved.

Fig. 5 The structured search strategy.

of resources should be considered. By no means all healthcare literature is indexed in MEDLINE: non-English language references are under-represented and only published articles are included. This, in itself, may introduce publication bias if studies with positive results are selectively published.[6]

Evidence-based dentistry research

Most questions associated with applying evidence-based dentistry to clinical dentistry will revolve around the effectiveness of competing interventions that are provided for patients. To answer these questions, up-to-date systematic reviews of randomized controlled trials (RCTs) are generally accepted as being the most reliable source of evidence. The best place to search for systematic reviews of RCTs is the Cochrane Database of Systematic Reviews (CDSR), one of the electronic databases in *The Cochrane Library* (see below). If there are no relevant, up-to-date systematic reviews in a particular area of interest, consider evidence contained in the individual reports of RCTs. The Cochrane Controlled Trials Register (CCTR), also available in *The Cochrane Library*, is recognized as being the best single source of such reports.[7] CCTR is the result of a number of ongoing projects within the Cochrane Collaboration worldwide[8] and brings together, in one bibliographic database, citations to controlled clinical trials from across the world (currently, in Issue 4, 2002, there are 345,378 citations). Updated quarterly, it is sourced from searching a wide range of electronic databases, conference proceedings, and trials found only through the Cochrane Collaboration's world-wide journal hand-searching programme.

The Cochrane Library is available through many university libraries and postgraduate medical centres. All residents in England, Wales and the island of Ireland can access *The Cochrane Library* via the internet (www.cochrane.org) free of charge thanks to government funding. Other countries that have free access are listed on the website. *The Cochrane Library* is also available on personal subscription on CD or via the Internet [details available from Update Software Ltd (Summertown Pavilion, Middle Way, Summertown, Oxford OX2 7LG, UK) or Update Software Inc. (1070 South Santa Fe Ave., Suite 21, Vista, CA 92084, USA)

or via websites www.cochranelibrary.com and www.update-software.com].

The Cochrane Oral Health Group (www.cochrane-oral.man.ac.uk) has developed and maintains a dedicated oral health register currently holding over 15,000 citations to reports of controlled clinical trials. This is a most valuable resource for those undertaking Cochrane Systematic Reviews and reviewers can arrange searches of the database through the Group's Trials Search Co-ordinator, who also offers support to reviewers in developing sensitive search strategies.

Hand-searching Journals

It can be seen from the foregoing that where thoroughness of literature searching is paramount, the serious researcher will need to broaden the search to databases beyond MEDLINE. It should also be appreciated that, even then, electronic searching has its limitations and 'hand-searching', which involves searching journals page by page, may need to be undertaken in order to trace as many relevant articles as possible.

The Cochrane Collaboration has recognized the importance of the need to identify randomized controlled trials for systematic reviews, and has set up a worldwide journals hand-searching programme to identify RCTs and CCTs. This is a highly organized programme, co-ordinated by the New England Cochrane Center, Providence Office, geared to avoiding duplication of effort by registering searches and making the results accessible to all through *The Cochrane Library*'s CENTRAL/CCTR database. The Master List of journals being searched can be accessed online via www.cochrane.us/cochranemainpage.asp. The Cochrane Oral Health Group contributes to this programme through its responsibility for the registration and overseeing of hand-searching of the oral health literature. The Group is always pleased to hear from anyone who can spare even a small amount of time to contribute to this important programme, which ultimately benefits researchers in oral health throughout the world. For an information sheet on the oral health journal hand-searching programme please contact Sylvia Bickley, Trials Search Co-ordinator, Cochrane Oral Health Group, MANDEC, University Dental Hospital of Manchester, Higher Cambridge Street, Manchester M15 6FH, UK (email: sylvia.r.bickley@man.ac.uk).

Limitations of electronic searching

To demonstrate the limitation of electronic searching and emphasize the importance of hand-searching journals, we undertook an exercise to examine and compare the results of searching for randomized controlled trials and controlled clinical trials on MEDLINE relying on searching the indexing field 'Publication Type' (PT). Four orthodontic journals for the publication period of 1991–2000 inclusive, which had also been hand-searched as part of the Cochrane Oral Health Group's journal hand-search programme, made up the test-set for the exercise. (NB: the *British Journal of Orthodontics* changed its title to *Journal of Orthodontics* in year 2000 and these two titles were included in the MEDLINE search.)

SRB searched MEDLINE via OVID, using the following search strategy:

1 *American Journal of Orthodontics & Dentofacial Orthopedics* (journal).
2 *British Journal of Orthodontics* (journal).
3 *Journal of Orthodontics* (journal).
4 *Angle Orthodontist* (journal).
5 *European Journal of Orthodontics* (journal).
6 Controlled Clinical Trial (pt).
7 Randomized Controlled Trial (pt).
8 1 OR 2 OR 3 OR 4 OR 5.
9 6 OR 7.
10 8 AND 9.
11 Limit 10 to yr = 1991–2000.

The combined results of the electronic MEDLINE search and manual hand-search identified a total of 304 citations as either RCTs or CCTs. The MEDLINE search identified 143 citations and hand-searching of the journals identified 266 citations. The MEDLINE search identified 105 of the 266 (39.5%) citations that had been found by hand-searching journals together with an additional 38 records. The 38 unmatched MEDLINE citations (12.5%) were examined and 32 (84.2%) of these were found not to be controlled clinical trials. These included 17 *in vitro*, five retrospective, and four matched control studies, cross-sectional, and non-clinical studies. The remaining six citations (15.8%) were found to be controlled clinical trials and these had been missed by hand-searchers (Table 1).

The MEDLINE search only matched 105 of the reports of CCTs or RCTs that had been found by hand-searching leaving a total of 161 reports that were found only by hand-searching. Of these, 81 were full papers

Table 1 Results of the exercise to compare a MEDLINE search for controlled clinical trials with hand-searching in four orthodontic journals for the period 1991–2000 inclusive. The MEDLINE search focused the search on the indexing field 'Publication type' (pt) using search terms 'Randomized Controlled Trial' or 'Controlled Clinical Trial'

How the citations were identified	Total	%
Medline and hand-searching	105	34.5
Hand-searching only	161	53.0
Medline only	38	12.5
Total	304	100.0
Design of citations identified by Medline only	**Total**	**%**
Was a clinical trial	6	15.8
Was not a clinical trial	32	84.2
Total	38	100.0

that should have been indexed in MEDLINE, but had not been indexed as 'Randomized Controlled Trial' or 'Controlled Clinical Trial' in the Publication type (pt) field. Conference abstracts accounted for the remaining 80 reports of trials. However, these are not indexed in MEDLINE, but can be a rich and important source of trials. It may be expected that some of these abstracts will ultimately be published as full papers, but for reasons that have been alluded to earlier in this paper, by no means all of them will be. Unpublished trials are an essential component of systematic reviewing and conference abstracts provide an important tracking system to identify both published and unpublished trials.

In presenting the results of this exercise, we would like to emphasize that there is no intention to denigrate the unquestionable value of MEDLINE. It is a resource that allows us to search and download swathes of valuable literature without moving from our desks. Nor would we wish this report to be seen as a criticism of the National Library of Medicine's professional indexers because there are a number of things, outside their control, which may lead to incomplete or inappropriate indexing of publications, including unclear descriptors of study design and/or methodology. Several of these problems could be addressed by journals using structured abstracts.

This exercise serves to emphasize that when thoroughness of searching is paramount, for example for systematic reviewing, there are several points that you need to be aware of: These include the:

- limitations of electronic searching if too much reliance is placed on it especially when searching on single fields, e.g. the publication type (PT) field alone;
- need to devise structured search strategies that use a combination of controlled vocabulary and free-text terms to aid sensitivity of the search;
- need to hand-search journals to find information on trials that may not be indexed in MEDLINE or other electronic databases;
- value of an organized programme of hand-searching to avoid duplication of effort.

In conclusion, in this article we have endeavoured to give an insight into approaching searching the literature systematically, whilst cautioning against too much reliance on electronic searches. It has been shown that effective searching requires a knowledge and understanding of the many facets and anomalies of searching, concentrated effort, and practice. Where there is limited experience in searching and where accuracy of searching is paramount, we would advise seeking the guidance of a medical librarian or information specialist.

References

1. Dickersin K, Scherer R, Lefebvre C, Identifying relevant studies for systematic reviews. *Br Med J* 1994; **309**: 1286–1291.
2. Harrison JE, Ashby D, Lennon MA. An analysis of papers published in the British and European Journals of Orthodontics. *Br J Orthod* 1996; **23**: 203–209.
3. Haynes, RB, Mulrow, CD, Huith, EJ, Altman, DG, Gardner, MJ. More informative abstracts revisited. *Ann Intern Med* 1990; **113**: 69–76.
4. *Ad Hoc* Working Group for Critical Appraisal of the Medical Literature. A proposal for more informative abstracts of clinical articles. *Ann Intern Med* 1987; **106**: 598–604.
5. Begg C, Cho M, Eastwood S, Horton R, Moher D, Olkin I, Pitkin R, *et al.* Improving the quality of reporting of randomized controlled trials. The CONSORT statement. *J Am Med Ass* 1996; **276**:637–639.
6. Clarke M, Oxman AD, (Eds). Locating and selecting studies. Cochrane Reviewers' Handbook 4.1.5, [updated April 2002]; Section 5. In: *The Cochrane Library*, Issue 4, 2002. Oxford Update Software. Updated quarterly.
7. Egger M, Davey-Smith G. Meta-analysis bias in location and selection of studies. *Br Med J* 1998; **316**: 61–66.
8. Lefebvre C, Clarke MJ. Identifying randomized trials. In: Egger M, Davey-Smith G, Altman DA (Eds) *Systematic Reviews in Health Care: meta-analysis in context*, 2nd edn. London: BMJ Publishing Group; 2001.